Implementing Resources for Reform: One Teacher’s Experience with a Standards-Based Mathematics Curriculum

Royer

Follow this and additional works at: https://scholarworks.wmich.edu/masters_theses

Part of the Educational Leadership Commons, Educational Methods Commons, and the Science and Mathematics Education Commons

Recommended Citation

This Masters Thesis-Open Access is brought to you for free and open access by the Graduate College at ScholarWorks at WMU. It has been accepted for inclusion in Master's Theses by an authorized administrator of ScholarWorks at WMU. For more information, please contact wmu-scholarworks@wmich.edu.
IMPLEMENTING RESOURCES FOR REFORM: ONE TEACHER'S EXPERIENCE WITH A STANDARDS-BASED MATHEMATICS CURRICULUM

by

Lynn Best Royer

A Thesis Submitted to the Faculty of The Graduate College in partial fulfillment of the requirements for the Degree of Master of Arts Department of Education and Professional Development

Western Michigan University Kalamazoo, Michigan December 1996
This study addresses the issue of implementation of a reform mathematics curriculum, focusing on one teacher's personal experience. Its purpose is to uncover what motivated this teacher to persist in learning new ways to teach mathematics. There is greater emphasis on discovering what discouraged this effort. Impediments to implementation are emphasized because of their potential to undermine the movement to restructure mathematics education.

This case study used common methods of qualitative data gathering and analysis. Interviews, observation, and video tapes were recorded, transcribed, and analyzed. The impediments to implementation which emerged were then compared to reports from similar reform projects.

The findings of this study indicate that this teacher's efforts to implement a reform mathematics curriculum faced many impediments. It concludes by urging others to pursue research on this subject and recommends that it be used to inform developers and prospective users of reform curricula.
INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

UMI
A Bell & Howell Information Company
300 North Zeeb Road, Ann Arbor MI 48106-1346 USA
313/761-4700 800/521-0600

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Copyright by
Lynn Best Royer
1996
ACKNOWLEDGMENTS

I want to thank the members of my committee, Dr. Zoe Barley, Dr. Robert Laing, and Dr. Richard Harring, for their help, support, and their generous donations of time throughout the writing of this thesis. Each of these people responded kindly and thoughtfully to my frequent questions and requests. The many miles between my home and Western Michigan University complicated their lives as well as mine, but they never failed to be supportive. Because of them, this project became not only the fulfillment of a requirement, but also a useful and enjoyable learning experience.

I also want to thank "Karen Adams," a pseudonym for the teacher who was the focus of this study. When I approached her and asked her to be part of this project, she agreed immediately. Karen, like most teachers, already has many personal and professional demands on her time, but she did not hesitate to participate in this endeavor. During a series of interviews, an observation, and two video taping sessions, Karen remained positive, good-natured, and helpful, and had the grace to say that she enjoyed the experience. She reviewed all parts of this study, from interview transcripts to the final draft. Karen is a superb teacher and has become a treasured friend and colleague.

Finally, I dedicate this project to my husband, Jon. His support and caring through 3 years of graduate study made it all possible. His
Acknowledgments—Continued

encouragement, understanding, and willingness to take on extra work himself provided the place for this project in our lives.

Lynn Best Royer
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>ii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>vi</td>
</tr>
<tr>
<td>INTRODUCTION: THE ORIGIN, ISSUE, AND PURPOSE OF THIS STUDY</td>
<td>1</td>
</tr>
<tr>
<td>A REVIEW OF THE LITERATURE</td>
<td>5</td>
</tr>
<tr>
<td>PROJECT DESIGN AND METHODOLOGY</td>
<td>11</td>
</tr>
<tr>
<td>NOTES FROM AN OBSERVATION</td>
<td>15</td>
</tr>
<tr>
<td>THE PROJECT: A BRIEF DESCRIPTION OF THE CONNECTED MATHEMATICS PROJECT</td>
<td>23</td>
</tr>
<tr>
<td>THE CASE</td>
<td>28</td>
</tr>
<tr>
<td>The Setting and Context</td>
<td>28</td>
</tr>
<tr>
<td>The Informant: Personal and Professional Perspectives</td>
<td>29</td>
</tr>
<tr>
<td>Impediments to Adoption</td>
<td>39</td>
</tr>
<tr>
<td>The Fourth Row--Cards 3, 6, 8, and 13</td>
<td>42</td>
</tr>
<tr>
<td>The Third Row--Cards 4, 11, 15, 7, and 14</td>
<td>44</td>
</tr>
<tr>
<td>The Second Row--Cards 16, 5, 12, 2, and 10</td>
<td>48</td>
</tr>
<tr>
<td>The First Row--Cards 1, 18, and 17</td>
<td>57</td>
</tr>
<tr>
<td>Impediments to Adoption Noted by Other Reform Projects</td>
<td>67</td>
</tr>
<tr>
<td>Scenes From a Classroom: Evidence of Impediments to Curriculum Implementation</td>
<td>72</td>
</tr>
<tr>
<td>ASSERTIONS</td>
<td>78</td>
</tr>
<tr>
<td>APPENDICES</td>
<td>81</td>
</tr>
<tr>
<td>A. List of Mathematics Projects Funded by the National Science Foundation</td>
<td>82</td>
</tr>
</tbody>
</table>
APPENDICES

B. Cards for Contrast Questions Used in Interview 3 ..... 86
C. Approval of the Human Subjects Institutional Review Board for This Study .............................................. 90

BIBLIOGRAPHY ................................................................. 92
LIST OF FIGURES

1. Karen’s Last Card Sorting Activity: An Arrangement of Elements That Were Impediments to Her Implementation of CMP ................................................................. 41
INTRODUCTION: THE ORIGIN, ISSUE, AND PURPOSE OF THIS STUDY

During the summer of 1995, I met with the three members of my thesis committee to decide on a topic for this study. During the previous 2 years' work in each of their departments, there had been contact with many interesting and important issues in mathematics education. Classes in curriculum development, assessment practices, and program evaluation had all involved projects that helped provide background for this meeting. I came with a list of possible topics for a study, prepared to work on any one of them, or on any topic the group developed.

The idea that emerged from this discussion was different from any specific topic on the list, and it grew from our common interest and commitment to current efforts to reform mathematics education. These reforms place emphasis on thinking, on communicating ideas, and involving students in constructing their own mathematical knowledge (National Council of Teachers of Mathematics [NCTM], 1989). Changes in teachers' perceptions of their role in mathematics instruction are also very important to the future success of the reforms. In a new vision of mathematics instruction, teachers become facilitators of students' thinking rather than sources of information. Their job now involves helping students develop and test their own mathematical reasoning rather than providing rules and processes for students to memorize and follow.

These reforms, suggested and explained by the National Council of Teachers of Mathematics Standards documents, have spurred the
development of curriculum projects that exemplify and promote new ways of teaching and learning mathematics. Many of these projects were developed with funds from the National Science Foundation (NSF) and other grantors. One thing these projects have in common besides the vision of the Standards, is a radical change in teachers' thinking and actions as they prepare and deliver instruction and as they evaluate the efforts of their students. It is likely that implementation of these projects on a day-to-day basis would involve both positive and negative experiences for teachers. Some things, such as increased student understanding of mathematics, might encourage teachers to persist in their efforts to use the new materials. Others, such as the difficulty of assessing student performance, might inhibit the implementation process and have a negative effect on teachers' commitment to reform. It seemed that this question was worthy of investigation. If these projects are to succeed, the issues that influence teachers' implementation of a reform curriculum must be recognized, and those that cause concern, addressed.

Although there is a substantial body of literature on the process of curriculum implementation (Berman & McLaughlin, 1976; Snyder, Bolin & Zumwalt, 1992; Elliott & Adelman, 1974; Fullan & Pomfret, 1977; Shipman, 1974) and convincing argument that change in mathematics teaching may be more difficult than in other curriculum areas (Ball, Cohen, Peterson, & Wilson, 1995; Spillane, 1995), there is only a small body of literature that specifically addresses the implementation of reform mathematics projects. Early in this study each of the NSF-funded projects was contacted and asked for information on teachers' experience with implementing their materials. Several projects did not respond.
Some replied to this request with information on student achievement. One project answered that it "currently had no teacher evaluation data in a form that we can make available," and another said that the material being sent "is preliminary; . . . we are still in the field test mode and will not have final reports for some time." Only two projects sent information responding directly to the request for material that addressed teachers' perceptions of the positive and negative aspects of implementing their programs (see the section Impediments to Adoption Noted by Other Reform Projects, p. 67). The lack of specific data on teachers' implementation efforts with reform mathematics programs helped verify a need for this study.

This investigation is a case study of a teacher who is involved in implementing the Connected Mathematics Project, the reform curriculum developed at Michigan State University, with funding from the National Science Foundation. An effort is made to uncover what encouraged this teacher to persist in her efforts to implement reform. There is a greater emphasis on discovering what inhibited that commitment. The impediments to implementation of a reform curriculum were of special interest because of their potential to diffuse or possibly destroy the effort to improve mathematics instruction. Because of its limited focus, this paper can only suggest what broader studies could discover. It is a small piece of an important quest: to understand forces that both promote and detract from reform curriculum implementation. Eventually, this understanding may help facilitate teachers' transition to new ways of thinking about mathematics and new ways of developing this thinking in students.
The purpose of this study was to shed light on the issue of curriculum reform by focusing attention on one teacher's personal experience with an NSF-funded mathematics project. As you hear her praise its many benefits, you will also hear her struggle to cope with the demands it creates on her time, her energy, and other personal and professional resources. And, as we will hear her say, even she is not sure what lies ahead for this project's future in her classroom.
People interested in current efforts to reform mathematics curriculum and the teaching and learning of mathematics should find it useful to learn about curriculum reform efforts of the past. This perspective should not only inform our discussion, but in describing our past successes and failures, provide insight into actions that either promote or discourage the process of curriculum change.

Various articles from the 1992 edition of the Handbook of Research on Curriculum provide details and further sources of information on the history of curriculum development and implementation. Rugg was cited in Snyder, Bolin, and Zumwalt's (1992) article on "Curriculum Implementation" that gives a succinct historical perspective, describing the influence of textbook writers. This article also said that, during this era, college entrance requirements helped provide the impetus for a supporting school curriculum. Teachers' place in the curriculum implementation process was first recognized when their influence in interpreting curriculum was noted, and the importance of having their involvement in curriculum design was later acknowledged (Caswell, 1946, 1950). These studies provide background for addressing teachers' participation in curriculum design and delivery.

More recent studies have centered on crucial issues of curriculum implementation. Fullan and Pomfret (1977) have had great influence in defining the purposes and value of curriculum implementation research. In their article "Research on Curriculum and Instruction Implementation,"
these authors set the stage for studies such as this one when they asserted that it is "important to examine implementation . . . to understand some of the reasons why so many educational changes fail to become established," and suggested that "by investigating implementation directly . . . we can begin to identify some of the most problematic aspects of bringing about change" (p. 337).

Additional insights into the process of effective implementation of reform curriculum come from detailed descriptions of failed reform movements. In reviewing these, some scholars provide "maps" that may guide us through the precarious process of change (Fullan & Miles, 1992; Miles, 1981). These maps (more like "caution signs") call our attention to aspects of change which align with teachers' experience with implementing a reform curriculum. Other scholars detail elements of and reasons for curriculum change and stability (Cuban, 1992).

In 1989, the National Council of Teachers of Mathematics (NCTM) published its Curriculum and Evaluation Standards for School Mathematics. This book was followed by two other Standards documents: Professional Standards for Teaching Mathematics in 1991 and the Assessment Standards for School Mathematics in 1995. These documents have helped define and illuminate the efforts for mathematics reform nationwide, and they are the foundation on which current reform efforts are based (Cody, 1995; Fuhrman, 1995). Each of the NSF-funded projects, as well as the more recent commercially-developed mathematics texts, maintain that their materials reflect the Standards in intent, purpose, and practice. The Standards documents' have changed the course of mathematics curriculum development. They have provided the
impetus for creating standards for other disciplines as well (Goodlad, 1995).

A large body of literature based on the NCTM's **Standards** now exists, focusing attention on various aspects of those documents. A wide variety of recent NCTM publications address Standards' issues. Assessment, as we will see, has been a major topic of these like-minded endeavors, as has problem solving, and most of the recent literature on teaching specific mathematics strands such as geometry, algebra, and fractions. The influence of the Standards was purposeful. In the preface to the original Standards book, this is made explicit: "As school staffs, school districts, states, provinces, and other groups propose solutions to curricular problems and evaluation questions, these standards should be used as criteria against which their ideas can be judged" (p. v). Schools' efforts at mathematics reform have access to these materials to guide the vision of change as well as its actual implementation.

The first and second sections of this literature review address the history of curriculum development and curriculum reform in general, and the philosophy of the current movement for mathematics reform in particular—important background for anyone involved in an effort to adopt and implement the new ideas in mathematics education. A third element of importance for this study involves the practice of the reforms.

One of the objectives of this study was to find the impediments to adoption of a reform mathematics curriculum experienced by the informant of this case. Eventually, through a series of interviews and observations, a list of concerns emerged which were significant for her. The following sections of this review address literature relevant to the issues
that she identified as impediments to her implementation of a reform mathematics project.

The first information comes from the NSF-funded mathematics projects themselves. These projects are creating curriculum which explicitly supports the NCTM's Standards. (A list of these projects appears in Appendix A of this study.) The Connected Mathematics Project (CMP, 1995) in the publication, Getting to Know CMP: An Introduction to the Connected Mathematics Project, stated: "The four overarching goals in the National Council of Teachers of Mathematics (NCTM) Curriculum and Evaluation Standards for School Mathematics--Problem Solving, Communication, Reasoning, and Connections--serve as the major process goals for CMP" (p. 3). Other aspects of the project are explicitly linked to the Standards as well. The materials supplied by each of these projects offer practical suggestions for lessons and for classroom implementation of the projects themselves. One project has done extended assessment of teachers' response to implementation issues. Findings of the University of Chicago's pilot projects which are similar to specific aspects of this study appear later in this paper and may be found in the section entitled Impediments to Adoption Noted by Other Reform Projects (p. 67). There are obviously areas of common concern. Issues such as assessment, use of manipulatives, and the question of including skills and practice are part of teachers' experience with both the Connected Mathematics Project (CMP) and the University of Chicago School Mathematics Project (UCSMP). As other projects review teachers' implementation issues, a larger body of information may appear which can be used to guide future planning and decision-making as a reform curriculum is enacted.
There is other literature which informs the direction of this study. Assessment and teachers' mathematics background were implementation concerns addressed by a number of reports from the National Center for Research on Teacher Learning (Ball, 1988b, 1990; Featherstone, Smith, Beasley, Corbin, & Shank, 1995; Mead, 1992; Wilson & Ball, 1991). Assessment in a reform mathematics program is also the subject of many recent books and articles. The 1993 NCTM Yearbook, Assessment in the Mathematics Classroom is another source of information on assessment issues and practice. Other authors have created works that both detail the need for change in assessment practices and give models of new methods for teachers' use (Ann Arbor Public Schools, 1993; Stenmark, 1989). Two of the Standards documents (Curriculum and Evaluation Standards for School Mathematics [NCTM, 1989] and Assessment Standards for School Mathematics [NCTM, 1995]) mentioned earlier are also references for both background and practical information on assessment issues. (For a detailed description of reform mathematics assessment practices and issues, see pp. 57-63. Teachers' mathematics background and its implications for implementing a reform project are discussed on pp. 47-48.)

"Dwindling Support of the CMP Staff" is identified as an implementation concern by the informant in this study. Related to this issue, NCTM's 1994 Yearbook, Professional Development for Teachers of Mathematics contains thoughtful contributions on the subject of teacher support and professional development during a period of change in mathematics curriculum. Of specific interest are pieces which emphasize the importance of regular peer contact and continuing time
for learning about changes, planning for reform, and reflection (Clarke, 1994; Hyde, Ormeston, & Hyde, 1994; Weissglass, 1994). Other scholars support this position (Sykes, 1996; Wilson, Peterson, Ball, & Cohen, 1996). The need for and use of calculators to support a reform curriculum is the subject of the 1992 Yearbook Calculators in the Classroom. Some articles emphasize the potential of graphing calculators to influence students' mathematics understanding in middle school and high school (Burrill, 1992; VonderEmbse, 1992). The 1989 Yearbook New Directions for Elementary School Mathematics has information which helps define the place of computation in a reform curriculum, answering, in part, questions teachers and parents raise about the need for skills and practice (Coburn, 1989). The growing body of literature indicates that many teachers have similar needs and are anxious for ideas and assistance to ease the transition to new ways of teaching mathematics.
PROJECT DESIGN AND METHODOLOGY

The design of this study began during the summer of 1995. Plans were made with members of my thesis committee to structure and focus a project related to the implementation of a reform mathematics curriculum. During the fall and early winter of 1995-96, the necessary permission to do human subjects research was obtained from the Human Subjects Institutional Review Board at Western Michigan University (see Appendix B), and a mathematics project, a site, and an informant were located. The site and project were selected after having determined locations near my home that were involved in the implementation of NSF-funded mathematics projects. Proximity was an important factor. While completing this study, I was also teaching full time and needed to be able to reach a site quickly during days when both the project school and mine were in session.

Initially I had chosen the University of Chicago School Mathematics Project (UCSMP) as the focus curriculum. It has been in use longer than any of the other NSF-funded mathematics projects, and there were several sites within an 80 mile radius of my home where the project had been in place for more than one year. The time factor was an important design consideration. I hoped to gain insight into forces that both promote and impede a project's implementation and which tend to be persistent rather than transient. The University of Chicago had completed extensive evaluation of its efforts which could be a source of corroboration for the findings of this study and had been
generous and prompt in its response to my requests for copies of those documents.

Eventually, however, I chose the Connected Mathematics Project (CMP) for this study. I had experienced difficulty obtaining permission to use the nearest UCSMP site and found willing administrators at a CMP school nearby. Choosing the Connected Mathematics Project had an additional benefit: their offices and project directors are located at Michigan State University, not far from my home.

At the CMP site, I found a willing informant for my case study. Karen Adams was my second contact at the school, and she proved to be unfailingly available and helpful.

My study used common methods of qualitative data gathering. As a case study, it used an approach based on the suggestions of Spradley (1979) in his book *The Ethnographic Interview*, and methods usually associated with "naturalistic inquiry:" interviews and observations. An initial meeting between the informant and the ethnographer was followed by four one-hour interviews, an hour-long observation of the informant's fourth hour mathematics class, and video tapes of each of two other classes. The interviews were recorded and transcribed, and both they and the video recordings of Karen’s classes were carefully analyzed. The interviews, using Spradley's ideas, moved from a general line of questioning and analysis to increasingly specific ones. These interviews produced a list of "domains"—those "larger units of cultural knowledge" to which Spradley referred (p. 94). The emerging list of domains reflected Karen’s own identification of elements of CMP which either promoted or inhibited its effective use in her classroom.
Succeeding interviews searched for verification of domains using "structural questions" to verify and expand them, and to "explore the organization of an informant's cultural knowledge" (Spradley, 1979, p. 94).

Part of this process was in conflict with Spradley's (1979) advice. He mentioned that "interviews are influenced by the identity of both parties" (p. 45) and urged the ethnographer to study an "unfamiliar cultural scene" (p. 46). I often felt dangerously familiar with Karen's experiences as a teacher and had to remind myself not to "lead my witness." I was never wholly successful at this, but awareness of the problem has, I hope, limited the influence of our cultural similarity. In fact, there were many differences in our experience: Our age, training, number of years of teaching, grades taught, and project familiarity were very different. It was possible to talk with Karen and discover domains and structures that were either new or strikingly different from my own experience.

Lincoln and Guba (1985), in their book, Naturalistic Inquiry, echo another tenet of Spradley's (1979) in urging that "iterations [be] repeated as often as necessary until redundancy is achieved" (p. 188). Careful domain identification and verification were done during the gathering of data. In later interviews contrast questions helped reach the limits of the categories that had emerged. The final interview produced elaboration of some domains, but no new ones. I had confidence that the limits of this study—the search for all the major elements that promote or inhibit the implementation of this reform curriculum in this teacher's experience—had been reached. Karen Adams, the informant in this case study, has reviewed this paper and offered her comments and suggestions.
Finally, the format of this case study follows suggestions made by Stake (1995) in his book, *The Art of Case Study Research*. I have used his ideas for structuring the report (p. 123) and have tried to make it both brief and readable. Those proved to be the most difficult directions to follow, and the reader must be the final authority on how well these goals have been achieved.
NOTES FROM AN OBSERVATION

On Wednesday afternoon, March 6, I went to Norris Middle School to observe Karen Adams's sixth hour class.¹ I had taught my own third grade class that morning and had parent conferences later that afternoon. My principal had given me permission to extend my lunch hour to observe Karen's class, an opportunity which I had arranged with her several weeks earlier.

Karen had been absent on Monday. Her daughter had become ill during the day, and Karen had left school before her sixth hour class to take care of her. Karen had parent conferences herself on Tuesday, and feeling that she didn't quite know where things were in her lesson plans had almost rescheduled this observation. However, she had decided to let it happen. "After all," she said to me later, "this is how things really are."

When I arrived in her building about 12:15 p.m., Karen was in the storage room that connects four adjoining classrooms, and she was on the telephone. She smiled and waved, concluded her call, and we had just enough time to find a place for me to sit in the room when the students began arriving.

This is a seventh grade math class, all of whom Karen had earlier in the day for language arts. She described them as a group of students

¹Names of people and places in this paper are fictitious. However, the Connected Mathematics Project developed at Michigan State University is the mathematics project being used in this classroom.
who could, at times, be difficult, but who are bright and able learners. There are 23 students in this class, 14 boys and 9 girls. Four of them are members of ethnic or racial minorities: two African American, one Asian, and one student who is Hispanic. The class makeup reflects the increasingly diverse ethnic population of the school district. It also mirrors the wide range of income levels of families in this community, from the very wealthy to those whose children receive a free or reduced lunch at school. Shortly before 12:25 p.m., students come in noisily and sit down at tables, each of which accommodates four students. They are not seated as groups; all sit facing the board. The lesson in which they are involved is from the Connected Mathematics Project’s unit, "Comparing and Scaling." Karen had put these directions on the overhead projector:

PLEASE WRITE A DESCRIPTION OF HOW YOU SOLVED 6.2 [a problem in the Connected Math Project’s book Comparing and Scaling].

PLEASE BE SURE YOUR DESCRIPTION INCLUDES NUMBERS AND PROBLEMS YOU SOLVED.

Karen is dressed casually—slacks and an overblouse. Her blond hair looks windblown, as though the tumultuous entrances and exits of these 13-year-old students have created a breeze in her windowless room. As they find their way to their seats, they talk easily, sometimes kiddingly with Karen. To my eyes, used to a classroom of third graders, these are BIG kids.

Karen greets them, and says, "Hey! Get settled! Get started!" and they do. The students make their way to their seats down the narrow aisles between the tables, open books, and take out notebooks. Karen
reminds them that she was absent on Monday, and they had been taught by a substitute teacher. She tells them that because of that, they need to review 6.2—something the students had done on Monday when she wasn’t here. (Problem 6.2 is a unit on ratio and proportion. This particular investigation involves finding population density.) One student says matter-of-factly that he hasn’t done it. Karen encourages him to start now.

While the students work, Karen takes roll. All the students are quiet and all are working on the problem. Karen walks around, checking in with the students. She has introduced me briefly as someone who wants to see "how this program works." Several students glance in my direction and then continue with their problem solving.

The problem involves the populations and areas of North and South Dakota, and asks that students determine the population density of each state. Two students go to the board at Karen's invitation and start writing solutions. One student is setting up a proportion to compare population density. Karen refers to both solutions, clarifies the task and the students' notation. Karen says, "Once you have these numbers (696,000 people in 75,956 square miles), what do you do with them? Pick up your calculators! Punch some buttons!"

The Connected Mathematics Project (1995), in its publication Getting to Know CMP, is clear about the need for graphing calculators in the seventh and eighth grade programs: "Students will have access to calculators at all times--the 6th Grade students need standard, four-function calculators; in the 7th and 8th Grades, we assume that students will have graphing calculators with table and statistical-display
The frequency of graphing calculator use is made clear two pages later. After stating that each CMP unit has an "electronic technology component," the graphing calculator's place in the program is clearly defined: "Seventh and Eighth Grade units include generally a bit less computer work, but roughly half the units do include graphing calculator activities" (p. 40).

Karen's seventh grade students, however, are using the same four-function calculators I use in my own third grade classroom. Karen told me in an earlier interview that when the seventh grade teachers began their pilot of CMP, the project had supplied graphing calculators in numbers sufficient for every student in the program. As the pilot process was in its second year, the calculators became available as one set per grade level, and finally, at the pilot's conclusion, the project's calculators were no longer available at her school. Not replaced by the district, there are currently no graphing calculators for seventh grade students.

The class progresses to the last part of the question--trying to decide how to even out the population density in states of unequal size, with unequal populations. How many people would have to move, and where would they have to move, to equalize the population density of both states?

Karen poses questions about this problem and students respond. There are multiple approaches being offered. She keeps checking with Dan to see whether the question is clear to him. She accepts another student's answer to the problem and encourages the class to check their answers to see whether they agree.

Karen offers some explanations and also puts students' ideas on
the board. She asks Tom to clarify his answer, and she asks him whether he had guessed or if he knew. Tom says he knew and describes his thinking. Karen puts his ideas on the board. "Guess and check is what we're doing. . . . Did anybody try something different?" she asks. The next student called on says she doesn't think she got the problem right. Karen offers her encouragement, and this student also begins to develop her own solution. Carol, another student, adds that the first girl's solution ignores the question of population density.

The class is quiet and engaged in their work. They've been here 15 minutes. Suggestions are tried. "What do you think?" Karen says. "Is this reasonable? No?"

Karen offers an idea. Erasing the line between North and South Dakota on a map she has drawn on the board, she says she has just created a new state—"South Dakota," and the students are asked for its population. Since the actual populations of both states were given in the students' books, she warns, "Be specific!" "Be specific!"

Karen tells the students to "stand up when you've got it," and checks in with a boy sitting next to me who seems confused. He responds to her help and stands. The total number of people and square miles is determined for "South Dakota." "If you agree, stand up!" Karen repeats. She circulates, checking with students. The boy next to me who has been standing, sits and goes back to work with his calculator.

Karen suggests how to use the combined figures for "South Dakota" to make the population of North and South Dakota equal. Her manner is cheerful, encouraging, and her energy level is high.

One student asks, "How did we get that?" A second student
offers an explanation. Karen puts this idea on the board, adding information as she goes. The class is now 25 minutes along. Everyone is working and thinking. Is it always like this? It is an amazing show of enthusiasm and encouragement on her part, and a lot of serious work and response on the students' part. If there are discipline problems, they are not evident.

The students stand up again as they find answers. The boy next to me is still confused. Karen sees him sit down and hears him say, "I still don't get it." She offers help and he goes back to work on the problem.

Tom has an answer which is accepted as "close enough" by Karen and the class, and by Karen as an acceptable answer for a test question. Someone else now admits to being confused. This student asks definite questions, not the "I don't get it" kind. Karen responds with examples of simpler but related problems which use ratios in their solution. Someone else offers another idea for the solution to the uniform population density problem, and Karen shows him that he's not taking the states' different areas into consideration. He says, "Oh, I see."

One student asks, "Why would this ever matter?" Karen gives credence to his question and says the final question in 6.2 ("How many people would need to move to make the population of both states have a uniform density?") seems unlikely to have an application in real life. But she affirms, with examples, more pragmatic and useful applications of population density.

It is 12:56 p.m., and the class moves on to a new problem which
concerns traffic density. As a lead to this, Karen says, "Write down two causes for traffic jams that you might have seen or been in." Students write and begin to volunteer their ideas. Jon says, "An accident." Angelina says, "Snow." Karen begins to record the answers as they're spoken: "Construction." "An event--a lot of people going to the same place." "Old people who drive slow (laughter)." "Too many cars." "Rush hour." "Broken traffic light." "Traffic hazards." The child next to me raises his hand belatedly--after many answers have been given--but by this time the brainstorming is over.

This discussion sets the stage for the relationship between traffic jams and traffic density, and Karen helps the class see the connection to population density. She clarifies that traffic density will be dealing with linear miles as a unit of measurement--not square miles as in the "Sorth Dakota" problem.

It is 1:02. The students are asked to take notes, and all do. They are also asked to check back into notes already taken and some leaf backward in their notebooks.

Karen connects the old problem of population density to the new one of traffic density. She asks for ideas of what operation might work. When students respond, "Division," she asks how they know.

"Why not use city blocks instead of miles?" she asks, and a student recognizes the problem that would be created: city blocks are not of uniform length. "Can anyone think of another way to solve this? Cars per mile or miles per car?" She stresses labeling parts of the information and answers to make things clearer.

Karen then asks about Hong Kong--tapping into prior knowledge.
"What do you know about it?" she asks. She sets the stage further for the math to follow by gathering more information about the city. The child next to me says, "They ride bicycles there." This is the first time he's volunteered, and Karen acknowledges his answer and adds a comment that validates his contribution. The students are using their calculators to figure out the traffic density from the given information. Karen circulates among the students, looking at answers and asking if they seem reasonable. When the answer 346 cars per linear mile appears, she asks for a mental image of that density. Since miles might be hard to imagine, she suggests trying to work it out in available feet of highway per car. She asks, "How many feet in a mile?" When a student volunteers the right answer, she affirms that the class has enough information to complete the problem.

The bell rings. The past 45 minutes have gone very quickly. Karen is still explaining the homework assignment: each student must find the length of the family's car. She suggests that because of the weather, the owner's manual might be a better resource than a tape measure. She then shows them Problem 6.3 and points out an error in the pilot book.

Even after the bell rings some students linger to talk to Karen. She is responsive and reassuring. She jokes lightly with the group who has gathered, then hurries them on their way to their next class.
THE PROJECT: A BRIEF DESCRIPTION OF THE CONNECTED MATHEMATICS PROJECT

The Connected Mathematics Project (CMP) is one of 16 exemplary mathematics programs funded, in part, by grants from the National Science Foundation (NSF). CMP shares a history with the Middle Grades Mathematics Project which also received funding from NSF.

The Connected Mathematics Project was developed at Michigan State University in East Lansing, Michigan. The materials address the need for reform mathematics curriculum for Grades 6, 7, and 8, and provide eight units of study for each grade. Pilots of CMP's sixth grade units began in 1992, and those are now in publication. The seventh and eighth grade materials are following a similar path. CMP is being published by Dale Seymour Publishing Company.

CMP's efforts address major issues in curriculum reform, and its authors tie their project to the National Council of Teachers of Mathematics (NCTM, 1989, 1991, 1995) Standards documents. The project is described in a book designed for CMP users, published in May 1995:

This curriculum is devoted to developing student knowledge and understanding of mathematics that is rich in connections--connections among core ideas in mathematics, connections between mathematics and its applications in other school subjects, connections between the planned teaching/learning activities and the special attitudes and interests of middle school students, connections among the mathematics strands of a modern elementary and secondary school program, and connections with the applications of mathematical ideas in the world outside school.

Observations of patterns and relationships lie at the heart of acquiring deep understanding in mathematics. Therefore, the curriculum is organized around interesting
problem settings—real situations, whimsical situations, or interesting mathematical situations. Students solve problems and in so doing they observe patterns and relationships; they conjecture, test, discuss, verbalize, and generalize these patterns and relationships. (Connected Mathematics Project, 1995, p. 1)

Like the NCTM Standards, CMP (1995) also addresses two other major issues of reform. Not only do these materials present curriculum, but they also promote teaching practices such as "encourag[ing] higher level thinking and problem solving, and . . . making sense of mathematics and its uses" (p. 1). Cooperative learning is encouraged, and so are multiple solutions to problems. The project also includes assessment practices that align with the suggestions of the Standards. In this model, assessment has multiple purposes: informing many audiences about students' progress, teachers' actions, and mutual decision making.

Each of CMP's 24 units centers around a mathematical concept such as statistics, or proportional reasoning, or transformational geometry, but each incorporates multiple strands of mathematics. Technology is a valued tool:

The content and design of the CMP curriculum reflects two central assumptions about electronic technology: (1) Students will have access to calculators at all times—in the 6th Grade students need standard four-function calculators; in the 7th and 8th Grades we assume that students will have graphing calculators with table and statistical-display capability; and (2) computer software will be provided with the curriculum that students will be able to use in tandem with the curriculum. (CMP, 1995, p. 38)

Student materials are printed in paper-backed books and include:

A set of Focusing Questions to Think About to pique student curiosity about what they will learn in the unit.

A short discussion that Sets the Scene for the unit.

Mathematical Highlights of the unit listed as goals for
students.

Some units have a final Project that is launched at the beginning of the unit.

Four to seven Investigations, each of which has the following features:

- A short discussion to set the theme for the investigation.
- One to four Problems are posed to be discussed and solved over several days.
- Homework is assigned regularly from the Applications--Connections--Extensions section.
- The investigation is summarized with a Mathematical Reflections section. (CMP, 1995, p. 25)

Replicas of the students' books appear in each unit's teacher's edition. These also include useful teacher support materials such as mathematical background for the unit, lists of materials needed and a timeline for the unit, ideas for teaching, samples of student responses, solutions to problems and investigations, a variety of assessment materials to be used both during and after the unit, and suggestions about evaluating student responses on assessment (CMP, 1995, pp. 37-38).

CMP, like a number of the other NSF-funded projects, places emphasis on investigations as a setting for mathematical learning. In doing so, CMP bears little resemblance to the textbooks that presented the traditional mathematics with which most adult Americans are familiar. There are no pages devoted to skills practice, and the problem-solving emphasis is embedded in the investigations themselves and grows naturally from them. No word problems appear at the bottom of a page of computation. There are no chapters devoted to learning algorithms. Journals, projects, and student self-assessment have
replaced the quizzes and tests that used to be the main source of student evaluation. As a curriculum, CMP has much in common with other reform projects, but bears little resemblance to the mathematics with which we grew up, or that of traditional curriculum still being taught across this country in many, if not most, classrooms. It is this difference, this reflection of the Standards, that causes CMP and similar mathematics projects to be both hailed and reviled, and which threatens to sweep away years of struggle for reform in a tidal wave of reaction. There is tension in the air—the call for change and the comfort of the known and familiar joust for influence in mathematics classrooms across this country.

CMP (1995) warns prospective users about some important implementation issues. In its publication, Getting to Know CMP, there are useful suggestions about easing the transition to a reform curriculum. In a section called "What It Takes to Make CMP Work," needs of teachers, students, and parents are addressed. There are reminders to help teachers acquire the necessary mathematics background to be able to use the materials effectively. The need for sufficient time to teach lessons is also highlighted: "Very often in classes with less than 45 minutes there is not time to make significant progress on a problem. Consequently, during the next class period the teacher and the students must repeat much of the exploration and discussion of the previous day before they can continue their work" (p. 75). Parent needs are given extensive consideration with suggestions for parent letters and meetings. Presentation materials are provided for use with parent groups. However, as is the case with all the new projects, school districts are
free to accept or ignore this advice.

A thoughtful implementation of CMP in any district faces many challenges. Some administrators and school boards may be looking for a "quick fix" for the failures of their traditional programs, and may purchase materials without provision for the needs of those whom it will affect. Perhaps a basic difference, as Karen Adams would attest, is that "you can't just pick up the book and teach a lesson." CMP and other reform curricula represent such a departure from our traditional experience with mathematics that their adoption requires learning a new language and all of the structures that give it meaning. Like the Tower of Babel, the reform curricula may fall, lost to the failure to learn and use a common tongue.
THE CASE

The Setting and Context

Statesville School District is located in south-central Michigan. Its four elementary schools, an intermediate, middle, and high school serve a middle-class suburb of a large metropolitan area. Norris Middle School is one of a group of the district's buildings on a large and pleasant campus. The classrooms are all on one floor, and the 522 students form a racially and ethnically diverse population that mirrors the cultural contours of the country as a whole.

In the years before Michigan stopped using property taxes to fund schools, Statesville Schools were generously, if not lavishly, financed. The schools benefited from the district's location near stores and factories, all of which paid taxes but sent no children to Statesville's classrooms. Homeowners benefited from low tax rates, and students enjoyed the "extras" those tax dollars provided. Music, physical education, and art classes were held twice weekly in the elementary schools. The middle school and high school were air conditioned, and all the secondary buildings had swimming pools. This financially comfortable condition had also provided in-house, innovative teacher training. Cooperative Learning, Effective Instruction, and other classes were offered after hours and sometimes even during school in one or another of the district's buildings. A well-trained group of staff development coordinators assisted teachers in all major curriculum areas. When Michigan moved to
adopt goals and objectives reflecting national standards in mathematics or a new definition of reading, Statesville was diligent in preparing its staff to deliver the reformed curriculum.

During the 1992-93 school year, the sixth grade classes in Statesville were still housed in the middle school. These classes became a pilot site for the Connected Mathematics Project (CMP). CMP is an innovative mathematics curriculum developed at Michigan State University, and funded by the National Science Foundation. One of 16 exemplary mathematics projects designed to create curriculum reflecting the National Council of Teachers of Mathematics' (1989) *Curriculum and Evaluation Standards for School Mathematics*. CMP and Statesville Intermediate were a good match. Innovative curriculum was placed in the hands of enthusiastic and competent teachers. In the fall of 1993, Statesville opened a new intermediate school to house the fifth and sixth grades. That same year, the seventh grade mathematics teachers at the middle school also became part of the pilot effort.

**The Informant: Personal and Professional Perspectives**

Karen Adams is 35 years old. She teaches seventh grade mathematics and language arts at Norris Middle School in Statesville. Karen was a student in this district herself, graduating in 1978 from Statesville High School, just across the grassy campus from her classroom. Karen is an enthusiastic person; a mother of two young daughters; a wife; a highly competent teacher; and for the past 3 years, Chair of the Mathematics Department at her school. At our first meeting, she told me about her other interests. An accomplished singer, she had been part of choirs.
and choral groups in high school and had auditioned for and been accepted at Westminster Choir College after she graduated. However, because of high tuition at Westminster, Karen went on to a local community college and then to Central Michigan University (CMU). She graduated in 1984 and became a substitute teacher in Statesville. In 1989 she was hired by the district to teach seventh grade. The other mathematics teachers at her level were using an Addison Wesley text, but during her second year at Statesville she was asked to pilot the Houghton Mifflin series which she continued to use after the pilot year. "I liked the approach better," she said. "Cooperative learning was one of the teaching strategies. The material was much the same in the two series, but the presentation was better in Houghton Mifflin. There was more use of manipulatives" (from my initial meeting with Karen, January, 1996). When I asked her what had made her aware of manipulatives as a teaching tool, she mentioned her interest in a manipulatives-based mathematics in-service she had attended in the fall of 1990, and mathematics methods courses she had taken at CMU after she received her BS degree. She had purchased multilink cubes for her class and also used homemade manipulatives cut from paper place mats to help her class learn fractions concepts. Early in her career, Karen had recognized the potential of a conceptual approach to teaching mathematics.

When CMP proposed extending its pilot project into Statesville's seventh grade classrooms, Karen was not opposed. The sixth grade teachers had been using the CMP materials for one year and so had one seventh grade classroom. Karen knew about the project and was interested. She said, "I'd had enough experience with kids 'not getting it.' I
liked that [CMP] kept coming back to topics. It seemed to match up with things I'd read coming from the State Department of Education and other places."

Karen's experience with CMP, and that of other seventh grade teachers, was different from the sixth grade teachers'. The sixth grade teachers had moved to a new school (Statesville Intermediate) and had asked for that assignment. In a real sense, there had been a commitment to change among the members of this group. Also, Statesville's elementary schools and fifth grades were already using an innovative, standards-based curriculum, and there was momentum--an urge to carry on a similar program in the sixth grade. The seventh grade teachers came to the project later. People who could have been their mentors, the sixth grade teachers were now at the intermediate school and were not available to share what they had learned about CMP. The seventh grade teachers' closest colleagues were the eighth grade teachers at the middle school, and they were teaching a fairly traditional curriculum.

Karen and her colleagues had substantial support and response from the CMP directors and staff. They were always available to help. Karen was specific and generous in her praise of both the project and personnel: "CMP . . . the [authors and support staff] were really helpful. . . . We have their number up by the phone because we can call them any time, and they're very willing to get back with you and talk to you." She spoke of CMP's authors' regular presence in the building as being helpful: "For awhile, one of the authors was here in the building. . . . I think he was here every week, and he would stop by and see how things were going. So he was very supportive." Even after the
close of the 2-year pilot period, Karen gratefully acknowledged the continuing help and response from CMP. As recently as this spring she had called the CMP project office at Michigan State to ask to look at some materials: "He [one of the project's directors] was here that afternoon. . . . They're still [available]."

There was also generous technical assistance for the seventh grade teachers during the 2-year pilot project. "The second year of the project we had a bulletin board system through Michigan State that we could log onto and write to other teachers, and that was helpful. Teachers of the project . . . had time to connect." The graphing calculators that CMP provided for the project were mentioned in every interview. "When we first had CMP, . . . they provided us the graphing calculators; that was really neat. We all had our own set. We had one for the overhead. It was marvelous! The kids loved it. They were so excited to use them that they would come in excited about mathematics, and that was nice to see."

Some structures that had been in place to help the sixth grade teachers with their pilot of CMP never materialized for the seventh grade teachers, however. No "recorder" was designated for them. "No one here wrote reports," Karen said. "There were no forms, no response things. We all mentioned it . . . but it never happened." Of the five seventh grade teachers currently using the project, two are new to it this year and have not had the summer in-services that had been provided for everyone during the pilot years. But, on the whole, Karen's response to CMP is very positive. After describing the program in some detail, she said, "the idea of the story problems and the real-life applications and all
of those things are there. I don't think there's any one tool out there that would be the end-all, be-all . . . but this is . . . much better than what we were using before."

There were many things about CMP that Karen liked. She had been excited about the changes in her teaching, in her students, and in herself that were associated with her work with CMP. In the first interview, she responded at length to the question, "How would you describe CMP as a curriculum? . . . What does it do for you? What does it do for kids?"

Well, it's problem centered. . . . It's story problem driven. Everything is based on solving problems. . . . There's an attempt for the story problems to be real-life problems. So that's a major difference . . . comparing that to a traditional book. It is modular where you can take individual units. They do suggest a sequence, but you can . . . change that if you'd like to. There are some books that obviously have to come before others, but it's more flexible that way. Once you have a skill then you come back to that skill in other units, so it's much more . . . flowing, I guess is the word. . . . It will come back to a topic much more . . . many more times than one time. So they'll see a topic or they'll see a skill, or they'll see a strategy for solving a problem, and then it will come back. . . . So it's circular . . . a spiral kind of pattern that we see coming out more and more from books that are published lately.

Karen continued with information about students:

What it does for the kids, I think, it makes mathematics more realistic. And they have approaches to problems that they may not have had before. When we talked about area . . . they've been taught that area has a real-life application. And that's coming through CMP. And they do that with all of the content they teach. It's trying to be more realistic, more hands-on.

Then reflecting on the change in herself and her teaching:

I'm not always the person in charge, and . . . the kids can be in charge more. It lets me be a more diverse thinker because I see all of the other strategies that the kids come up with whereas before it was "This is the process, this is the path
or the solution. And this is the way I'm going to solve the problem." And now I look at problems much more openly, along with the kids. It lets me be more involved with the kids instead of being distant.

Karen frequently returned to this idea of the teacher as a learner, and it was one of the things about which she was most enthused. In the first interview she had said, "I'm more of a learner with them. Whereas before I had to know the answers first and impart that to them. So even the use of the words 'to' and 'with' was a big change."

Karen felt that students are more self-reliant and more likely to reflect on whether or not answers are reasonable when using CMP than when using a traditional curriculum, and she was also pleased with this. "The students themselves decide if they think their answer makes sense more than before," she said. "They think 'Well, this works. It makes sense. My answer appears logical, so I think it's right.'" CMP helped shift responsibility for learning from the teacher to the student, and students seemed more involved in their mathematics work. After describing another problem-solving situation, Karen had challenged an answer: "Does that make sense? And [the students go] back into the problem and find out where their difficulty was. So they're more motivated to do that for their own learning."

Karen noted other benefits for students as well. There is more risk taking and more willingness to get involved in problems and their solutions.

I have kids a lot of times when we talk about homework or we talk about a problem, they'll start off by saying, "I don't know if this is right, but this is what I did." So it's that kind of philosophy that's different. We're not always striving for the right answer. We're trying to see how we're applying mathematics and see if it gets us to the right answer.
Karen talked about the CMP materials themselves: "There's always a 'Launch'--how to launch a problem. . . . The summary . . . there are always some other ideas in the summary section when you get finished." Later I asked a question about the use of a teacher's edition: "Is it connected in such a way that you move from the first page pretty much to the last?" She had responded, "Pretty much. Pretty much." Then I asked, "Would I have to go get other things?" She replied, "No, not really. There are some things that you need to get for hands-on materials, and it's nice that they have that listed." Finally, I had asked about homework. "Is the homework in here also?" Her answer verified that the materials themselves were well-organized. "Yes . . . it's all right in here. Yes. So it's very complete."

Along with being a learner with her students, Karen had one other observation about CMP and how it had changed her as a teacher. This involved how she prepared to teach and was an interesting revelation. It had come up in our first interview, but was mentioned several times:

There's no way you can pick up this [book] and teach it. I know there are teachers that could do that with the other book. They would just pick up the book and say, "Okay. Here we go. This is what we are doing." . . . This, you really have to be invested. You have to do the problem. You have to try it. A couple of times. I've done all these problems. Every year I do them again just to make sure I don't miss anything.

Obviously pleased with her own professional growth, she reflected on this aspect of the program when she mentioned this issue again in a later interview:

You can't just pick up a book and teach a lesson. . . . It's not a major thing. . . . I like that. I used to think it was yucky. I would like to just come in and pick up a book and teach. But that's not really what we need to be doing.
It was clear that the adoption of CMP had resulted in changes that were both personally and professionally satisfying for Karen.

During our initial visit, Karen had mentioned some things that caused her difficulty in implementing CMP. Parents' concerns were named as an issue: "Parents struggle with it," she said. "Since they aren't in the math class, they don't have a clue as to how to help [their children]." Discussion of this problem would reoccur in each of the subsequent interviews; it was obviously a serious problem for her, and one for which she and her colleagues had not found a remedy.

Over the 2 months that I worked with Karen, interviewing, observing, and reflecting with her on the transcripts of previous interviews, she emerged as genuinely positive about CMP and her experience with it. In the second interview I had asked her, "You've taught two different curricula here, right?" to which she answered affirmatively. "You've taught Houghton Mifflin? Which one (CMP or Houghton Mifflin) seems more like who you are? To you?" She responded, "This one. CMP." But also during these interviews she revealed that the future of CMP in her school was in some jeopardy. To my question, "Is it going to be continued? At seventh grade?" she replied,

We're sort of trying to decide that now. I think that we're now starting a district-wide math steering committee, and I think part of the reason or the force behind that committee is that we're not real sure what we want to do at this building. . . . So I think as we go through this steering committee process, that will be one of the questions that's addressed. I know that people in this building . . . teachers . . . are happy with it and not happy with it at the same time.

This answer had surprised me, and its causes will be explored extensively in the following section of this study.
Karen proved to be a willing and forthcoming informant during the course of this study. She also proved to be a skilled teacher and a serious professional who continued to learn and look for ways to foster students' learning in her classroom. I worried at first about having chosen her for this case because she seemed so competent and positive about many aspects of teaching a reform mathematics curriculum. Was Karen the "right" person to study? Would she be able to identify and discuss both the positive and negative aspects of teaching a reform curriculum in ways that might prove informative and useful? Later I was able to appreciate the luck that had led me to find her. Basically convinced that CMP provided a solid learning environment for her students and herself, she was also thoughtful and clear in her description of implementation concerns such a program posed for her.

Karen's only contact with a reform curriculum was with CMP, but the implementation issues she raised could threaten the success of any of the other new mathematics projects. Most of these issues involved various CMP audiences who were unaccustomed to mathematics teaching based on the National Council of Teachers of Mathematics (NCTM) Standards documents. Because the depth and persistence of these implementation problems had not been anticipated, they continued to weigh heavily on teachers in her building. Even Karen, an enthusiastic CMP advocate, was burdened with these issues. In our final interview, I had given her a prompt: "Implementing CMP is . . . ?" to which she had responded,

Challenging. I don't think you can go into this naively. I think you really have to spend some time talking to people who are teaching CMP, talking to people who are writing CMP if
you can, and get it all out front. All the concerns and all of
the issues, because like we said, if we have hindsight, then
we should give that to somebody else so that they don't
have the problems that we have had.

Eventually, as we talked, some 17 impediments to CMP's imple-
mentation would emerge, scattered broadly across Karen's experience
with this exemplary curriculum. Some, like the parents' concerns, lay
beyond the boundaries of her school building. Others were internal
issues—pressures from eighth grade teachers for more skills and practice
for seventh grade students, for instance. A few were related to day-to-
day teaching practice such as issues of effective, yet feasible, assess-
ment. For a teacher who had declared herself for "this one. CMP," and
who obviously enjoyed the learning CMP provided for her students and
herself, these issues were crucial, for they were things that threatened
the future of mathematics reform at Norris Middle School. In a final
interview, I asked her to think about what she might do differently if she
and the other seventh grade teachers were about to implement a reform
mathematics project. What advice would she give to others who were
thinking of adopting one? The impediments to adoption of a reform
mathematics curriculum and the solutions we may develop should be of
concern to everyone committed to mathematics reform. All of us must
be aware of the fragile relationship between teachers and the new
mathematics projects that both support and confound teachers' best
efforts to fulfill the vision of standards-based mathematics instruction in
America's classrooms.

The implementation concerns that emerged came from all phases
of my contact with Karen. The videos, interviews, and the observations
brought each one into focus repeatedly, often from different perspectives. In presenting them in the following pages, I used Karen's perceptions of their depth and relative importance. In the two final interviews, I asked her to sort a number of index cards. In the activity, each card had a name or descriptor of an impediment to project implementation which she had identified. I told her, "I want you to put them in some kind of hierarchy of impediment. . . . When we get all through, let's see if we have some kind of a structure that gives me the feeling of how things have acted as impediments to you." The cards were sorted, discussed, and often rearranged. This process of construction and reflection helped develop a structure which displayed her best thinking about the cards and the ideas they represented. Here, then, is Karen's discussion of the impediments to the implementation of CMP, the reform mathematics curriculum which she uses in her classroom.

Impediments to Adoption

The purpose of this study was to describe Karen Adams's experience as she implemented a reform mathematics curriculum in her classroom. During 2 months of interviews and observations, Karen described many aspects of this new curriculum that helped her persist in the effort to change her teaching of mathematics. She also described impediments to her use of the mathematics project she and her colleagues had piloted for 3 years. These impediments are looked at in some detail in this portion of the study.

The teacher's concerns both substantiate findings in the literature on mathematics reform, and uncover others which are unique.
Comparisons of Karen's experience to other research will be made in the following sections of this study. This part will focus on the description and impact of the impediments to implementation that emerged during the time that data were collected for this study.

When Karen and I met for the last time, on April 11, I asked her to use the index cards described in the previous section of this paper. Each card had the name or description of an impediment to adoption of CMP which she had already identified. We had worked with these cards during the third interview, and she had done similar sortings (see Appendix B). However, as we continued to talk about them in the fourth interview, it seemed that the values assigned earlier might have changed. Our discussion may have clarified her perspective on some concerns, and a final sorting should reflect her current thinking. What caused her difficulty as she sought to implement a reform mathematics curriculum? Why, when she was so positive about so many aspects of this reform curriculum, was she willing to consider adopting a different program for the seventh grade mathematics classes?

The results of this sorting activity can be seen in Figure 1. Karen placed the cards in four rows. Each row contains cards whose "impediment value" are similar. Her most serious concerns are at the top of the page, and those with the lowest influence are at the bottom. Note that two cards (#17, "Time," and #18, "Finishing Books") overlap, and "Time" is slightly higher in its rank than the other elements in the first row. On the following pages Karen's card placements will be described and the influence each had on her teaching efforts explained.
Figure 1. Karen’s Last Card Sorting Activity: An Arrangement of Elements That Were Impediments to Her Implementation of CMP.
The Fourth Row—Cards 3, 6, 8, and 13

These cards display impediments which were of the least concern to Karen. They include "Discipline" (#3), "Dwindling Support From CMP Staff" (#6), "You Can't Just Pick up the Book and Teach a Lesson" (#8), and "Teachers' Teaching Styles" (#13).

As Karen talked about these four categories from the study, she made it clear that they had had little influence on her teaching of CMP. As documented in the section of this paper called Scenes From a Classroom (p. 72), discipline did not appear to be a problem for Karen. In the fourth interview, she commented:

Discipline problems . . . once you get [students] started there's not that concern. We just have such a group this year that I don't want to throw it [the card] out. Because it is a problem. . . . Like I said before . . . this is the only year I've had my room in rows all year. I would like to have them in groups of four, but I just can't because we have so many . . . immature kids. They just wouldn't handle it. So that's still a problem. More so this year than in years past. . . . Before I wouldn't have even put that card in.

An interesting extension of these remarks followed. I reminded Karen that she had indicated that she felt CMP helped her manage discipline better than the traditional curriculum she had taught before: "Your response said, actually, you thought it was less with . . .," to which she responded: "Yes, I think so. Because they get more engaged in the problems. They're not just sitting there, you know, number crunching mindlessly. They're really thinking through things."

Card 6, "Dwindling Support From CMP Staff," was nearly eliminated as well. "No," she said, "That has to happen as time goes by, so I don't see that as an impediment, and they're still willing to be there for
us." However, the card remained as part of the sorting at the end. Perhaps this was an oversight, or an indication that this loss was still a small impediment, even though it had been anticipated since the pilot's beginning.

Card 8, "You Can't Just Pick up the Book and Teach a Lesson," was also dismissed as a serious impediment for her in this discussion, but the card still remained at the end of the final sorting. Karen had indicated in earlier interviews that this had been an impediment earlier on, and remained a concern for some teachers and certainly for substitutes. But about herself, she said:

This isn't a bad thing. I like this . . . that I can't just teach a lesson . . . . It makes me be more involved with what's going on. There were days in the past when I would do that [just pick up the book and teach when she was using a traditional curriculum]. Because even though you say the math book is not going to be the curriculum, everybody knew in a traditional class that's what it would be. You'd start on page 1 and you'd work through the book . . . and so . . . you didn't have to be vested in it. And I think the kids could sense that . . . if I wasn't vested in it, why should they be? . . . So that is gone . . . . that feeling that I can just wing it. I'm better now. I don't have to be as frantic about preparing as I used to be. . . . I'm more familiar with [CMP] as time goes by. But I know I will always pick it up, read through it, look through the problems. It will never be a time when I just say, "Okay, I know I'm doing this lesson," because it is so varied and so different.

"Teacher's Teaching Styles" (#13) was also a limited concern. The card had originally read "Teacher's Learning Styles," but she had asked to change it to help her focus on the issue. This time, after a brief glance, she said, "Teacher's teaching styles? . . . It's not a major problem for me. I know it is for other teachers . . . but I was okay with that." CMP had filled a need rather than created one for this teacher and her style of teaching. She was comfortable with an investigative approach to
teaching mathematics and welcomed the thinking and involvement CMP
sponsored in her students.

The fourth row, then, were minimal impediments to Karen's
implementation of CMP. They were left in, perhaps, because they had
posed a difficulty at one time, or because they continued to pose a diffi-
culty for others. Our discussions had resulted in Karen's placement of
these cards in the lowest row.

The Third Row—Cards 4, 11, 15, 7, and 14

These cards display impediments which were of greater concern
to Karen than those in the fourth row. They include "No Graphing Calcu-
lators" (#4), "Problems With the Pilot Books" (#11), "Pressure for Skills
and Practice" (#15), "Coping With Students' Varied Responses" (#7),
and "Teachers' Own Math Background" (#14).

Karen placed these five cards in the third row. Looking at their
titles brought back scenes from our interviews and a recognition of their
difference from those lower in her sorting scheme. These third row
topics had been mentioned more often, and with more vehemence
(graphing calculators, for instance), or had caused more soul-searching
(the importance of teaching and practicing skills). They had occupied her
time, her energy, and her concern to a much greater extent. While some
cards in the lowest row named items that might have dropped from the
impediment list all together, all in the third row had a permanent place in
her memory.

One card's placement was a surprise. Karen had mentioned the
absence of graphing calculators as being a serious concern for her in
each interview that we did. None of the others in this row seemed to have quite this much weight. When she talked about calculators at our second interview, she was specific about the problem:

Investigation 6 is one that uses the graphing calculator. And we don't have access to those this year. When we first started CMP . . . the very first year that we piloted, they (CMP) provided us through Texas Instruments, a classroom set of graphing calculators for every teacher . . . teaching CMP. It was marvelous! The second year they gave us one set for the seventh grade. . . . People weren't using them because you couldn't have them in your room all the time. It was too much of a hassle to get them and reteach the calculator . . . every time. This year we have none. . . . [Now] I have one student who has a graphing calculator. So in one of my classes he will punch in things that we're talking about and show the kids so that they at least see it, which isn't very effective.

In Interview 3, she had said, "No graphing calculators . . . yes. That's an impediment. It makes me crazy!" And in the final interview, she talked about the problem once more as she held the card with this impediment's description:

Graphing calculators is still an issue. We're still trying to buy them. We've put in our budget for next year four sets of graphing calculators--two sets at eighth grade, two sets at seventh grade. I don't know if they'll go for that because it's quite an expense, and I don't know how well sharing calculators will work because it didn't work the year we shared calculators. Because you need to have them every day . . . in your room every day. . . . So it's still something I struggle with. But it's not something I can control.

The graphing calculator issue was still present, and still a focus of her concern. This impediment lay clearly outside the curriculum itself. CMP (1995) stated that graphing calculators are essential for the seventh grade program (p. 38), and Karen's school had known that the calculators were only available through the project for a limited time. The frustration the calculators' absence had produced was obvious each time it
was mentioned.

Another item in this row was the pilot books. There were mistakes in the pilot series that included typographical and computational errors, and this posed problems for students and for some parents who objected to their children being involved in the pilot of CMP. "They felt like their children were guinea pigs. And they didn't feel real comfortable with that," she remarked in the third interview. But she acknowledged that this impediment will disappear when the books are revised and published. Originally, when reflecting on the influence pilot materials had had on parents' reactions to the program she had suggested that pilot materials be placed in the highest category of concern during the card sorting activity. But in the final interview, it had moved to a lower position: "So that was a problem in the beginning," she said. "I don't think that would be so as we keep going . . . [with published materials].

The pressure to include more mathematics skills and practice had been so great that Karen and the other seventh grade teachers had decided to teach CMP Monday through Thursday, and devote Friday to skills and practice sessions. The pressure had come largely from the eighth grade teachers who were using a more traditional program. But this approach to including skills had not proven very effective. "It's not working like we wanted it to, because it's only once a week. My problem is that it's Friday . . . sometimes that's not always the best time to work on math and it's not the best time to practice a skill." She had mentioned at this time that the adoption of a new, less traditional series for eighth grade instruction would improve the situation. "Hopefully, we can abandon [the skills and practice] part of our curriculum," she said.
The skills and practice issue had resurfaced during each interview, and was expressed with varying degrees of concern. In the second interview Karen expressed some ambivalence about the time that should be spent teaching skills and practicing them. She talked about a teacher in her building who spent time on computation of fractions, and then fell behind in teaching the CMP units. She had done this because the Friday class idea wasn’t working for her students. Karen worried, "So she'll be further behind than I am, but her kids may have some skills that my kids don't have. So there's still that concern."

In the last interview, as she placed this card in the third row, she said,

> Pressure or need to teach more skills, do more practice is still there, and it's not pressure from myself. It's pressure from others. People keep saying, "Well, what are we doing about this. How are we going to make sure we have this practice built in?" . . . because we don't want the skills to go down.

It was interesting that when I gave Karen the draft of this paper to review, she chose to comment on this issue: "I do feel the need to get other things with CMP. There isn't enough practice built into the units. I supplement with dittos I create or find from other sources."

Karen mentioned "Teacher’s Own Math Background" along with "Coping With Students' Varied Responses," linking them in an obvious way. She also noted that they were both more of a problem at first.

I guess when these things were [first] happening I felt like I didn't know anything. When the kids came up with the answers that I didn't expect and couldn't figure out where they came from, I was really frustrated. Because I thought, "I should know where this is coming from, and I don't" . . . because you have to do it on the spot [here she snapped her fingers] and you don't have a lot of time with seventh graders to stand there and think about it. . . . But . . . as . . . I get

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
more comfortable, that has dropped down. It could probably be in the last row. But it is an impediment for other people looking at CMP.

This issue of math background and student responses becomes more evident when it is tied to students' written work and test taking. At the end of this section on impediments where assessment issues are discussed, the pervasiveness of these two concerns becomes more clear.

The impediments in row 3 differ from those in row 4 by the degree to which they affected Karen's ability to implement CMP. None in the third row could easily be dismissed from the card sort, nor had Karen anticipated and accepted these impediments, as she had with the "Dwindling Support of CMP Staff" in the fourth row. Mathematics background is more an issue in the third row items, teaching style is not. Although some of these cards represented problems that had persisted, such as the absence of graphing calculators, the others' influence had been more transient, such as problems with the pilot books, all of the named concerns had produced a memorable impact during the 3 years Karen had been involved with CMP.

The Second Row--Cards 16, 5, 12, 2, and 10

These impediments were of greater concern to Karen than those in row 3. Found in this row were "Loose Leaf Binder" (#16), "Transfer Students From Traditional Curriculum" (#5), "Too Much Paper Pencil Work, Not Enough Manipulatives Used" (#12), "Parent Concerns" (#2), and "Substitute Teacher's Difficulty Teaching CMP" (#10).

If this were a marriage instead of a curriculum implementation, the
second row would represent the real dangers—the threats to a continuing relationship. Here, parents, students, and substitute teachers are directly affected. There is a concern that this project may have too much work with paper and pencil and that concepts are not being modeled or built with manipulatives or activities. The loose-leaf binders that held the teachers' materials for the pilot edition were also a frustration for Karen. Sometimes she removed pages from the binder herself, and sometimes they had fallen out from repeated use. She mentioned this, and how it compromised her own need for organization several times. One incident is visible on the first video tapes; a page eludes her grasp and slips to the floor. We were able to laugh about the loose-leaf binder and its escaping pages, even though it was obviously a cause of repeated stress.

There was never any laughter about the other cards in row 2. "Oh, man!" Karen exclaimed when she picked up the card that read "Substitute Teacher's Difficulty Teaching CMP." "I should have put this up higher!" "Where does it belong?" I asked. "I have it on the last row. . . . It's probably in the second row," she replied.

As I watched her move the card from the fourth to the second row of her card sort, she exclaimed, "I didn't realize it was down there!"

That's a really big problem for me. You just can't expect them [substitutes] to come in and do this. . . . So you've got really two problems built in there. Because . . . the kids know it's busy work, and that the real teacher's not here. And the sub can't do the mathematics because they don't know all of these other things that are going to happen. And you cannot write down a script of what might happen. You cannot say, "Watch for this on this problem." It would take you too long. . . . It is just horrendous. I've tried to do that before, and you just can't.
This problem had been particularly troubling for Karen, and was first apparent during my observation of her room. Her younger daughter had been ill frequently during the school year, and Karen had been absent from school more days than usual. During the observation and a later video tape, she had to reteach lessons that had been left for substitutes, taking precious class time as the dimensions of the missing lesson pieces were explored with her students. "Substitute teaching is such a problem any time," Karen said later. "And then you throw on a difficult . . . program. It is just unreal." Karen went on to elaborate on the problem for two pages of transcript--one of the longest discussions of any impediment to implementation. "'Substitute Teachers' Inability to Do CMP Lessons' is an impediment," she had said, holding this card during the fourth interview. Number 10 . . . that's the worst. To be sick and then you have to figure out every step they're going to take!

Karen had worried about new students or those who transferred to her classroom from schools with more traditional programs. She was also concerned about many parents who were equally confused by CMP's approach. In answer to a question in the second interview, Karen noted the problems CMP posed for new students--and for her. This was in response to a question mentioned earlier in this study. To recall, I had asked: "Is CMP going to be continued at seventh grade?" Karen had replied that she wasn't sure. "We're sort of trying to decide that now. . . . I know that teachers in this building are happy with it and not happy with it at the same time." She went on to talk about transfer students: "It's very difficult for new students to come into this district, and you know, we have so many transition students right now. . . . And
they just are lost." Sometimes new students' needs are met by class review, "But," she said, "they just have such difficulty, just jumping right in." Later, as I prompted her, speaking of new students' concern: "This is . . . this is one of the" and Karen finished my sentence, "one of the drawbacks with CMP." She repeated this in our final interview. I had again given an open-ended prompt: "Transfer students are . . .?" to which she replied:

Lost. They really are. They just get lost. . . . Until you change into a new book, or until they've been here and been through three or four investigations which may take three or four weeks, they're lost. Probably a month, I would imagine.

Later in the same interview she said emphatically as she reread the card, "Transferring Students From Traditional Programs' is still a major thing." And a few lines further down she emphasized how difficult and persistent the problem had been for her.

I still struggle with that, and I think that we need to do something differently if we decide [CMP] is the way we're going. We have to come up with a plan, right away, at the beginning, and say, "The only way we'll adopt this is if there's a plan for these transfer students who come in.

"Parents' Concerns" (Card 2) were also a great concern for Karen. Parents were unfamiliar with the ideas of mathematics reform in general and with CMP in particular. Discussion of this impediment to CMP's adoption began early in our meetings. On January 23, I had met with Karen briefly to discuss my study. She had mentioned some positive and negative aspects of teaching the program. In one statement recorded in my notes she had said, "Parents struggle with it. . . . They don't have a clue as to how to help [their children]. There are not enough examples for parents to see."
As mentioned earlier, some parents felt their children should not be involved in a pilot project. Students coming from the intermediate school had been in the pilot of CMP in the sixth grade. Now, for a second year, they were part of a transition to a reform curriculum—one with some errors in the materials, and being presented by teachers still struggling with the dramatic changes in their mathematics curriculum. Parents' concerns were real, and Karen recognized that not anticipating and planning for parents' needs had made them worse. During our second interview, she spoke forcefully about these issues. Pilot curriculum and teachers' inexperience were addressed first:

I think that we should have made it clear that it was a district . . . need to get the parents on line. I understand the parent concerns. We had the group of students . . . in seventh grade piloting for the first time . . . the first time that I went through it . . . . They had also piloted the sixth grade book. So that was a real concern, because you had parents who saw these raw materials for two years in a row for their child. . . . I've heard comments from parents that . . . they thought sixth and seventh grade was just a waste as far as mathematics was concerned. . . . That is a big problem that I think we could have addressed as a district. . . . We have very vocal parents here in this district. And if they're not brought along, then it's a problem.

Karen had enjoyed access to a computer bulletin board during the first year of the implementation of CMP and, thus, the opportunity to communicate with other teachers who were using the project. She found a school system in southern Michigan that had carefully developed parent support, an effort whose importance she now realized:

I know there are solutions to parents [concerns]. I know that people in [____], Michigan, have a lot of parent support for this program, because they brought the parents along with them, and that's something that we haven't done because we felt just so overwhelmed . . . at the beginning. But people in [____] have . . . had Parent Nights. [T]hey [got] parents involved in the mathematics. And that seems to help
because then the parents see the mathematics in there, and they have done the investigations, so they can help the kids at home. . . . The parent support I know is there for other districts that we don’t have. And I think that we could get it.

There were personal accounts of parents’ discomfort. In the third interview, Karen recounted part of a recent parent conference:

Since we just had conferences, there was one parent . . . [who] had a big concern about how educated they are and how inept they feel with this program. [This] parent has said to me two or three times this year, "Well, I have a master’s and my husband has a master’s, and we can’t figure out what we’re supposed to do with these problems." . . . They want to just be able to look at the problem, pull out what they need, and help their child. And I can understand that. . . . If they took the time to try the investigation I don’t think they would have any trouble. But that’s a little bit unrealistic for them to go through, you know, 45 minutes of work before they start to help their child. So they look at it and just are . . . I don’t know if it’s intimidated or just frustration. . . . They’re frustrated because they can’t help. That’s the biggest thing.

Toward the end of the third interview, looking at the card that said "Parent Concerns," Karen said emphatically, "Parent concerns are an impediment. I still have to deal with them." In the final interview, she responded to the open-ended prompt "Parents are . . . ?" by saying, "Parents are struggling. . . . [T]hey’ll say, ‘I don’t know how to help my kid!’ And I’ll say, ‘I know! Isn’t that frustrating?’ And until we figure out how we’re going to solve it, then they’re still struggling."

CMP (1995) stressed involving parents in the implementation of curriculum in its handbook Getting to Know CMP, and provided good resources and suggestions for including parents in the project. Karen now knows this would have been worth the effort. In our last interview, I had asked her what she might suggest to another district that was thinking of adopting CMP, based on her own experience with this

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
The first thing she mentioned was parents' needs:

I know for a fact I would do more to bring the parents along, because that's been a concern since day one. And I think that we just ignored that as a concern because we had so many other issues on the table. Getting everybody else comfortable with it . . . [the] dramatic change in teaching style and assessment and everything, we were just boggled with what we had.

She went on to mention that the CMP staff itself could and probably would have assisted in this effort. "That would have been helpful, . . . and taken some of the pressure off of us. Because [at the beginning] we didn't really feel like we knew what we were talking about."

Finally, there was one issue specific to CMP itself. Card 12 read, "Too Much Paper/Pencil." Karen was as much concerned about the needs of students this age to get a chance to move and be active as they learned as she was about the value of building concepts through investigations and manipulative use that promote concept development.

As we were first exploring the things that made her either comfortable or uncomfortable as a CMP teacher in the second interview, I reviewed my notes, and then asked, "You talked about things that seem to support your comfort level with CMP. . . . I'm going to [ask] you personally. Are you pretty comfortable with CMP? . . . Would that be an accurate description?" To which she replied:

I think so. I know it's different than I used to be. I used to be more manipulative-oriented. . . . [T]here are still days that the kids are in a book with paper and pencil, and they're not up and about. . . . When we were in meetings all day today, it really hit home how long a day this is to sit in a chair. And so there would be times that I would want the kids to move more.

She went on to discuss some investigations that do involve more activities, but she said,
That's not always the case. There are days that we move. . . . But there are a lot more days when we sit and read a problem . . . and mentally work the problem, but we don't physically get up and move. And so I would like more of that. If I had more of that I would be happier.

In the third interview, Karen confirmed that this card still belonged in her sorting arrangement, and in the final interview, she discussed this problem further:

"Too Much Paper/Pencil and Not Enough Activities or Manipulatives" [she said, reading the card]. I think it's still a problem. . . . The problems are wonderful problems, but they still tend to be paper/pencil problems. This book that we're in right now is more hands-on, so it changes . . . it varies from book to book.

I responded with a second question: "If you were going to advise people about new curriculum, or if you had a wish for CMP, would addressing this problem be something you'd want?" and she replied, "Yes! Yes! . . . I used to do neat things with geometry. You know, we used to build house plans and do [things] where the kids were sprawled all over the floor, and I don't see that happening any more." She extended this response to go beyond just student activity later in this section. She talked about a time when manipulatives were becoming popular and how their use sometimes failed to connect with mathematics concepts and learning. To clarify this Karen said:

You would do these manipulative [activities], but they wouldn't have any connection to what really happened in the real world. . . . So I think you have to be careful. I don't want manipulatives just for manipulatives sake. I want them to be useful. I want them to be . . . problem solving and still doing all the things CMP does. . . . I don't know if we can build that in or not.

Karen obviously had strong feelings about this aspect of her math program. On the videotapes and during my observation in her classroom,
two of the lessons had involved students' work with data, using calcula-
tors. There had been a lot of active problem solving going on, but no
model for this activity--no physical representation of it. Perhaps, as
students were working with the population problem in North and South
Dakota, cubes or other manipulatives could have been used to stand for
units of population. These might have helped students deal with the
adjustments necessary to equalize the population of the two states.
However, all the students had been engaged and had been working dili-
gently to solve the problem. It was hard to make a judgment, not
knowing what might have gone on in this investigation before I was in
the room. Karen had attended to students' restlessness, at times, by
encouraging them to stand when they had an answer or felt they had
solved the problem. This opportunity to move and respond physically,
though not part of the lesson itself, seemed to help them stay on task.

The second row items were very important to Karen. She felt that
these five concerns, the loose leaf notebook, the problem a reform cur-
riculum posed for substitute teachers, students transferring into a reform
curriculum from traditional programs, parent concerns, and too much
work with paper and pencil and not enough use of activities or manipula-
tives to promote learning, and they interfered significantly with her
comfort in implementing the new curriculum. During our interviews we
had used the terms comfort and discomfort as we explored her feelings
about various aspects of this project's implementation. These five named
impediments contributed significantly to her discomfort. This teacher,
who had described herself as happy with the philosophy of reform cur-
riculum and pleased with the changes she saw in her students and
herself, was distressed by the burden created by these aspects of her mathematics program. Some impediments, such as the parent concerns and substitutes' inability to teach CMP might have been planned into the district's seventh grade CMP implementation. Since they had not been included, the problems remained, some 3 years into the project. The problems with the loose-leaf binder were about to fade as the CMP pilot moved toward its commercial publication. However, all of the concerns named in row 2 of her card sorting activity had had a serious negative impact on Karen's attempt to implement a reform mathematics curriculum, and continued to do so at the time of this study.

The First Row—Cards 1, 18, and 17


This discussion of the impediments to implementation of CMP concludes with those Karen felt to be most serious. There is compelling discussion of the influence of assessment, the need to finish the units, and of the need for more time to teach the project effectively. There is also a relationship among the three. Time, the over-riding concern, is a direct influence on the other two, and intimately related to the need to finish books. These two cards overlapped at the conclusion of the sorting activity and their placement defines the relationship between them. It will be necessary to choose from among many pieces of information to keep this portion of the narrative within reasonable limits.

As this paper turns its attention to Karen's concerns with
assessment, some background may be in order. The mathematics assessment with which most of us are familiar involved tests of basic skills, such as operations with whole numbers and fractions, or unit tests and cumulative tests of content at the end of textbook chapters. These assessment pieces were usually not used to inform instruction or guide students' learning. They were judgments about student achievement that were entered in teachers' records and transferred, usually as an average, to students' report cards. In instruction guided by the National Council of Teachers of Mathematics (NCTM) Standards documents, assessment has a different meaning, a different place, and is accomplished in new ways. Assessment occurs throughout and is a part of instruction. It is concerned more with the process by which students reach their conclusions than with the conclusions themselves.

The main purpose of evaluation, as described in these standards, is to help teachers better understand what students know and make meaningful instructional decisions. The focus is on what happens in the classroom as students and teachers interact. Therefore, these evaluation standards call for changes beyond the mere modification of tests. (NCTM, 1989, p. 189)

A thorough discussion of Standards-based student evaluation is beyond the scope or need of this study, but a few additions to this description may be helpful. Since problem solving is the basis for Standards-based instruction, and since diverse methods of problem solving are encouraged, teachers must be prepared to reflect on a variety of student responses. This is complicated further by the Standards call for "Using multiple assessment techniques, including written, oral, and demonstration formats . . . [and including] calculators, computers, and manipulatives in assessment" (NCTM, 1989, p. 191). Of all the changes
in mathematics curriculum and teaching informed by the Standards documents, student assessment is among the most dramatic.

By the end of the four interviews, assessment had taken its position near the top of Karen's card arrangement. It had been seriously discussed as early as the second interview, as Karen mentioned both the positive and negative aspects of assessment practices in a reform curriculum. Again, I was trying to discover what made her comfortable with this project, and she had named several things. I prompted her again: "So, am I right in saying that the evidence really points to the fact that you are fairly comfortable [with CMP]? . . . Is that a true statement?" It was here that her assessment concerns first emerged:

If you mean by comfort, do I think that the kids learn mathematics in my room? Yes. There are . . . some levels of comfort that I have. When I'm with the kids, yes. I have confidence in the materials and confidence in what I'm doing. I'm not real certain about grading every paper.

Karen went on to elaborate on the difficulties a new program with new assessment techniques has created for her:

The management of how I'm going to deal with this . . . changes from year to year. So I'm still working toward "How am I going to handle all the paper that is generated?" When you have all the students solving problems in different ways, the grading of the paper becomes a battle. . . . [Y]ou could spend hours and hours on homework.

Karen spoke of the ways she and other teachers have tried to simplify dealing with written responses from as many as 78 students, working to assess thinking as well as answers to problems. Some teachers, she said, tried giving "credit" or "no credit" grades for papers turned in, but then commented:

I tried that one year . . . but I still wasn’t comfortable with that. One of the things CMP suggests you do is a lot of
group work and grade one paper. . . . [A]t this level . . . we still have to assign individual grades. I'm not always comfortable with that. But I did try it. So the management part of it . . . how I'm going to deal with all this paper. It's something that I'm not as comfortable with.

There is a contrast drawn between assessment in a reform program, and the assessment she had done in a traditional mathematics curriculum which highlights that the reform curriculum is much more demanding: "Before it was one right answer and you could grade it. [Now I spend] hours and hours on homework." I commented that assessing homework in a traditional curriculum was something you could do while watching television, to which Karen responded:

Yes! . . . [!]t was mindless. And this has been so much more of a challenge. . . . I'll just have to keep trying and trying until I can find a way that I can handle it. The very first year I collected every student's binder . . . at the end and went through every book to say, "Did you do this investigation? Did you do this? Do you have these pages?" And it was horrendous. It took me hours! So the next time I tried [having students] give me [one] investigation at a time. And so I would collect 80 packets of this booklet, look at it and give them back, and it would take me a long time to do it.

The time it took posed problems for the students as well.

[T]he kids didn't get . . . feedback quickly enough. So that's still a struggle. This year we do a lot more grading together. . . . And that part, grading together . . . seems to be working a little bit better for me this year. There are still times when I take home too many papers. Because I just want to make sure that they're doing the work. . . . We have 78 kids on the team. And usually . . . I collect a paper every day. From every kid . . . I know there are some kids who just aren't taking careful notes or whatever. So I have to look at what they're writing down. . . . I'm still struggling with that.

As Karen continued the description of her attempt to keep track of students' progress, she used the word "struggling" one more time. She talked about CMP's urging that students be allowed to revise work, and
the additional handling of paper that creates. She acknowledged that the authors of the program are aware of this and are trying to find solutions that accommodate both the needs of teachers and the philosophy of the curriculum. However, she did not say whether there have been significant changes in the project's approach to assessment.

In the third interview, Karen talked about "partner quizzes." She said, "CMP is a strong believer in working with partners and even doing things like partner quizzes . . . and allowing revision [of work]." She found that both she and parents were concerned about partner quizzes and the effects they had on the assessment of both the very competent students and those who had greater difficulty with math. Both she and the parents questioned the outcome: What does the grade on a partner quiz represent? She found herself still "struggling":

So, you know, assessment is still difficult. I try to do more assessment just with discussion with the students. But that isn't something that I turn into a letter grade. . . . I do that for my own feeling for how this child is doing. I'll sit down and talk with them about how they solved the problem. I don't use that as a way to get their grade . . . because I have . . . a concern . . . I don't know how to do that. . . . I need to get some more training. . . . How to trust what I see and what I think that I hear a kid saying.

The third interview is also filled with discussion about assessment, and here the word "time" is linked to the problem, although it has been implied throughout the interviews. "Time," one of the last three impediments in her card sort, and the one at the highest level of that sorting, is a major factor in her assessment struggle. She spoke about having to look at students' solutions and "work the problem through the kids' eyes . . . [going] through the steps of their thinking. So you know," she said, "being . . . willing to go through all these problems, all those
different ways." When asked to respond to the open-ended prompt about assessment, Karen responded by saying "Inconvenient? Because it's challenging for me to grade all of this."

It was interesting to hear how this discussion continued. In spite of everything she had described about assessment, in the very next lines she said, "It's not all negative. I like it when I see all those different ways to solve [a problem]. So I guess I could say that assessment is enjoyable sometimes . . . when I can see all the evidence of the thinking going on," and she elaborated on the differences between the information she got from traditional assessment and CMP's assessment. Even if the answer is wrong, she said, if it is simply a "clerical error," and the student's thinking is sound, she can make better judgments about what a student knows and doesn't know: "So I can still have evidence that . . . they know what they're doing. And I'm more confident in saying, 'Well, that's not a problem that you have this . . . incorrectly [solved]' ."

Later in this interview, Karen acknowledged that one way she has coped with the question of assessment is to make up her own evaluation materials. But in the final interview, her original concerns were mentioned again repeatedly; the amount of work it takes to do good assessment, the slow turn-around time so that students don't get feedback as fast as she would like. Another aspect of the problem that she had mentioned before is brought up again. As students share their varied responses to questions, other students "tune out." "They're not attending because they've already solved it their way and are happy and satisfied with the grade they have." As she holds the "Assessment" card
during the final minutes of our interview and considers its placement, we joke a little: "All right. Take your time," I said. "I don’t know how much time you have, but the tape has plenty." We both laugh. Then she said as she looked at the card, "So we want the higher . . . the [greater] impediment at the top, right? . . . and the less at the bottom?’ Pausing for just a second she placed the card: "We’ll put assessment right at the top!"

Less was said about Card 18, "Finishing Books," but Karen felt great pressure about this part of the program. As mentioned, CMP has developed eight units for each of the three middle school grades. When we were discussing lack of sufficient time as an impediment to implementation of CMP, getting through the material and doing it well became part of our conversation. I raised something I had seen in my notes: "One of the things that I wondered about is [that] you mentioned units that didn’t get finished in sixth grade." To which she responded, "And there are some at seventh grade, too." When Karen began to discuss this topic, it occupied most of the next five pages of the transcribed interview. She began by talking about a possible solution–putting some of the sixth grade units in the fifth grade curriculum:

We were . . . looking into putting some units at fifth grade. I think . . . there are three units that we thought would be appropriate for fifth grade. And that would free up sixth grade. . . . Currently at seventh grade we have to teach the sixth grade probability and the seventh grade probability. We try to combine them. Because sixth grade doesn’t get to probability at all. . . . We have a second unit of algebra that we’ve never gotten to, and we are all dying to. It’s new material for the kids and it’s real intense, and we just can’t get to it because of the time constraints.

One of the unsettled issues for the sixth and seventh grade
teachers was that students arrived in classrooms each September with such varied backgrounds. Because the curriculum was so full, teachers omitted different things or moved more quickly through some things than others. Karen was hopeful that spreading the curriculum across a larger time-frame might help with this implementation problem.

"If we go with CMP [if it becomes the district's adopted middle school mathematics curriculum at the conclusion of the pilot project], we need to align it. So we say, "You are expected to get through these books and don't just put it aside." We think this is happening. I don't know for sure that it's happening. But I think when I look at a student and he will say, "Yes, I remember doing this. We did this all the time." And another student will say, "I never saw this book," that people are choosing to spend more time in a book and just skim through another one.

An exchange followed. Confirming what I had heard her say, I responded, "So they're not coming to you with uniform sixth grade background?" Karen replied, "No. That's what we would like to see happen." When I asked her what advice she might give to another district that planned to adopt CMP, she thought a minute, then replied:

I would probably say the first year you're not going to get through all of the books you think you will. Because of the time that it takes to do the things that we said... Sometimes it takes two days to do an assessment tool. Sometimes it takes a day just to cover homework, if the kids had difficulty with homework. So there are other kinds... of things that affect all the time issues.

It had taken time to discover that parts of the curriculum were being treated lightly, or being left out all together. It was also taking time to find ways to cope with this concern. Had the sixth and seventh grades still been located in the same building, the problem might have been recognized more quickly, and a solution applied earlier in the program. Both time and distance may have impeded the recognition and
subsequent attempt to remedy this concern.

The influence of time, or more precisely the lack of time, was so significant that it became the high card in the sorting activity. As we talked, the time factor emerged as the one with the greatest influence, affecting many of the other impediments that lay below it. An ambitious new curriculum, new methods of assessment, and teachers' other responsibilities were the origin of much of the time issue. Another very significant factor was that Karen and the other seventh grade teachers had yielded to the pressure to teach a traditional "skills and practice" approach one day each week. Twenty percent of their teaching time was absorbed by this effort. So much attention to skills and practice was at variance with the philosophy of reform mathematics, but it remains a big issue for many teachers and parents. The pressure to retain this part of a traditional mathematics program is very strong.

From the top of Karen's card arrangement, the influence of time flowed to the lowest levels of the sorted cards, affecting some more than others, but obviously a pervasive cause of concern. Not enough time became a kind of mantra—a theme to which this final discussion turned again and again.

As described previously, time was a concern for doing a thorough job of assessment. It was also the central issue in teachers' inability to finish the CMP units in both the sixth and seventh grades. In both areas, Karen and other teachers had made changes of their own to cope with time issues. Karen had made other assessment pieces for her students while she struggled to gain competence in the ones CMP suggested. The sixth and seventh grade teachers hoped that some CMP units might be
taught at fifth grade to make it possible for all of the units to be taught thoroughly. Karen reminded me that time had been a big concern at the beginning of the pilot program:

The time I spent, at first, getting to know CMP and figuring it all out . . . I had to spend a lot of time getting ready. I think that as a district if we decide to go this way, we have to build that time in for the . . . new staff . . . or even the current staff. So they can revise . . . [A]s we were looking at the new materials that we just received there have been changes yet again. And that [time] has to be there.

Karen mentioned the need for time to do the program well once it had begun:

[Y]ou have to invest more time in this than the traditional approach. I remember days before that I'd admit I wouldn't even do [preparation] the night before and [I'd] come and "wing it." It's not the best way. You can't do that with CMP. You just can't. It would fall apart.

She mentioned the time needed to inform parents and substitutes, to recognize and respond to students' questions and solutions to problems, the time needed to help new students. If CMP requires anything, it requires teacher attention to learn, to implement, to grow, and to change. Toward the middle of the final interview I had said, "You've talked about what [resources] were comforting [to you]. What else would have added to your comfort?" Karen replied emphatically. "More time. More time."

Later while placing cards, Karen had said, "I think we have to put 'Time' and 'Assessment' at the top."

In the closing minutes of our fourth interview, I was reviewing Karen's card placement with her: "All right," she said, "So 'Assessment' and 'Time' are a big thing." I asked her to look at the card arrangement one final time. She looked carefully and said: "'Assessment' and 'Time' are probably the two major things. 'Time' encompasses so much; it also

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
encompasses 'Assessment.' It encompasses 'Finishing the Books.' So maybe 'Time' is the top one." At that point Karen moved the "Time" card to the highest point in her card arrangement.

I have a closing picture in my mind. It is at the end of the second video tape of her class. Karen walks around the room energetically, answering questions, probing, restating problems. She moves to the overhead projector and solicits students' ideas, and they are written down and discussed. The pace is quick; time passes rapidly. Just watching this tape makes me feel a little breathless. There is enthusiasm here. There is a flow of ideas. But the clock is always running, and the minutes slip away. The bell rings and its sound punctuates but doesn't end the session. "Hang on," she says as students begin to gather their things. "Time's tight! I knew we would run over. I will dismiss you," and she goes on to clarify the assignment. The pressure of time--of not enough time--is everywhere in evidence.

Impediments to Adoption Noted by Other Reform Projects

During the winter and spring of 1995-96, I requested resource material from other NSF-funded reform curriculum projects. I contacted nine of them by letter or e-mail and described this study. Of each I asked for information they had generated on characteristics of their projects that both promoted and inhibited implementation. Eventually I received responses from six projects, the majority from the elementary and middle school levels. The Core-Plus Project, which developed secondary materials with NSF funding, also supplied information about its efforts.
Most of the material received had comparative data on student achievement, or on changes in teachers' attitudes about mathematics teaching after becoming involved in teaching a reform curriculum. Two were largely evaluations of workshops held by the projects for teachers in field test or pilot projects. The University of Chicago Mathematics Project and the Connected Mathematics Project supplied the most useful information, for some of it dealt directly or indirectly with implementation issues such as those recounted in this study. A review of these two supplied verification for some of Karen's concerns. The University of Chicago Mathematics Project, in its study, *Classroom Implementation and Impact of Everyday Mathematics, K-3: Teacher's Perspectives on Adopting a Reform Mathematics Curriculum* (Aaron, 1993), was very useful. They noted a number of "Adjustment Problems" (p. 17) which included concerns such as "acquiring materials," or "new terminology." However, under "Implementation Difficulties," teachers noted some difficulties that are similar to Karen's. Sixteen teachers were interviewed in this study. Nine of the teachers had taught *Everyday Mathematics* for only 1 or 2 years, but the rest had between 3 and 6 years experience. Eleven of these teachers (69%) mentioned "too much to do in each lesson--need to pick, choose and adapt" as an implementation problem. Thirty-eight percent of the teachers mentioned that there was "more preparation on the teacher's end--teacher intensive was a term used by several teachers" (p. 13). No other problem was noted by more than two participants in the study. Later in UCSMP's study, teachers responded to the question, "Are there any particular difficulties that still remain [specific to *Everyday Mathematics*]"? These persistent areas of concern
include not having necessary materials, too much content in each lesson, and not having enough time to plan and set up lessons (p. 15). Some of this may be reminiscent of Karen’s concern for time, for calculators, and for teaching all the units—"Finishing the Books"—as the card read. Many of the other items mentioned were specific to content for the early elementary grades, and would not apply to Karen’s middle school program. A later focus group’s results were reported:

They also seconded some of the interviewed teachers’ frustrations with acquiring and maintaining manipulatives and other materials which are specific and significant for the proper implementation of Everyday Mathematics (e.g., slates, calculators . . .). Finally the focus group also reported difficulty and great initial fear about not being able to get through all of the material. (p. 16)

The University of Chicago also did a study of participants in its field test of fourth grade materials (Carroll & Porter, 1994). This time 13 teachers were involved in the study. In recounting implementation problems, one stood out. After discussing "Math Boxes" and "Homework," two components of Everyday Mathematics which had posed some concern, the following issue is brought forward: "A third issue that many teachers raised was assessment. Many found the written assessments to be difficult, time consuming, and that they did not provide the teachers the information they needed (e.g., for grading) (p. 12). The report went on to detail that adjustments were made in the materials in response to the teachers’ concerns:

Because more teacher-friendly assessments seemed to be a major concern, later units attempted to provide more short assessment opportunities for teachers. . . . Whenever a less-traditional assessment was included, some teacher options were also provided in the field test. However, assessment remained, and remains, a difficult issue for a number of reasons. (Carroll & Porter, 1994, p. 13)
A central problem is named: the philosophy of reform curriculum and assessment, mentioned at the beginning of this section on impediments to implementation, is often in conflict with the fact that "in most schools, assessment remains tied closely to grading a student and teacher accountability. Later, this document continues:

Clearly the major difficulties with assessment were three-fold: Assessments did not always match the unit; assessments that relied on more than short-answer pencil-paper items were more difficult to use, interpret, and use for evaluation; [and] the philosophy of the program and school practices (grades, mastery, and accountability) were not aligned. While the first difficulty could be corrected in revision, the second depended more on teacher beliefs and practices, and the last on school and district decision. (Carroll & Porter, 1994, p. 14)

This report also noted that the median number of completed lessons for the UCSMP field test teachers was 80%, a situation that seemed analogous to Karen’s experience.

The fourth grade students in this study are reported as having had little difficulty making the transition to a reform curriculum. But the authors noted:

The generalizability of these results should be taken with caution for a number of reasons. First, the teacher was part of the field-test group and so received more training and support than might normally occur. Second, the students had been in a non-traditional mathematics curriculum which emphasized conceptual understanding [italics added]. (Carroll & Porter, 1994, p. 62)

The field test of fifth grade UCSMP materials (Carroll, 1995) had somewhat different results. Assessment was not so much an issue for these teachers, and that difference is announced but not explained in the report. However, "insufficient use of manipulatives or of hands-on experiences" was mentioned and was later included in the materials.
"Pacing" of lessons was also mentioned (pp. 12-13). Also, of the 14 teachers involved in the field test, 57% expressed a need for "more practice (especially computation)" (p. 15). This sounds much like Karen's own concern about including skills in her mathematics program.

The Connected Mathematics Project's materials did not cite research or data, but did include suggestions that addressed implementation issues. This implies that the project is acting on field test or pilot experiences. In its handbook Getting to Know CMP: An Introduction to the Connected Mathematics Project (CMP, 1995), there is a section called "What it Takes to Make CMP Work." For teachers, they suggest "help in acquiring the mathematical knowledge needed to teach these materials . . . [and] having time to plan with other teachers to share ideas, to share frustrations [as being] critical to the success of such an implementation (p. 74). For the classroom they stress that "there will be sufficient time for the class to explore problems" (p. 75). Parents' needs are addressed as well:

In a program that is new and unfamiliar, such as Connected Math Project, parent involvement and support is even more important than in traditional programs. Being proactive about keeping parents informed, and about answering parent concerns will be a long term benefit, and is worth the extra time spent at the beginning stages. (CMP, 1995, p. 75)

Karen's own concern for the need for parent involvement is mirrored by this statement. As this review of CMP and UCSMP's materials show, 10 of the 17 concerns Karen developed in her card-sorting activity are also mentioned by the Connected Mathematics Project and the University of Chicago School Mathematics Project as issues in implementation of their curriculum.
The impediments to implementation mentioned by Karen and supported by teachers in other projects do not occupy a body of literature as extensive as that on student achievement in these projects. Nor have they been given the same consideration in project evaluation as changes in teachers' attitudes and perceptions about mathematics. It is likely, however, that these impediments are an important area of study, and may just as surely help decide the fate of reform curriculum. No matter how outstanding the materials, teachers' struggle to present them; to address the concerns of parents, students and colleagues; and to deal with the real issues of time, assessment, and a thoughtful and timely delivery of the curriculum may endanger their being adopted or continued.

Scenes From a Classroom: Evidence of Impediments to Curriculum Implementation

During the 2 months that I worked with Karen, I had three opportunities to watch her teach. One of these was an hour-long observation in her room, and the other two were on video tapes which were watched and analyzed for evidence of factors that influenced CMP's implementation.

The observation and videos made it plain that Karen had described herself accurately in our four interviews. She accepted and responded to students' thinking, guiding it with questions, seldom giving a direct answer. "Look back in your notes," she would say. "What do you think?" she would ask. "What information do you have?" and "What do you need to know?" were frequent responses to students' needs for
clarification. The videos show her moving around the room, sitting with students, helping them make sense of data and questions in their books. She is open and friendly in her demand for attention to problems' structure and solution, but there is focus that Karen models and that students practice that belies the casual atmosphere.

Karen had mentioned discipline as a concern with her math classes, causing students to be seated at tables side by side, rather than in groups. However, discipline problems were not very evident during the observation or the video tapes. Although only two classes were represented in these three encounters, there was never a serious discipline problem. No one did anything even moderately disruptive. On the second tape she spoke to one child three times, but the "reminders" were spaced throughout the tape, and each was no more than a single sentence—enough to make him settle down and resume work on the lesson. During my observation of Karen's room on March 6, I had been seated next to a student who was often confused, but who remained attentive and who kept trying, and to whom Karen responded with help and positive feedback. Once, toward the end of the second tape, she had approached two boys in the back of the room. The students had been using multilink cubes as they worked out a problem related to the surface area of various three dimensional rectangular solids. She reminded them twice to put the cubes away—they seemed to be playing with them rather than recording their work. "You have the answers to 'A' and 'B' written?" she asks a little impatiently. "Show me where they're written," she demands. "Where's your writing, Joe?" she asks one of the boys. She pursues this until she is satisfied that both boys know that written
answers to "A" and "B" are necessary. This is the most serious incident in 3 hours of recorded observation.

The vast majority of the time there are no discipline problems that require her attention. Her pacing of lessons, her questions, her involvement with her students helps keep them focused. In almost 3 hours of video tape and personal observation, Karen notes and responds to off-task behavior only 15 times. The incident with the two boys recorded above is the only one that takes more than a single statement to redirect the students involved. The observer did not notice any discipline problems that were ignored. Karen's classroom might contain potentially disruptive students, but difficult behavior was not in evidence during the times I recorded her lessons.

Other implementation issues were sometimes in evidence. The observation and first video showed students who were largely engaged in paper/pencil solutions to problems which was a concern of Karen's. However, the third lesson, the one involving surface area, was all done with models built with cubes, and the only use of paper and pencil was to record results.

On the first tape there was a brief incident with the loose-leaf binder that is the pilot's teacher's edition for the unit. Karen had complained about the binders in our interviews: "The loose-leaf binders are an impediment to me!" she declared in our final interview. Later in that same interview she had said, "Loose-leaf binder is still an impediment to me. I cleaned out my file cabinet today and found little stacks of papers. And I have to figure out where they go. . . . Organization has always been a problem, I think." On the first video, the loose-leaf binder is on
the table that holds the overhead projector, and as she flips through the pages, one slips out and another is obviously being held by only one ring. We laughed about this later—the binder's contribution to the lost page problem had been clearly evident. However, the loose-leaf binder format was a feature of the pilot edition of CMP. The published edition should not present the same difficulty.

But the observation and tapes were the source that had revealed the difficulty CMP posed for substitutes. When I had observed Karen, I had noted that she had been absent on Monday, had had parent conferences on Tuesday, and tried to resume her lesson on Wednesday, but was so concerned about what had been accomplished by the substitute that she had nearly canceled my observation. She had finally decided to allow me to come because this was an example of a disruption of instruction—a real implementation difficulty. In our subsequent interview, I brought up the problem of substitute teachers and CMP: "And so I was going to ask you, would you say that having a substitute is sometimes a problem with implementing CMP?" to which she answered, "I can't believe I haven't mentioned it before now!"

This closing incident occurs at the beginning of the second video tape. Karen introduces this herself in a subsequent interview:

The second tape that you'll see is a day that I came back after a sub was here, and you'll see that I had to throw my whole lesson plan out. I hope it's evident to you. . . . Because I had a whole different lesson planned and ran a whole different lesson for two classes, came in, and the sub had not done what I asked her to do, and had to throw everything out and backtrack. And so, you have to be ready for that kind of thing as a result of the substitute being here. . . . It's just unreal.

My husband and I watched part of this tape together. He
remarked that Karen looked tired, and I agreed. As she opened this
session, she began to search for the right place to begin:

Okay, let's get started please. . . . And, since I wasn't here
yesterday, I taught Miss _____ how to draw on isometric
dot paper, and asked her to teach you. If there are concerns
or questions about that you need to make sure as we go
through today to ask me to clear that up for you. . . .

It was difficult for me to be out yesterday and know
that I was leaving you guys high and dry because I'd been
with the other hours. It was really frustrating. I didn't really
know what to do. And I'm sorry that you didn't get to use
the blocks yesterday as a tool. Today you will. . . .

Now, yesterday. Clear me up on this. You did not get
through 2.2, "Saving the Trees?" Somebody raise your hand
and tell me what you did yesterday when Miss _____ was
here. I know she taught you how to draw on isometric dot
paper, but I also wanted her to go through 2.2. This might
be a whole change in what we're doing.

A student responds to her request for information.

You just did the drawings? And you went over surface area?
And that was it? Oh [disappointedly].

Some discussion ensues among the students about what actually did get
done.

All right. Well, that sets me back a day. We were going to
have a quiz tomorrow—we'll have to see if I can work out a
way to have this class on Friday so that we can take the
quiz on Friday.

All right . . . so . . . well that changes everything for
me.

The observation and videos sometimes provided stark testimony
verifying Karen's descriptions of her implementation difficulties. These
encounters were sources of frustration and fatigue and often had a sig­
nificant impact on her effective use of time. This time the evidence was
there, not only in her words, but in her face and in the tired shrug of her
shoulders that followed her discovery of an unfinished lesson. Karen
refocused her energy and attention, changing her plans to compensate for the substitute's lack of familiarity with CMP.
ASSERTIONS

The pages of this paper have painted a picture of a dedicated teacher, of her efforts to implement a reform curriculum, and of that curriculum's many strengths. There are bright and optimistic times in this narrative; a teacher enthused about the changes in her students and in herself, a project that holds the promise of including more teachers and more students in the study of mathematics. There is a dark side to this story, however. Problems have arisen as this project was implemented at Karen's school that threaten its being continued. Her descriptions of the impediments she encountered provide an important, but limited, perspective. There must be more research on those issues that confound teachers' efforts to deliver a new approach to mathematics learning. That research must then be used to inform and guide efforts for change. In the long run, failure to understand and respond to teachers' concerns could inhibit or destroy the impetus for reform.

We must collect this information and make sure it is readily available. Every group involved in the effort to reform mathematics education needs to know about both the positive and negative aspects of project implementation. Districts need to know that teachers need a strong mathematics background to be able to deliver a reform curriculum (Ball, 1988b; Featherstone et al., 1995; Wilson & Ball, 1991). They need to train substitutes to deliver instruction when teachers are absent. They must be willing to spend the money to supply the calculators and other technology to support teachers' efforts (Burrill, 1992; VonderEmbse,
Parents need to know what is being taught and why there has been a change in curriculum, teaching, and assessment of students' progress (Pipho, 1996). Teachers need information about, and opportunities to examine, the reform projects. They need help anticipating and coping with problems common to their implementation. Teachers also need support from one another to make a project work (Clarke, 1994; Hyde et al., 1994; Weissglass, 1994). This "up front" knowledge can help groups come together in a common effort, to endure, and to succeed in providing the best mathematics education for our students.

The projects themselves should look at the information and respond appropriately. The use of manipulative models can be examined, content spread across more grades, and teachers' learning styles accommodated. Dissemination of these projects could remain in the hands of the projects' creators, and not left to publishers' sales representatives. Perhaps grantors will find monies to sustain as well as to promote curriculum reform. These funds could provide teachers with continued training and extra time for planning to facilitate the process of change.

A note of caution seems appropriate. In a study of Everyday Mathematics, the University of Chicago's reform curriculum, Aaron (1993) discussed the difficulties teachers encounter with assessment techniques that complement and enhance the new mathematics learning found in UCSMP's work. Then she said, "Although this type of information will be useful in identifying ways to smooth the transition to Everyday Mathematics in the future, it seems impossible to wholly eliminate struggle and still maintain an adequate level of reform [italics added]."
(p. 5). Not only must we solicit teachers' response to curriculum change, but we must not respond to every concern with curriculum revisions or modifications. Implementation of new mathematics curriculum is difficult. Aaron's assertion that projects may only be able to manage some of these problems and still reflect the best mathematics content and teaching practice is important, and makes mandatory a thoughtful and cautious response to teachers' concerns.

The history of American education is haunted by the ghosts of failed reforms. People committed to the vision of the NCTM Standards and convinced of their power to redirect mathematics education must take care to hear, evaluate, and respond to teachers' needs. There is so much to be learned, and perhaps very little time in which to do so.
Appendix A

List of Mathematics Projects Funded by the National Science Foundation
<table>
<thead>
<tr>
<th>Name of project</th>
<th>Directors</th>
<th>Address</th>
<th>Intended grade levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperative Mathematics Project</td>
<td>Dr. Laurel Robertson</td>
<td>Developmental Studies Center 2000 Embarcadero, Suite 305 Oakland, CA 94606</td>
<td>K-6</td>
</tr>
<tr>
<td></td>
<td>Ms. Shaila Regan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investigation in Number, Data, and Space</td>
<td>Susan Jo Russell</td>
<td>TERC 2067 Mass Avenue Cambridge, MA 02140</td>
<td>K-6</td>
</tr>
<tr>
<td></td>
<td>Cornelia Tierney</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math Trailblazers</td>
<td>Philip Wagreich</td>
<td>TIMS Project University of Illinois at Chicago 950 South Halstead, M/C 250</td>
<td>K-5</td>
</tr>
<tr>
<td></td>
<td>Joan L. Bieler</td>
<td>Room 2075 SEL Chicago, IL 60607</td>
<td></td>
</tr>
<tr>
<td>University of Chicago School Mathematics Project</td>
<td>Max Bell</td>
<td>University of Chicago 5835 South Kimbark Avenue Chicago, IL 60637</td>
<td>K-6</td>
</tr>
<tr>
<td></td>
<td>Peter Saecker</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics in Context</td>
<td>Thomas A. Romberg</td>
<td>Wisconsin Center for Education Research 1025 W. Johnson Street Madison, WI 53706</td>
<td>5-8</td>
</tr>
<tr>
<td>Seeing and Thinking Mathematically</td>
<td>Glenn Kleiman</td>
<td>Education Development Center 55 Chapel Street Newton, MA 02158</td>
<td>6-8</td>
</tr>
<tr>
<td>Name of project</td>
<td>Directors</td>
<td>Address</td>
<td>Intended grade levels</td>
</tr>
<tr>
<td>------------------------------------------------------</td>
<td>----------------------------------</td>
<td>----------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Middle School Mathematics Through Applications Project</td>
<td>Shelly Goldman</td>
<td>The Institute for Research on Learning</td>
<td>6-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2550 Hanover Street</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Palo Alto, CA 94304</td>
<td></td>
</tr>
<tr>
<td>Six Through Eight Mathematics (STEM)</td>
<td>Rick Billstein</td>
<td>Department of Mathematical Sciences</td>
<td>6-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The University of Montana</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Missoula, MT 59812</td>
<td></td>
</tr>
<tr>
<td>The Connected Mathematics Project</td>
<td>Glenda Lappan</td>
<td>101 Wills House</td>
<td>6-8</td>
</tr>
<tr>
<td></td>
<td>Elizabeth Phillips</td>
<td>Michigan State University</td>
<td></td>
</tr>
<tr>
<td></td>
<td>William Fitzgerald</td>
<td>East Lansing, MI 48824</td>
<td></td>
</tr>
<tr>
<td>ARISE (Applications/Reform in Secondary Education)</td>
<td>Landy Godbold</td>
<td>57 Bedford Street</td>
<td>9-11</td>
</tr>
<tr>
<td></td>
<td>Solomon Garfunkel</td>
<td>Lexington, MA 02173</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Henry Pollak</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connected Geometry</td>
<td>E. Paul Goldenberg</td>
<td>Education Development Center</td>
<td>8-12</td>
</tr>
<tr>
<td></td>
<td>Al Cuoco</td>
<td>55 Chapel Street</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Newton, MA 02158</td>
<td></td>
</tr>
<tr>
<td>Core-Plus Mathematics Project</td>
<td>Christian Hirsch</td>
<td>Department of Mathematics</td>
<td>9-12</td>
</tr>
<tr>
<td></td>
<td>Arthur Coxford</td>
<td>Western Michigan University</td>
<td></td>
</tr>
<tr>
<td></td>
<td>James Fey</td>
<td>Kalamazoo, MI 49008</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Harold Schoen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name of project</td>
<td>Directors</td>
<td>Address</td>
<td>Intended grade levels</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------</td>
<td>---------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Interactive Mathematics Program</td>
<td>Lynne Alper, Dan Fendel, Sherry Fraser, Diane Resek</td>
<td>Interactive Mathematics Program  6400 Hollis Street Suite 5 Emeryville, CA 94608</td>
<td>9-12</td>
</tr>
<tr>
<td>Systemic Initiative for Montana Mathematics and Science (SIMMS) Project</td>
<td>Johnny Lott, Maurice Burke</td>
<td>SIMMS Project  University of Montana Missoula, MT 59812</td>
<td>9-12</td>
</tr>
<tr>
<td>University of Chicago School Mathematics Project (Secondary Component)</td>
<td>Zalman Usiskin, Sharon Senk</td>
<td>UCSMP  Department of Education University of Chicago 5835 S. Kimbark Chicago, IL 60637</td>
<td>7-12</td>
</tr>
</tbody>
</table>
Appendix B

Cards for Contrast Questions
Used in Interview 3
The first sorting asked, "Are these impediments to implementing CMP?"

**YES: These are impediments to CMP's implementation:**

2. Parent concerns.
3. Discipline problems.
4. No graphing calculators.
5. Transfer students from traditional math programs.
7. Coping with students' varied responses and answers to problems.
10. Substitute teachers' inability to do CMP lessons.
12. Too much paper/pencil, not enough activities or manipulatives.
15. Pressure or need to teach more skills--do more practice.

**These are not impediments:**

1. Assessment.
6. Dwindling support from CMP staff.
8. You can't just pick up the book and teach a lesson.
9. Negative responses from high school teachers about CMP.
11. Problems with the pilot books (errors, other).
13. Teachers' learning styles.
14. Teachers' own mathematics background.
The second sorting asked for personally meaningful categories.

These are major problems:

1. Assessment—At first said not to be a problem. When I added the word "time"—the time it takes to do assessment, Karen changed her mind. She mentioned time as a student factor as well.

5. Transfer students from traditional math programs.

10. Substitute teachers' inability to do CMP lessons.

11. Problems with the pilot books (errors, other). Initially, she had eliminated this one. But on reconsideration, it becomes a major problem also.

These are "sort of a problem"—medium importance:

2. Parent concerns.

4. No graphing calculators.

12. Too much paper/pencil, not enough activities or manipulatives.

15. Pressure or need to teach more skills—do more practice.

These are "not very much of a problem"—minor importance:

3. Discipline problems.

7. Coping with students' varied responses and answers to problems.

Third Sorting

The third sorting resulted in "problems I can fix," and "problems that others need to help me fix or must fix without my help."

**These are easily fixed problems—ones for which she needs no help:**

1. Assessment.
3. Discipline problems.
7. Coping with students' varied responses and answers to problems.
12. Too much paper/pencil, not enough activities or manipulatives.

**These problems are more difficult—ones for which she needs help:**

2. Parent concerns.
4. No graphing calculators.
5. Transfer students from traditional math programs.
10. Substitute teachers' inability to do CMP lessons.
11. Problems with the pilot books (errors, other).
15. Pressure or need to teach more skills—do more practice.
Appendix C

Approval of the Human Subjects Institutional Review Board for This Study
Date: January 10, 1996

To: Lynn Royer

From: Richard Wright, Chair

Re: HSIRB Project Number 96-01-06

This letter will serve as confirmation that your research project entitled "Implementing resources for reform: one teacher's experience with a new "Standards-Based" mathematics curriculum" has been approved under the exempt category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you must seek specific approval for any changes in this design. You must also seek reapproval if the project extends beyond the termination date. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: January 10, 1997

cc: Richard Harring, EPD
BIBLIOGRAPHY


Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.


