Complexity of Reforming Mathematics Education: Order and Chaos

Roland G. Pourdavood, Lynn M. Cowen, and Lawrence V. Svec

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Abstract

This case study explored the complex nature of reforming K-4 mathematics instruction in one school (1989-1999) to implement constructivist learning theory and recommendations from National Council of Teachers of Mathematics (NCTM) *Standards*. The study exposes the conflicts school leaders experienced when they attempted to change epistemological viewpoints and redesign school structures and cultures. The study also suggests that major instructional change may empower teachers and enhance their professional image as creative instructional designers and action researchers. Instructional change is closely connected to and dependent on reculturing assessment practices. Process of changing teaching and learning practices is nonlinear, uncertain, and often chaotic. Successful changes often emerge from conflict and disequilibrium. School leaders cannot control or predict the change events they initiate. However, by participating in and contributing to the mathematics activities of the school they may facilitate the requilibration process.

Introduction

Reform is a task whose complexity should not be underestimated (Secada, 1992, p. 404). This case study explores the process K-4 educators encounter as they attempt to implement the recommendations from the National Council of Teachers of Mathematics (NCTM) *Standards* (1989, 1991, 1995). The NCTM documents propose wide-ranging, radical changes in mathematics learning and teaching that are grounded in constructivist theory. According to constructivist theory, all knowledge is built by individuals when the person is actively participating in and contributing to the activities of the local community (Cobb & Yackel, 1996). To understand the impact of constructivism on mathematics instruction, it is necessary to describe how constructivism differs from the behaviorist practices that dominate current mathematics classrooms. Constructivist theory and practice includes several elements beyond the theory and practices of behaviorism. It is not always a simple replacement of traditional "feed-in, feed-out," "question-and-answer" teaching. Instead, constuctivist teaching in mathematics envisions a need for students to know mathematics in context and their need to understand and apply key mathematical ideas. The constructivist teaching/learning environment attempts to develop knowledge and understanding through communication, modeling, and reasoning.

Many of the intricacies of this type of school/instructional reform remain unknown. Little is known about how educators experience and lead complex change in an organizational culture which has historically resisted and hindered major reform (Dewey, 1933; Fullan, 1993; Giroux, 1981; Goodlad, 1990; Grundy, 1987). Less is known about how educators implement an epistemological shift contrary to the current organizational culture. Given the diversity and complexity of teachers' belief systems, it remains unclear how a reform agenda impacts organizational change in school. Therefore, the primary research questions of this investigation are: (1) What triggers major school change? (2) What complexities surround school change? And (3) What sustains the reform process and allows/encourages it to evolve?

Design of the Study

Doll (1993) suggests that modern curricular and instructional theories are based upon mechanistic causality, a false principle that constrains and closes curricula and leads to teaching and learning practices that lack some bases in reality. According to Doll, post-modern curricular and instructional designs create an open system that focuses on main ideas and processes learned in an authentic problem-solving environment.

This study emerged as a result of collaboration among the Ohio Department of Education (ODE), University of Toronto, four universities in Ohio,

and twelve public schools (five elementary, three middle, and four secondary). Twelve case studies and one cross-case study were reported in 1999. This research report is one of the twelve case studies (for more information visit the site http://tlc.treca.org). It is important to recognize that the mathematics reform in this K-4 school started in 1989 after the publication of the NCTM *Standards*. However, the case study reported in this paper began in 1997 and ended in 1999. The goal of the research was to understand the complexity of reforming mathematics education in an elementary school (K-4) and to engage the larger educational community in the lessons learned about instructional reform in this elementary school.

The case study was carried out by a team made up of two members of the K-4 school (principal and assistant principal), one secondary teacher, one local university teacher, and one local university research assistant. The team designed the study implementing Lincoln and Guba's (1985) ideas to understand and describe the complexity of reforming mathematics education. Data sources included interviews (of teachers, principals, district officials, students, and parents), classroom observations, surveys, and review of documents. Based on these multiple data sources, constant comparative data analysis (Lincoln & Guba, 1985; Guba & Lincoln, 1989, 1994) guided the conceptual framework for explorational analysis of the reform processes and milieu of reform.

Physical and Historical Landscape

To understand how mathematics reform evolved and impacted the school change, it is important to see this evolution within a physical and historical context. The K-4 school is located in a suburban metropolitan city. It is in a lower middle class neighborhood consisting of single and multiple-family units. The school enrolls 565 students (60% African American, 34% white, 6% other racial or multiracial groups). The school has 25 classroom teachers, five special area teachers, one principal, and one assistant principal. The average class size is approximately 22 students. Classrooms, like the trees, outline the perimeter of wide hallways. Students' work, primarily in art, mathematics, science, and writing litters the brick walls.

Mathematics solutions are shown through words, illustrations, and calculations. Classroom settings are teacher designed. Many classrooms have similar characteristics that include classroom libraries, large carpeted areas where students and teacher congregate away from desks and tables, computer centers, bookcases full of literature books and mathematics materials, home furnishings such as rocking chairs, sofas, throw pillows, and stuffed animals.

Several pivotal events impacted the K-4 school reform since 1989. These events imply the complexities and challenges that reform-minded leaders

experience. Capturing and describing school change is challenging because change is a complex phenomenon involving many key players such as teachers, principals, students, parents, and the public on several stages (i.e., local, state, national, and international). The following is a list of pivotal events and situations that unfolded within the intimate setting of one elementary school during 1997-2000.

- Curriculum and evaluation *Standards* (NCTM, 1989), *Everybody Counts* (NRC, 1989)
- Public private grant awarded by ODE (1990). The intent of the grant was to develop hands-on lessons on estimation, patterns, geometry, number relationships, and data collection.
- Collaboration among K-4 teachers, principals, middle and high school teachers, and local university mathematics educator (summer 1990-present).
- Principals began evening meetings with parents to communicate the instructional reform in mathematics (1994).
- Key mathematics concepts and processes were identified by elementary, secondary, and university educators (1995). Mathematics instruction focused on the ideas of **unit, change, chance, unitized systems, dimensionality, location in space**, and the processes of **combining, comparing**, and **partitioning**.
- "Families Talking Math" group met with principals to develop a parent support group for reforming mathematics education (1995). The group developed ways for parents and children to do mathematics at home.
- Eighteen teachers volunteered to conduct action research that targeted constructivist teaching/learning and assessment practices (1995). The individual proposals were aligned with national reform efforts in mathematics. Proposals were funded to cover materials, equipment, and release time.
- Parent-teacher-student conferences "triangular conferencing" began (1995).
- Ohio Fourth Grade Proficiency Testing began (1996).
- K-4 teachers, secondary teachers, and principals at the school designed a performance task assessment system (1996).
- Participation in reform became mandatory (1996). All classroom teachers and tutors were placed in one of four K-4 Instructional Design Teams (IDT) led by two teacher leaders. Tensions emerged over the selection of teacher leaders, especially the appointment of non-tenured and less senior teachers as leaders, and the fact that the reform was no longer voluntary. Tensions also emerged over instructional changes. IDTs met six hours each month to build a framework of lessons that targeted performance tasks. Permanent substitutes were hired and trained to cover classes one

day a week to facilitate staff development.

- Some teacher leaders conducted weekend and evening conferences (1996). "Saturday Scholars" program began for at-risk fourth grade students in mathematics to prepare for the Ohio Fourth Grade Proficiency Test (1996). Principals and teachers taught and planned lessons together.
- Constructivist theory and practice were challenged at school board meetings (1997).
- Teacher leaders were hampered by time constraints. Expanded mathematics curriculum and a constructivist model of instruction required more time for teaching and learning (1997).
- Proficiency "report cards" put increasing pressure on the entire school system. The district schools were not designated as "effective" on the state report card. Tuition-free summer school for at-risk incoming fourth graders started at the school to improve fourth grade proficiency scores (1998).
- Fourth graders scored very high on Mathematics Proficiency test (1999). The school received $25,000 award from the state government for achieving big gains in proficiency passage rates. Ninety percent of fourth grades passed the proficiency test in mathematics.
- For the second year in a row (1999 and 2000), 90% of fourth graders passed the proficiency test in mathematics.

Emergence of Tensions Created by an Epistemological Shift

Educators at this school live in an environment where principals (principal and assistant principal) rejected modern/traditional teaching, learning, curricular, and assessment practices for mathematics instruction. These principals encouraged an epistemological shift for K-4 teachers, a shift in epistemology about learning that implied major reculturing and restructuring of an elementary school.

Encouraging these reforms brought about turmoil and perturbation. Tensions emerged and deepened. The following events describe the dynamic and evolving nature of tensions provoked by events and initiatives implemented by educators in this school community. Despite a description of chronological events, there is no linearity to the reform process. The reform was chaotic, uncertain, non-linear, and indeterminate. It continues to emerge as a self-organizing, regenerative process.

Cosmetic changes: Business as Usual

Initial changes were mechanical, adapting new materials and exploring new content areas such as pattern, probability, etc. A team of senior teachers wrote lessons to use manipulatives for mathematics activities. The lessons and materials did little to change teachers' existing beliefs and practices about mathematics. Over time, teachers had seen an endless array of new

materials, curricula and instructional practices serpentine through classrooms. "You know, this is nothing new. We've done the 'hands-on' gig before" (conversation between a teacher and assistant principal). Teachers were accustomed to scripted lessons and prescribed materials. The new approaches and materials did not perturb the existing culture and structure of the school. Nor did the changes imbalance the traditional roles and relationships. However, "minor" problems emerged during these cosmetic changes.

The kids won't let me put away the math materials. My lesson has gone for over sixty minutes. They really like math! They cheer when I tell them it is time for math. But what am I supposed to do about all the other subjects? (conversation between a teacher and assistant principal)

Although teachers did not question the nature of imposed instructional changes given to them by senior teachers, they did question the issue of time for other subjects.

The reform took a different direction when some K-4 teachers, in collaboration with secondary mathematics and university educators, "reinvented" mathematics instruction around key ideas and processes within a relevant context for children. The restructured, "streamlined" mathematics curriculum focused on big mathematical ideas like unit, unitized systems, zero to infinity, change, chance, dimensionality, location and key mathematical processes like combining, comparing and partitioning. "When I leave this building, I feel better than when I came in" (secondary mathematics teacher/teacher-leader in the reform). Focusing on main ideas was seen by some teachers as unusual since this curricular design lacked a focus on numerous, specific behavioral objectives that dominated the school district's mathematics curriculum. The "new" curricular design was more connected to Bruner's (1960, 1986) idea of recursive learning and Doll's (1993) idea of a post-modern, emergent curriculum based on spontaneous generation that would "allow the human power of creative organization and reorganization to be operative" (Doll, 1993, p.117).

Tensions emerged as some teachers' instructional practices began to look different from other classrooms and teachers began to write lessons to supplement the district curriculum. Many teachers were unfamiliar with instruction that was emergent, flexible, and responsive to student voices. Teachers were also unfamiliar with mathematics instruction that was based on reasoning, problem-solving, communication, and mathematical representations. "When this reform started, I did not agree with it because I did not understand it. I had to have a conversion. I had to come to a place to understand it" (teacher-leader).

As the reform evolved, many educators struggled to make mathematics relevant to students' experiences. Some educators disregarded their dependency on mathematics textbooks, wrote instruction, and designed a perfor-

mance task assessment system to monitor student growth over five years. What emerged within this collaborative structure was a different pedagogy based on constructivist practice.

Several events were happening simultaneously that also created disequilibrium. A new mathematics textbook was adopted at the district level. Teachers at this school recommended to the principal that the new textbook should not be ordered for the school. "Don't order math textbooks. We write lessons better than that." (teacher-leader). The principal followed this recommendation. His decision was questioned by district administrators and some senior teachers. Not giving books to every student made some educators question the credibility of the reform.

Epistemological shift: Business as *Unusual*

Tensions began when school principals encouraged and valued individual teacher's efforts to design different instructional models and learning environments through action-research proposals. Action-research proposals were funded and supported with grant money. Teachers ordered materials and equipment necessary to develop their instructional models. A few senior teachers, who previously had been active participants in the reform, refused to submit proposals. "I'm not going to have my instructional model judged by anyone. No one is going to tell me whether I have met my goals or not." (teacher). Most teachers who refused to submit proposals distanced themselves from the reform process and thus limited opportunities to communicate their ideas and opposing views about instructional change.

When some participants built and implemented new models, they recognized incompatibility between the existing views of mathematics teaching and learning and their emerging constructivist perspective. Instead of "repairing" and "altering" mathematics curriculum and instruction, the models suggested a different vision of mathematics.

Classrooms and instructional practices began to look different as constructivist theory was embraced by some teachers and the principals. Tension began to escalate over the kinds of mathematical problems that were designed for kindergarten and first grade students. Some teachers complained that mathematics problem-solving was too difficult for young children. A few teachers were openly critical of what they called "developmentally inappropriate" lessons and instructional practices. They claimed the problem-solving experiences were "too complex" (dividing, multiplying, use of fractions) for 5 and 6 year old children. The principals responded to their "developmentally inappropriate" claims by citing research about young children's inventive minds, and suggesting that the existing curricula may really be "developmentally limited."

As mathematics looked more "unmathlike" in individual classrooms, stu-

dents, parents, and the principals responded favorably:

> You know, when I showed Molly's math papers to her teachers at her new school, both the principal and the teacher apologized for their mathematics program, and they immediately put Molly into the gifted and talented math class. To be truthful, even the gifted and talented program doesn't do what you guys did in grades K-4 to develop her mathematical thinking and skills. (former fourth grade parent)

People noticed that young children enjoyed the rigors of complex problem-solving. Children were relating well to mathematics within the context of their everyday experiences and solving problems that normally would not be introduced for several years. Students used multiple strategies to solve problems such as adult role playing, building concrete models, illustrating and dialoguing about strategies and solutions.

> I like mathematics so much more this year because the teacher lets us draw our problems out. When she sees my drawings, the teacher thinks I am real smart. Last year in third grade, I wasn't that smart in math. All we did was math papers from a book and we never really spent much time talking about ways to do a problem—just finish the page. (Fourth grade female student)

Some non-participants saw little value in mathematics dialogues and problem-solving with young children. "These little kids shouldn't be sitting so long on the floor talking about math with the teacher. They should be actively touching and building things themselves. They can't sit still for over ten minutes" (conversation between a teacher and principal).

Despite the complaint about mathematical dialogues with young children, some teachers continued to refine dialogues and value them as a key component for building mathematical understandings. Teachers connected the mathematical dialogues to student problem-solving mathematics journals where students colorfully illustrated, wrote, and calculated their solutions. Parents and outside educators were impressed by the degree of sophistication young children demonstrated in these mathematics journals. This perception from outside educators and parents sparked personal resentment and jealousy from some dissenting teachers who attacked the principal's decision-making style in an effort to stifle reform.

Criticism and tension began to be accepted as a "normal" occurrence. The principals refused to allow tension and criticism to discourage or stop par-

ticipants. They determined that "business as unusual" could coexist with "business as usual." They ceased trying to "convert" non-participants and instead decided that everyone did not have to participate.

> I came to the realization that the reform could go on without total consensus. My team leaders, the teachers who were actually building new instruction and assessment practices, recommended that waiting for everyone to "get on board" would not be good. I just followed their advice. (principal)

Some non-participation did not preclude individual teachers from developing effective reformed practices. Allowing the coexistence of two seemingly opposing views/cultures created constant dissonance in the school where teachers were often reminded how much they were changing. "I don't want to be like them [non-participants]. I'm really different now. I like this change! How can I make sure that you don't see me as thinking what they do?" (conversation between a teacher and assistant principal). This dissonance may be responsible for nurturing the synergy that surrounds the reform and keeps the reform moving forward.

> We let people make choices about how to implement change. Some took the challenge, others did not. I think, though, people were surprised that we pulled the train out of the station without everyone on board. But the reality was that if we waited, like we used to do, for everyone to be 'on board,' we still would be at the station. They were surprised we could go on without them. I think they were also surprised at how fast and far the train went. I guess all of this was most unusual and disruptive to some. I didn't think about it at the time. We were given grant money to do this, and the reform was interesting and exciting! (Assistant Principal)

Non-participants' objections to the reform seemed to focus more on the personal and socio-political atmosphere of the school than on the theory and practices within the reform. Often, non-participation seemed to be beyond intellectual and philosophical differences and more focused on changes in rules, roles, and relationships such as not treating everyone the same, not requiring all teachers to "be on the same page," not requiring sole reliance on district curriculum, allowing teachers to make choices, encouraging experimentation, celebrating the creation of different learning environments, valuing risk-taking, and promoting research and intellectualism. All this was not "business as usual." Tension seemed to escalate as participants deliberately

moved forward despite criticism and resentment from some non-participants.

The principals were criticized for discriminating between "haves" (participants in the reform) and "have-nots" (non-participants). Their decisions were viewed by some non-participants as creating an elite group in the school. This was contrary to the conventional notion of school as a "happy family." The principals were aware of the factious nature of these decisions and the potential risks.

> They do want to change behavior and instructional practices and to me that gets to be a challenge. The school will have to learn to find ways to start to work with people and certainly they have done that to a certain extent. However, they need to make everybody feel they have something to contribute so that the teachers begin to change their instructional practices. Therefore, it is something internal, something that motivates them and not that they feel it is dictated by the organization. That makes a difference. (district administrator)

About 75% of classroom teachers supported the reform process and worked toward designing instruction, curricula, and assessments according to constructivist theory. A key group of 12 supportive teacher-leaders included 6 new, non-tenured teachers who were guided and mentored by the more senior teacher-leaders. It was the recognition of this teacher leadership group that upset the social and political environment within the school building. Some senior, tenured teachers resented not being selected by principals to be "teacher-leaders." They felt excluded from the instructional reform even though all teachers were invited to professional development sessions about mathematics led by teacher-leaders.

Teacher-leaders emerged as change agents for the reform. Teacher-leaders assumed the role of decision-makers, adult learners, designers, mentors, staff developers, instructional leaders, and action-researchers. To some teachers the selection of teacher-leaders and the teacher-leadership role was thought to be unconventional. Traditionally, leadership in education has been vested mainly in the principal-administrator position. Principals who encourage, grant, and depend on leadership from teachers may be creating cultural disequilibrium, especially when the purpose of teacher leadership is to create an epistemological/paradigmatic shift in mathematics instruction and curricula. Morgan (1997) suggests that there is often unconscious resistance to organizational change because individuals are often trapped in a "psychic prison" and upset when forced to give up "teddy bears and dolls."

Some non-participants complained to union leaders, district administrators, and the principals about the divisiveness of the reform and low morale

among some senior teachers who felt ignored and excluded from leadership opportunities. "You guys better spend some time healing your building" (district administrator to assistant principal). Such statements and actions seemed to imply that some people saw conflict as destructive and wanted a return to "business as usual."

> I feel we need to do something to help improve the morale around here. We all used to be so happy—laughing in the halls, doing things after school, and having fun at staff parties. We're not all like that anymore and it's sad. We need to do something to bring everyone together. (conversation between a teacher and assistant principal).
>
> I believe everyone has a special gift to do something. No matter what it is, that special gift needs to be recognized here at school. (conversation between a teacher and assistant principal)

The loss of the "happy family" was also regretted by some teacher-leaders. Principals tried to make teacher-leaders understand that paradigmatic changes usually occurred in an atmosphere of disequilibrium, ambiguity, and tension. Principals believed a transforming school depended on disturbance to the established equilibrium, and therefore accepted the fact that the course of change would not be smooth. Morgan (1997) states that dialectical contradictions are natural occurrences during organizational flux. So leaders must expect a constant clashing of opposite perspectives, and they must learn to lead such complex conflict.

Some teacher-leaders did not agree that the school suffered from low morale. They met with a district administrator to explain and defend the reform process and the principals' decisions about instructional reform. Teacher-leaders began to realize that major instructional reform involved political tension and maneuvering.

Emergence of Critical Mass

Teachers as action researchers and writers evolved in different ways. Teachers sought new ways and materials to improve classroom instruction. They wrote grants and lobbied principals for additional school funds. Teachers were expected to share the results of their action-research projects with other staff members. Their instructional practices were then used by other teachers. These action-researchers became teacher-leaders.

The teacher as instructional designer was fundamental to professional development and adult learning. As the reform evolved, it became clear that

teachers reflected on what they knew about mathematics and connected it to how children learn mathematics. Teachers writing instruction had a significant impact on staff development programs. In-service programs were designed to expand teacher content knowledge and pedagogy. Secondary mathematics teachers worked closely with principals and teacher-leaders to design staff development meetings that helped teachers write instruction.

Structures were created to inform parents about changes in mathematics teaching. Parent-Teacher Math Nights were designed and led by teacher-leaders and principals. These meetings communicated the reform to parents. During these meetings, parents actively engaged in building models, drawing, and writing about mathematics. Through these activities, parents began to see the differences between traditional and constructivist mathematics teaching and learning. These meetings also suggested how parents might support and facilitate student learning at home.

Ongoing communication about pedagogy also emerged from the reform efforts. Teachers began dialoguing about changing instruction and learning environments to accommodate a different teaching/learning theory. When teachers asked different types of questions, valuing student experiences and supporting student risk-taking, they saw differences between what they taught and what students learned. This provoked individual teacher change. "It is hard to change people's minds. You couldn't change mine. It just so happened in my own pursuit, my own reason. I came upon it and changed my mind" (teacher-leader).

The reform began to break down the walls of isolation among teachers. Teacher-leaders discussed instruction and student work with each other and with secondary and university mathematics educators. Collegial relationships and professional discussions encouraged many teachers to take risks and learn mathematics (Pourdavood & Fleener, 1998). Collaborations and common interests among teacher-leaders seemed to encourage the development of a professional school community where trust, professional respect, and pride in students' abilities to do significant mathematics were valued.

Fragility within Chaos and Order

Radical educational reform abounds with complexity (Fullan, 1997; Hargreaves, 1997). School leaders may expect complexities when implementing NCTM *Standards* (1989). The *Standards* challenge school leaders to renew existing educational cultures and structures to implement NCTM reforms. Creating an epistemological change in learning and teaching may expose weaknesses and flaws in current educational practices. Epistemological changes perturb existing education systems and create conflict because a "business as usual" mentality reacts to cultural/structural changes.

> . . . disturbances of an established equilibrium are key to the equilibration process; they are the stimulus or burr that excites organisms to reshape themselves. However, the environment does not shape the organism; organisms shape themselves . . . organisms (including humans) make 'positive reactions' to environmental pressures. (Doll, 1993, p. 81)

Tensions and conflicts may provide school leaders opportunities to better understand the nature of change and develop strategies to lead instructional reforms. A reflexive relationship between status quo and reform may be a source for renewing and sustaining change processes.

Instructional reform at this school supports research findings on organizational change. Changes at the school ventured far from equilibrium. Conflict emerged that challenged the value and credibility of the NCTM reforms. For instance, state proficiency tests began in the midst of the reform. The Fourth Grade Mathematics Proficiency Test was not congruent with this school's curricular and assessment reforms. For the first three years of the state mathematics proficiency test, fourth graders scored about the same as fourth graders at four other elementary schools in the school district. State level and district educators and the general public expected the school's Mathematics Proficiency Test scores to be higher. "We are so excited about your mathematics project. It is truly remarkable. However, politically, your Proficiency scores hurt you. And your credibility suffers" (conversation between a department of education official and assistant principal). From 1995 to 1998, the school's Proficiency Test scores were low or about the same as the other district schools. However, in 1999, the school's passage rate on the state mathematics proficiency test rose from 60% to 86%. This was about 15% higher than the district average. The school gained attention and respect for its mathematics test scores in 1999. Also, because of their great improvement in proficiency test score in 1999, the school received a $25,000 award from the Ohio Department of Education. Again in June 2000, the school's fourth graders scored high with 90% passage rate on the mathematics proficiency test.

Whereas many factors were cited for the successful performance such as tuition-free summer school for third graders, Saturday Scholars for "at-risk" students, and after-school mathematics tutoring, perhaps the most pivotal factor was the realization that constructivist teaching and learning mathematics necessitated more time. This school's classroom teachers taught ninety minutes of mathematics daily, double the state requirement of 45 minutes each day.

Moreover, mathematics reform at this school represented an epistemological change. Teacher-leaders moved away from behaviorist dominated instruction toward teaching and learning practices that reflected

constructivism. This represented a paradigmatic shift for teacher-leaders and principals because it transformed classroom settings, communication with parents, teacher interactions, leadership roles, instructional/assessment practices, and the role of student voices in mathematics classrooms.

The change process was also chaotic. Chaotic situations challenged conventional leadership strategies, interrupted stability of the school climate, and suggested an uncertain future. Chaos and uncertainty forged new leadership strategies to value the creation of new roles and relationships dependent upon teachers as writers and risk-takers. Principals focused on preparing teacher-leaders for an unknowable journey. The reform seemed to depend on teachers and principals who believed in the need to restructure and reculture schools, and who were willing to take risks and spend the time necessary to do it. Furthermore, students seemed to play an important role. Student voices and experiences acted as catalysts for teacher development (Pourdavood & Fleener, 1997). Students and teachers constructed mathematical understandings together.

Within all these complexities there may be good news for fundamental changes in instruction, organization, and professional development. It is not unusual for good news to emerge from within a climate of constant conflict and disequilibrium (Fullan, 1997; Pourdavood, 1997; Prigogine, 1997; Senge, 1990; Stacey, 1992; Waldrop, 1992; Wheatley, 1994). However, good news may still depend on the following uncertainties: (1) Can this, or any, instructional reform exist beyond the building level? (2) Will other educators take risks to promote school change? (3) What is the fate of this school community and those individuals who have taken major risks to change traditional beliefs and practices? (4) How will improvement in student understanding be meaningfully evaluated? (5) How can schools be restructured to facilitate and encourage fundamental change? These questions are echoed by many voices in the school community. Doll (1993) expressed similar ideas on organizational change by quoting Maturana and Varela (1980) about an autopoietic system:

> a network of processes of production (transformation and destruction) of components that produces the components that through their interactions and transformations continuously regenerate the network of processes (relations) that produced them. (p. 85).

Doll added that Manturana's and Varela's assertions emphasized that " a system . . . can regenerate itself but, when it does not receive enough perturbations to perform transformations, will disintegrate" (p. 85). Likewise, Morgan (1997) reminds educational leaders that "using the image popular-

ized by chaos theorists, the invitation is to recognize that although we may be no more than 'butterflies' in terms of our power on the overall system, we can have enormous effect . . . the more butterflies the better" (p. 300).

There is hope that school communities like the one in this study will take risks to restructure and recreate themselves. Cowen (1995) reflected on the importance of Papert's (1993) notion of megachange in education occurring in little schools:

> Megachange in education may only occur through a grassroots approach, the emergence of little schools' where teachers, parents and children explore and create new learning situations . . . networking among these schools would prevent isolation and elitism and provide an opportunity to select successful changes (p.47).

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Roland G. Pourdavood is an assistant professor in the College of Education at Cleveland State University in Cleveland, Ohio. Lynn M. Cowen is the assistant principal at Lomond Elementary School in Shaker Heights, Ohio, and Lawrence V. Svec is the principal at Lomond Elementary School in Shaker Heights, Ohio.