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Teacher change in math education

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Abstract

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The sources referenced come from research studies involving classroom practices and professional development programs, journal articles related to the math reform movement, and books on the same topic. They date from 1989 to 2000.

The main recommendations are as follows: increase teacher awareness of the change process, increase teacher knowledge of research in math, change teacher understanding of math from procedural to conceptual, and implement longterm professional development and support networks.

Teacher Change in Math Education

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ABSTRACT

This literature review addresses the process teachers go through in order to change their instructional practices in math. The purpose of this review is to compare traditional math practices with practices being advocated by reform initiatives, to look at hurdles preventing teachers from adapting these reforms, and share suggestions for removing these hurdles to allow a smoother change process for teachers. The sources referenced come from research studies involving classroom practices and professional development programs, journal articles related to the math reform movement, and books on the same topic. They date from 1989 to 2000. The main recommendations are as follows: increase teacher awareness of the change process, increase teacher knowledge of research in math, change teacher understanding of math from procedural to conceptual, and implement long-term professional development and support networks.

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INTRODUCTION

Recent reform is asking teachers to use a constructivist approach to the teaching/learning process (Manouchehri, 1997). Typically, reform ideas such as this are only talked about, but not acted upon (Senger, 1999). This appears to again be the case as research concludes that teachers are not changing their instructional practices even with knowledge of reform movement ideas (NCTM, 2000; Price & Ball, 1997; Stipek, 1998).

In this paper, I will address three questions dealing with the current math reform movement. The first question being how do the math reform initiatives compare with traditional math instruction? Within this question I will address a description of traditional math instruction, a description of reform initiatives, and the changing role of the teacher with these initiatives. The second question will be what are the hurdles slowing or preventing teachers from adapting reform initiatives? Lastly, what suggestions are there for removing the hurdles to allow a smoother change process for math teachers?

METHODOLOGY

A literature review was chosen to answer these questions because of the extensive amount of material written on the topic and because of the difficulty of performing a research study involving teachers changing practices. The sources selected come from research studies of classroom practices and professional development programs, journal articles related to the math reform movement, and books dealing with the same topics.

The sources date from 1989 through 2000, with the majority written in the last five years. The material was read with special attention paid to the topic of teacher roles and how teachers must change in order to adapt reform initiatives to their practices. Sources were considered only if they dealt with classroom research or opinions based on direct observation or experiences in classroom settings. It is hoped that this paper will

aid educators reforming practices in math education.

ANALYSIS

How Does Traditional Math Education Compare with Math Practices Advocated by the Reform Initiatives?

Description of Traditional Practices

Walking into a typical, traditional math classroom an observer is likely to witness a general pattern of instruction as follows: the teacher introduces a skill by modeling, the teacher leads the students as they practice as a group, and finally, the teacher asks the students to practice independently. The independent assignment usually consists of practicing the skill many times as homework.

According to Peterson and Knapp (1993), early educators believed this drill and practice of correct procedures strengthened mental bonds. Contrary to beliefs about forming connections that are prevalent in education today, these educators believed teachers needed to keep similar material separated or students would form incorrect bonds.

A historically positive view of drill and practice for math instruction has been sustained. Due to the emphasis placed on skills, conceptual learning and problem solving have been a separate part of math. This has lead to the current state of math education in which almost all students are learning basic skills, but are not able to apply these skills to new situations or explain why they work. Trafton and Theissen (1999b) believe that teachers using traditional practices offer a dualistic program, keeping skills and computation separate from the use of problem solving.

In a traditional math classroom, the teacher is the final authority and expert on math knowledge (Schifter, 1993). The teacher is responsible for conveying knowledge to

the students. Another aspect of this pointed out by Resnick, Bill, Lesgold, and Leer (1991) is that teachers follow a step-by-step approach to instruction. The belief is that students must not be introduced to material until all steps leading to it have been instructed. According to Resnick et al., teachers believe introducing material before instruction guarantees failure or extreme frustration for students. As a result, teachers in traditional math classrooms will generally follow the typical pattern of direct instruction of skills followed by repeated practice by students with little or no problem solving involved in the process. The traditional method of teaching has led to many U.S. students' inabilities to problem solve and transfer skills learned to real world situations.

Description of Reform Initiatives in Math

Due to the need to improve problem solving skills, reform efforts have investigated ways to improve these areas. Although the reform initiatives are many and cover all aspects of math instruction, in this paper the focus will be on the general set-up of the instructional time in relation to teacher-student interactions. Justification for the initiatives are often included due to the unfamiliarity some readers may have with the reform initiatives. Schifter and Fosnot (1993) believe the main focus of math instruction needs to move away from the skills and step-by-step practices toward problem solving and conceptual understanding. Many feel that young children's problem solving abilities are traditionally greatly underestimated and we need to allow even kindergartners to solve problems involving addition, subtraction, multiplication, and division. In a research study by Carpenter, Ansell, Franke, Fennema, and Weisbeck (1993), seventy kindergarten students were interviewed and given problems involving all four operations. The results showed that over half of the students were able to solve the most difficult problems using direct modeling even without formal learning of those operations. The results of this

study indicate that even very young students have natural abilities they bring with them to school for problem solving and should be given opportunities to use them.

Trafton and Theissen (1999b) advocate that teachers allow students to use their natural problem solving abilities to acquire skills instead of deciding for students how problems should be solved. This means students need to be allowed to use their own invented strategies for solving problems (Carpenter, Franke, Jacobs, Fennema, & Empson 1997; Trafton & Theissen, 1999a, 1999b)). According to Carpenter et al., students who use invented strategies before any formal strategies understand base-ten concepts earlier, use their strategies flexibly, and are able to explain why they work. Bruning, Schraw, and Ronning (1999) add that problems that don't allow students to form their own representations are not likely to aid them in becoming successful problem solvers.

Promoting students to problem solve means letting go of teacher control and moving toward greater student autonomy. In a traditional view of education, Mikusa and Lewellen (1999) make the comparison of students being considered blank slates for teachers to write their knowledge. They believe math reform follows more of a constructivist view where students must actively struggle to make sense of information. Teachers need to make the change from deliverer of knowledge to facilitator of understanding (Fennema & Nelson, 1997).

Stipek, Givven, and Salmon (1998) add to this topic by stating that student autonomy to solve problems encourages the belief that competency is the result of personal effort and not something you are born having. Many students who lack this belief feel that they are helpless and not able to effect their work quality. On the other hand, students given greater autonomy over their learning will begin to believe their efforts make a difference and will also improve their attitude about learning (Bruning et al., 1999).

Fennema, Franke, Carpenter, and Carey (1993) agree that the problem-solving environment allows students to learn math and develop a positive attitude toward the subject.

Continuing with the topic of student autonomy, students must be asked to explain their solutions (Cobb et al., 1991; Lester, 1996). Cobb et al. also add that a problem-solving environment where students must explain their work becomes less ego-involved for students because the correct answer alone isn't highly valued. Carpenter et al. (1993) also add that students learn new strategies from listening to their peers share.

This communication process is another important aspect of the reform initiatives. The creation of a math culture or a community of math learners is emphasized in the reform movement (Lester, 1996; Trafton & Theissen, 1999a). Heibert et al. (1997) state the importance of communicating in math class. This communication includes talking, listening, writing, demonstrating, and observing. Students who communicate and reflect on math ideas are in the best position to form connections and understand math. Cobb et al. (1991) add that social interaction and communication play an important role in creating opportunity for learning to occur.

In a classroom integrating reform initiatives, a typical day's lesson might have students presented with a problem, allowed to gather tools and materials of their choice, given ample time to solve the problem with or without others as the teacher observes and questions to encourage thinking, and finally, asked to share their solution strategy and thinking process. With the sharing of thoughts comes reflection on their own thinking and making comparisons with the thinking of others (Fennema et al., 1993; Trafton & Theissen, 1999).

Throughout all of the aspects of the math reform initiatives, helping all students

make sense and understand mathematical concepts is the goal (Heibert et al. , 1997; NCTM, 2000; Schifter & Fosnot, 1993; Trafton & Theissen, 1999a) Heibert et al. state that understanding is one of the most intellectually stimulating experiences. This internal reward is what educators hope will keep students actively engaged in math learning.

When students are motivated intrinsically, they are more likely to persevere with learning. This self-motivation will promote feelings of autonomy in the students. The positive feeling and internal rewards associated with one deeply understanding a concept will increase student interest and improve attitudes toward the subject (Bruning et al., 1999). Helping students make sense of math will go a long way in helping students become mathematically literate.

How Will the Teacher's Role Change?

The teacher's role in math class will be very different from traditional instruction. There are five aspects to the teacher role which stand out as areas of change. The first to be discussed is that of mathematical knowledge. NCTM (2000) makes a general statement that teachers must be knowledgeable in math concepts. They must have the same deep understanding of mathematics that they will be helping students construct. Along with this, Fennema et al. (1993) found in research conducted with first grade teachers, that the more knowledge teachers had in the area of addition/subtraction frameworks and how children begin to think about these, the better their students performed in skills and problem solving. Both of these encourage an increase in conceptual knowledge and pedagogical knowledge in math by teachers as they begin to change their roles.

Tinto and Masingila (1998) agree with this and recommend teachers be able to use math concepts not only relevant to their grade level, but beyond that as well. Because the

reform efforts do not align themselves with a textbook curriculum, teachers will need to make more decisions based on their own knowledge of math. That is why Fennema et al. (1993) believe that it is important for teachers to have research based knowledge in the area of children's thinking in math, as well as their strong knowledge of math concepts.

Along with having a deep working knowledge and understanding of math concepts and research, a second role that will be changing is that of being the creator of a math culture. In order for students to have frequent opportunities to share, question, and justify their thinking and that of others, the teacher must work to create an environment where students feel comfortable and confident in their abilities (Cobb, 1991). Lester (1996) discusses the planning time and effort by the teacher it may take in order to create a math environment where students can begin learning math. Giving students opportunities to talk about math concepts in nonthreatening ways beginning the first day of school helps to establish the expected behavior. She emphasizes that teachers need to use great care in planning these initial math experiences to be sure all students are involved and feel comfortable in sharing.

A third area of the teacher's role that will be emphasized is allowing for student autonomy. Brown, Stein, and Forman (1996) relate this to Vygotsky's writings about the zone-of-proximal-development. Students need to be allowed to think and progress on their own, but teachers must understand when students are in the "zone" and then step in to assist only as much as needed. They point out the benefits for both the teacher and students from this type of learning model. Teachers learn how to guide instruction from students' changing performances and students are guided by teacher instructions. Teachers must stay alert to student misunderstandings and use questions to ensure students reflect and verbalize problems (Schifter & Fosnot, 1993). By encouraging

student autonomy teachers allow students to use their own sense making skills instead of following those of the teacher (Heibert et al., 1997).

A fourth major change in the teacher's role from a traditional textbook style curriculum is that teachers must select the tasks in which students take part each day. An over reliance on textbook instruction may have led to teachers putting little thought into planning day-to-day tasks. Graham & Ferrucci (1998) state that most reform recommendations have been made to show teachers how to teach, but little is focused on what to teach. A reason for this is that students' needs must guide the curriculum making it impossible for reformists to write a prescriptive plan to tell a teacher how to carry out this type of instruction.

Instead of relying on the textbook, teachers will need to use their knowledge of students and curriculum to make these decisions everyday (Ball, 1996). Heibert et al. (1997) point out three things teachers will need to consider as they select appropriate tasks for students: do they create a problematic situation for the students, do they connect with where the students are currently, and do they engage students in important math thinking? Many resources are available which suggest problematic tasks and help teachers understand the concepts and connections between concepts, but each teacher will need to use them as appropriate for their individual students. This will require that teachers spend more time planning tasks and informally assessing student understanding to be sure the next task or problem is effectively building on students' current understandings.

The last role that will be emphasized, more so with the reform initiatives than has been traditionally, is that of ensuring equity in math for all students. Heibert et al. (1997) see this as treating all students as individuals, making tasks accessible to all

students, providing opportunities for every student to share their thinking, and allowing every student to contribute to class. NCTM (2000) states that teachers must assume all students are capable of learning math, but they note this does not need to mean identical instruction. They believe this demands appropriate accommodations so that all students learn math. Trafton and Theissen (1999a) find that it is easier to accommodate the different levels students are at because each will be allowed to use methods that make sense to them. Although these changes in the teacher's role are not new ideas for instruction, they are being given considerably more emphasis as the reform movement begins to take hold in American math classrooms.

What Hurdles Are Slowing or Preventing Teachers From Changing Math Practices?

Lack of Leadership

Changing our personal habits and behaviors is never easy. There are unfortunately many hurdles in our way which discourage teachers from pursuing changing their practices. The first to be discussed here is the lack of leadership. A leader for a reform movement needs ample time and expertise to guide others thoughtfully through the process (Koch, 1998). Administrators often have too many other commitments to be fully committed to math reform (Price & Ball, 1997) and when teachers do become involved and begin changing their practices, they are often isolated or singled out because they may seem threatening to others (Koch, 1998). When teachers do become experts, even if others are accepting and encouraging, they are most likely not prepared to properly train their peers for the transition of reform. This may be due to short-term professional development that does not follow through with leadership in the transition period.

According to a study by Stipek et al. (1998), short-term professional development

is often damaging to the reform movement due to the lack of interventions and limited time for teachers to consider the change. They found that long-term professional development with extensive interventions had powerful results when it came to changing teachers' behaviors. With a lack of strong leadership, the reforming of math education may be all the more challenging. Teachers need someone to look to as an expert and support person as they attempt such major changes in their practices.

Products of the System

One of the most obvious hurdles for teachers dealing with math reform is that they are products of the system that needs changing (Ball, 1996). Teachers hold beliefs that math needs to be taught in the traditional way. These traditional ways emphasize skills, procedures, and teacher-directed instruction. The reform initiatives call for conceptual learning, but today's teachers most likely learned math in a procedurally oriented manner dominated by the textbook. Manouchehri (1997) believes without the teachers' conceptual understanding of math it may be impossible to teach using this approach. Teachers may need to relearn math conceptually as part of their professional development.

Many teachers continue to desire using textbooks to guide their teaching. Unfortunately, even if textbook publishers change according to the NCTM's Principals and Standards for School Mathematics and other reform documents, they will only be able to guide curricular ideas (Price and Ball, 1997). Textbooks usually do poorly at planning instructional conversations and recommending accommodations specific to each student's needs which are important aspects of the reform movement. Because it is difficult for reformists to write a prescriptive plan in advance for teachers to follow, teachers must make decisions each day according to their students' needs (Ball, 1996;

Peterson & Knapp, 1993). Because teachers rely heavily on textbooks for math instruction and have experienced their own math education through a textbook (Schifter & Fosnot, 1993), this reliance on textbooks is a major hurdle to overcome.

Another belief that is a hurdle for teachers to overcome is changing from a teacher directed approach to a student directed approach (Fennema & Nelson, 1997). Teachers have a hard time letting go and allowing students to guide the curriculum. Along with this, Ball (1996) adds that because the traditional view of the teacher is isolated, teachers do not feel right about questioning the practices of others and starting dialogue and disagreement necessary to beginning the change process. Teachers are used to being in control of their own classrooms and showing other teachers respect by not getting involved with their instructional practices. In order for reform to occur, teachers will need to give up this control and isolation and begin working together and allowing students' needs to guide learning.

Reform Weary

Classroom teachers are often left out of the scholarly discourse pertaining to reform initiatives (Peterson & Knapp, 1993). Price and Ball (1997) discuss a typical scenario of a fifth grade teacher given the new standards and a new textbook series. Even with the new materials, she didn't change her practices at all. When interviewed she wasn't even aware of the reform movement in math. Although this is only one teacher, they see it as a common occurrence. They note that district curriculum guides, even when updated to compliment the reform initiatives, also are seldom used by teachers and so have little impact on changing practices. Teachers may use new curricular material, but due to little interest in changing, will most likely retain their preferred teaching styles.

When teachers do become aware of the reform movement, they are often not

willing to change until they see proof it will benefit their students (Fennema et al., 1993). Teachers often need a guarantee it will work. They will ask themselves at what cost will time spent on learning concepts have on the students' abilities to perform math algorithms required on standardized tests (Senger, 1999). Often, they are not willing to find out.

Finally, in a case study by Senger (1999), a teacher who experienced teacher education during the New Math reform movement was very skeptical of changes in math because of its failure. This skepticism caused him not to want to change his ways. Teachers' thoughts on reform are powerful and can be considerable hurdles when it comes to forwarding the reform movement. If teachers do not feel open to the new ideas, they will not begin to internalize them and will ignore the issue all together, especially when support from the community and other teachers isn't there.

Mixed Messages

The math community may be calling for more conceptual learning, but the public expects math competency and defines it by speed and computational skills. It is difficult to gather support from the public if they do not see the value in it and, for many, efforts in reading and writing seem more important to emphasize (Price & Ball, 1997). When it comes to math, many believe that we have computers and calculators to assist those who need additional support, so why would it be necessary to change or emphasize it even more?

Another reason messages to teachers may be mixed is because reform, being a lengthy and on-going process, doesn't appear to be happening at all levels. This includes changes at the school, district, state, and national levels, including higher education. Teachers also need to see change happening in public awareness and

expectations in order to feel it is worthwhile and important (Tinto & Masingila, 1998). If changes are not occurring at all levels, the process is unlikely to proceed.

Another area where messages are mixed is within each teacher. On a personal level, they feel confusion when they experience reform ideas, especially when they see students being allowed to use many different strategies to solve a problem and the lack of teacher correction when misconceptions occur. This confusion, if not resolved, will lead teachers to not accept the reform ideas. All of these changes require time and effort.

Time

Teachers need time, which is usually lacking. They need it to plan lessons, meet with colleagues, observe others teaching using desirable practices, and have sessions of discussion and reflection on changing ideas (Tinto & Masingila, 1998). Time is also important for the students. The conceptual learning their students will be doing will take more time before results are evident. This delays teachers from seeing the success reform initiatives put into practice can bring and may cause teachers to go back to their old ways (Trafton & Theissen, 1999a).

What Suggestions Are Given for Removing the Hurdles and Encouraging a Smoother Change Process for Math Teachers?

Awareness of Change Process

The solution to helping teachers change their practices from a traditional style to a more constructivist, student-centered style is obviously very complex. Senger (1999) suggests that as researchers continue to make suggestions for improving learning environments, they become aware of the change process teachers must go through. Because of this, teachers' underlying beliefs must be considered in reform efforts, as well as the curriculum and teaching methods (Shifter & Fosnot, 1993). Manouchehri (1997)

notes that teacher education programs also need to be addressing beliefs and assumptions in order for new teachers to deal with the changing face of math education. Price and Ball (1997) state that because a teacher's beliefs and assumptions about math education will direct the use of curricular material, including textbooks; these issues must be confronted or real change will not occur.

As part of this change process, teachers must begin to see confusion between their former thinking and assumptions and the new ideas in math. In theory, as humans, we change our thinking only after we have worked through this confusion or cognitive disagreement. We resolve it by reflecting, reasoning, and discussing (Wood, 1999). Schifter and Fosnot (1993) cite Piaget's work as they suggest teachers, just like children, must experience this disequilibrium in their thinking to give meaning to the reform initiatives.

A process of change has been outlined by Senger (1999). She has found that the process of change is not linear, but recursive. It involves a recursive process between the following stages: awareness of reform ideas, mental imaging of new possibilities, experimenting with new practices, verbalization about ideas, reflective thinking, rejection of some ideas and practices, acceptance of other ideas, and reforming classroom practices. Because the process is recursive, the more opportunities teachers have with experimenting, both mentally and in practice, the better the chances of them accepting the new ideas for their own.

Increasing and Changing Knowledge Base

If teachers change their beliefs and are ready to try new constructivist ways, but have little personal experience with them; they are not likely to succeed. That is why Price and Ball (1997) argue that reform will not progress unless teachers and

administrators have opportunities to learn math content again in a constructivist manner. This experience with relearning math must be powerful enough to overcome the many years of learning math in the traditional, teacher-directed manner (Schifter & Fosnot, 1993). Teachers will need to become math learners, developing conceptual understandings and relationships for the math level they teach, as well as more complex levels (Heibert et al., 1997; Schifter & Fosnot, 1993).

A knowledge of research related to children's thinking in math is also shown to be very effective (Fennema et al., 1993; Hiebert et al., 1997). In a study by Fennema et al., as teachers' knowledge of research in this area increased, they used problem-solving more and taught skills less frequently. Teachers were also found to use more varied instructional strategies, listen more to students, and have a better understanding of student knowledge. Manouchehri (1997) also found that as teachers' conceptual knowledge of math increased they allowed students to talk more about math ideas. They were more effective at orchestrating the discussions about math instead of dominating them. Spillane and Zueli (1999) encourage reformers to design policies to support the need for increasing the knowledge base of teachers.

Professional Development and Support

If teachers' beliefs are to be confronted and their knowledge base to be increased, professional development and teacher support will need to be extensive (Stipek et al., 1998) and over long periods of time, meaning at least one year (Schifter & Fosnot, 1993). Stipek suggests professional development allow time for reflection and development of new practices. Tinto and Masingila (1998) give an example of how a successful professional development plan should not be prescriptive for practices, but instead focus on encouraging teachers to see themselves as learners, asking teachers to investigate and

construct the knowledge necessary for them to understand the reform movement, and encouraging teachers by creating enthusiasm about using these new ideas. One teacher participant is quoted as saying, "I started understanding things that I had only memorized before" (p. 48).

As part of the professional development, Petersen and Knapp (1993) believe that teachers must reflect on their understandings about math. They must think for themselves and consider themselves to be lifelong learners, just as they hope their students will do and be. The professional development must address these beliefs, assumptions, and understandings related to math through a long-term process. It must allow time and opportunity for teachers to develop conceptual confusion between old and new practices. It must then give opportunity for teachers to work through this confusion to a point of accepting the new ideas. However, the professional development must not isolate the teacher. Everyone involved in the change must be included. Teachers, administrators, parents, students, and the community will all need to understand the changes that will be occurring and why conceptual change will improve math education for all.

Often professional development does not include informing parents and the community of changes. Including all groups in the process will avoid potential opposition from those who may have been left out. Parents could be especially upset if math practices begin to change and they no longer see daily homework assignments asking their children to practice skills. When questioned by their parents, students may not even understand that the new methods being practiced by their teachers are still "math." Students familiar only with the traditional teaching methods may even tell their parents they aren't learning math anymore. By including parents from the beginning, these

misunderstandings and possible opposition may be avoided (Chapin, 1996). This communication may provide knowledgeable support from the community as teachers begin experimenting with new practices.

As professional development begins, researchers encourage the use of teachers who have incorporated reform measures into their practices to be used as models for others. Ball (1996) states that seeing the constructivist practices in use with students can bring up both negative and positive feelings in teachers. Traditional teachers often have difficulty understanding why so many different strategies are used by students to solve one problem or why constructivist teachers do not step in immediately and correct student errors or misconceptions. On the other hand, they are usually amazed at the higher-level thinking students display and their ability to solve the problems on their own and are curious as to how they can get similar results with their own students.

In 1996, Ball suggested using videotapes of teachers implementing the new style of teaching math as one way to expose teachers to good modeling. She pointed out a concern that little research has been conducted on the effects of using videotapes for this purpose in professional development, but because every school will not have a practicing teacher to observe first-hand, she believes it is a worthy way to reach a greater number of educators. Senger (1999) warns that teachers must be used as models for reflecting on classroom changes, not as models for specific activities or lessons.

As teachers begin to experiment with reformers ideas, there is considerable agreement that they need to have colleagues to work with as they change. Trafton and Theissen (1999b) find that if a colleague is implementing the same ideas, it allows a teacher to compare notes, discuss possibilities, and support one another. Tinto and Masingila (1998) state that teachers need this dialogue with other teachers in order to

process the new concepts about math teaching.

It is suggested that teachers team up to observe, analyze, and discuss ideas (NCTM, 2000). Price and Ball (1997) also confirm that teachers need the opportunity to explore the issues around math reform with other teachers. Forming a collaboration with another teacher or being part of a group of teachers involved with the reform movement is essential to creating real change in practices (Fennema et al., 1993; Schifter & Fosnot, 1993). To compliment the colleague support, regular classroom consultation by other professionals involved with the reform movement needs to be included in the extensive, long-term professional development (Schifter & Fosnot).

CONCLUSION

Even though publications on the math reform effort sound promising, the reality is that little change has taken place. The study by Spillane and Zeuli (1999) does show evidence that a small percentage of teachers are changing; and many of those teachers had followed very traditional styles for many years. I believe, as they do, that more teachers will convert their teaching styles, but slowly. Many of the stories of teachers experiencing this transition say it has taken up to two years and they still need continual support to feel reassured that what they are doing is the right way to teach (Lester, 1996). They are most often reassured by their own students' abilities to problem solve and discuss math with real understanding.

It has been said that no one can give knowledge to someone else. We all must develop our own understanding by constructing our own relationships between concepts. I believe this applies well to how children must learn math and also how teachers must begin to understand the math reform movement. As Senger (1999) points out, each teacher must be given the opportunity to experiment, observe, question, and discuss again

and again until connections have been formed and understandings of what math education should look like are created.

I agree with Trafton and Theissen (1999a) that schools need to encourage teachers to work together by allotting time to observe colleagues and discuss teaching experiences. Teachers must be included in the research efforts as well. Most are too busy to spend time reflecting on their practices unless schools encourage them to do so and allow time for this (Senger, 1999; Peterson & Knapp, 1993). Based on the literature by Koch (1998), I feel a teacher leader in the math reform effort will be needed in every school to keep teachers current on the latest research efforts, provide support, and to encourage continued reflection between teachers.

If teachers are allowed to participate in an extensive professional development program helping them to confront their personal beliefs about math, increase their own math understandings, promote teacher support networks, and create dedicated leadership by administration and teachers, I believe more teachers will begin to commit to the changing ideas in math education. The change will be slow, but real, as teachers will have been given the time and opportunity to construct their own understanding of what the change is about and why it needs to happen.

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