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TAKING COLLEGIAL RESPONSIBILITY FOR IMPLEMENTATION OF STANDARDS-BASED CURRICULUM: A ONE-YEAR STUDY OF SIX SECONDARY SCHOOL TEACHERS

By

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ABSTRACT

TAKING COLLEGIAL RESPONSIBILITY FOR IMPLEMENTATION
OF STANDARDS-BASED CURRICULUM: A ONE-YEAR STUDY
OF SIX SECONDARY SCHOOL TEACHERS

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Curriculum that moves from traditional teacher-centered and technical skill proficiency to student-centered inquiry-oriented instruction is a primary component in the reform of mathematics education. While curriculum developers design materials that conform to the standards set out by the National Council of Teachers of Mathematics, we need to know more about the classroom implementation of such radically different materials.

This study examines what happens when experienced high school mathematics teachers take collegial responsibility for sincere and earnest implementation of a new standards-based curriculum. The study explores the major differences between the curriculum materials of a traditional algebra course and the Core Plus Mathematics Project. It investigates the challenges teachers faced with the instructional model, and issues that affected timing and pace of instruction.

DEDICATION

This work is dedicated with love and appreciation to my husband, who never faltered in his support and encouragement throughout all of my endeavors and to the memory of two gifted teachers, my father, and my mother.

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A number of people helped to make this work possible and to each, I wish to say thank you.

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CHAPTER 1

INTRODUCTION

The Problem

The National Council of Teacher of Mathematics (NCTM) produced three documents concerning reform. The *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) and *Professional Standards for Teaching Mathematics* (NCTM, 1991) recommended content and pedagogy to bring about improvement in the teaching and learning of mathematics in schools. The *Assessment Standards for School Mathematics* (NCTM, 1995) helped to define ways to know what students have learned about mathematics. These three documents articulated for teachers and school personnel what should be taught, what would characterize instruction, and what students were expected to know and be able to do.

The vision of reform took on a scope broader than merely defining objectives and offering instructional practices. Solid curricula, knowledgeable teachers, policies that support learning, access to technology, and commitment to meaningful mathematics education for all students continue to be high priority goals for mathematics reformers. The underlying assumption in the reform movement was that continued improvement in curriculum and instruction would make meaningful mathematics accessible to more students. Furthermore, students who became mathematically literate would be better prepared to live and work in a technologically oriented society. The goals and objectives of the reform movement in mathematics education have a clear objective – an assault on mediocre mathematics instruction and marginal mathematical knowledge for our children.

Responding to the reform envisioned by the NCTM standards documents, publishers revised existing textbooks, produced new ones, and then marketed them as aligned with the NCTM standards. In addition, groups of mathematics educators created completely new and innovative material that restructured the scope and sequence of the content and redefined the pedagogy of mathematics instruction. These curriculum development projects incorporated an instructional model where students investigate and explore mathematics in a fashion quite different from traditional teacher-centered instruction.

Teachers and school systems had several options to consider regarding their mathematics programs instruction following the first NCTM standards document (1989). They could: 1) do nothing, and as such continue to use existing textbooks, 2) amend and revise current curriculum to align with the content outlined in that document, 3) replace old textbooks with new ones that would accommodate reform recommendations, to varying degrees.

When schools and teachers elect to change to curriculum, which embodies the vision of the new standards, unprecedented challenges emerge. Anderson (1995) addressed the difficulty teachers could be expected to encounter as they make the transition from the source of knowledge in a classroom to the facilitator of learning. Ball (1996) concurs and goes further to assert that the change will be difficult, takes considerable time to accomplish, and will not occur simply because a teacher decides to teach differently.

The community of mathematics educators not only is involved in the development of curriculum, but has the responsibility to document reform as it occurs and make recommendations for professional development of teachers (Ferrini-Mundy and Graham, 1997). There are elements related to teachers and teaching that might be expected to encumber educational reform.

Teacher and student school history and experience make them resistant to change. Lortie (1975) fully describes how our years of schooling, our "apprenticeship of observation," firmly imbed images of teaching and learning. Schools are complex social structures where an obvious intervention such as new curriculum, can produce results that are not always obvious consequences of the initial change (Anderson, 1993). The change from listening to a lecture on algorithm and procedure to conducting mathematical inquiry is an example of an initial change that may result in student behaviors that appear to be unrelated to the change in instruction.

When teachers make significant changes in practices and procedures, they need support, continuing professional development, and collegial collaboration time (Anderson, 1995; Crawford, 1993; NCTM, 1989; NCTM, 1991). The teaching profession has been characterized by isolation and individual effort. Today many teachers work together in immense urban school buildings, however, they are still isolated from their colleagues. Lortie (1975) also describes the limitations of the school environment that impede teachers from sharing experiences and relying on each other for support and information, in spite of how collaboration and conversation between colleagues might benefit them. Teacher preparation does not often model collaboration and collegiality. Consequently, on-the-job learning is often a singular effort. It is challenging to overcome the separation obstacles and use a community of teachers for support and professional growth.

Teachers interact directly with the students. They have the autonomy to interpret and implement curriculum materials according to their experience and make judgments regarding appropriate adaptations for their students. These "street level bureaucrats" hold the key to the delivery system. Teachers must be recognized as a powerful and necessary tools for implementing change (Lipsky, 1980, Crawford, 1993).

In the best of possible worlds, teachers would create customized learning plans for their individual students. They would assess needs, plan lessons and carry them out (Kerr, 1981) connecting new learning to students' prior experience (Dewey, 1938). A rich and meaningful curriculum, appropriate for individual students is certainly desirable, but developing such a curriculum is a daunting task for a group of math educators who focus solely on that task. A teacher with five classes, two or three different preparations, and as many as one hundred and fifty students is at a grave disadvantage to create one hundred and eighty lessons designed specifically to meet the needs of their own students each year. Thus, teachers use curriculum materials that were created for a range of classrooms.

In doing this, they relinquish the ideal of meeting individual needs in that the curriculum developers have made the choices with regard to content and method. Teachers, in turn, interpret and implement what they have in hand. The tasks and learning experiences were not designed specifically for individual students and classes but for classes of *average* students. When necessary, teachers modify curriculum materials to meet the needs of their students or to fit within the boundaries of their teaching expertise and level of comfort. Teachers find themselves in the proverbial *Catch 22*. The curriculum materials may not effectively accomplish their stated objectives when modified to meet the need of their students, but the materials will not work in classrooms with specific students without adaptations.

Students are as resistant to change as teachers and would prefer the familiar patterns and procedures of a traditional mathematics class rather than one that is focused on teaching for understanding (Anderson, 1993, Ball, 1996). The inclination for teachers to rely on instinct, experience, and established methods in the face of uncertainty is strong (Anderson, 1993, Ball, 1996, Preston and Lambdin, 1995). Tension can occur when teachers feel that the constraints of curriculum and their commitment to reform conflict with their personal judgements and experience.

New curriculum in the hands of seasoned teachers might be expected to function exactly as the authors intended. It would be reasonable to expect that because mature teachers bring experience to the classroom they would not be expected to be intimidated by new pedagogy or content. However, research shows that even veteran teachers have concerns regarding new curriculum and pedagogy (Friel and Gann 1993). The question "How will this affect me?" hovers in the minds of teachers as they anticipate using innovative new curriculum in their classrooms. We need to be able to provide better answers for teachers regarding that question. In their work with schools and reform, Fullan and Miles (1992) conclude that if teachers were cognizant of the problems inherent in the use of radically different curriculum and had the opportunity to think about how new practices impact their classrooms, they might be better able to anticipate and avoid significant classroom problems and obstacles. There is a need to study what happens in classrooms and to communicate the issues to others who will follow their endeavors.

The Purpose of this Study

The purpose of this study was to document the use of a newly developed, standards-based, and research-based set of curriculum materials and to determine the central problems and issues associated with its use in classrooms by several teachers. The larger educational community of curriculum developers, teachers, school personnel, and teacher educators can benefit from specific knowledge about reform in practice.

Many questions need answers regarding what happens when teachers embrace reformed curriculum materials. What parts of the planned curriculum work as anticipated with students? What parts are problematic? What do teachers need to know before embarking on implementation, and how can schools and educational institutions support those changes that practitioners must make in established practices and procedures?

The Core Plus Mathematics Project (CPMP) was one curriculum development project that designed materials to embody the NCTM vision of reform. In 1992, it was one of four secondary curriculum development projects to receive 5-year funding grants from the National Science Foundation. The CPMP mathematics educators worked to design, test, and revise high school curriculum that would be consistent with the vision proposed by the *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) and the *Professional Standards for Teaching Mathematics* (NCTM, 1991) recommendations. This project produced a radically different and comprehensive set of curriculum materials for secondary schools.

CPMP approached mathematics as a connected body of knowledge, not a series of facts and procedures to be memorized and technical skills to be mastered. They reorganized the traditional mathematics into integrated courses wherein the content and the configuration was completely different from traditional high school mathematics scope and sequence. The curriculum provided a three-year common core of mathematics for all high school students and a fourth year course which continued the preparation for college mathematics. The curriculum emphasized mathematical modeling and each year featured the strands of algebra and functions, geometry and trigonometry, statistics and probability, and discrete mathematics. These strands were connected via fundamental themes, common topics and habits of mind (Hirsch and Coxford, 1997). The CPMP curriculum provided students and teachers the materials with which to engage in mathematical inquiry. The investigations offered a meaningful way to learn, to understand, and to use mathematics in real world contexts.

So little time has passed where reformed curriculum materials have been widely used in classes with large numbers of students. We need to know more about what teachers and students experience in classrooms with standards-based curriculum materials. Harvey and Charnitski (1998) acknowledge that the task of modifying the roles in classrooms and monitoring the changes will be a formidable assignment. Preston and Lambdin (1995) studied several teachers who began and then dropped out of a field test of reformed middle school mathematics materials. They question if the reform is workable for all teachers.

The challenges for teachers who strive to make changes and improve their practice are complicated. Anderson (1995) documented a tension between the image teachers have of reform and what they can actually achieve. He also noted that the shift from source of knowledge to facilitator of learning is problematic in many ways. However, he did not articulate specifics. Teachers have questions regarding what they might expect in their own classrooms, which remain unanswered. He identified barriers to reform, including the difficulty of learning new roles. The teacher learns the role of helping students take responsibility for learning, and students learn to overcome passivity and instead become proactive learners. It will take time for the teaching and learning of mathematics to change (Anderson, 1995; Ball, 1996; Ferrucci, 1997).

This study seeks to examine the nature of change in the context of new curriculum and to identify essential elements that will make future adoption of reformed mathematics curriculum easier and more effective for teachers and learners.

CHAPTER 2

METHODOLOGY

Introduction

This study examines what happens when experienced high school mathematics teachers take collegial responsibility for sincere and earnest implementation of a new standards-based curriculum. It grows out of a five-year school improvement project aimed at raising the achievement level of mathematics students, particularly those students taking the equivalent of a first year algebra course.

The study was originally conceived to examine a broader question: What does it look like from the inside, when teachers implement a reformed curriculum in ways they believe the curriculum developers intended?

Subsidiary questions. Embedded within the primary question are several other areas of interest that helped to frame the study and the analysis of data.

- What happens when the teachers try to implement the inquiry-oriented instructional model of classroom organization?
- To what extent do student tasks and the classroom organization work together to support the instructional model?
- What influences the choices professional educators make when using new curriculum materials?
- What impact might modifications and adaptations of the curriculum materials have on their ultimate effectiveness with students?

Design of the Study

This study followed teachers through the first of a five-year mathematics curriculum improvement plan. It looked at some of the issues that arose when a group of teachers used new and innovative materials with students. The study explores the major differences between the curriculum materials of a traditional algebra course and the Core Plus Mathematics Project. It investigates the difficulties teachers had with the instructional model, and issues that affected timing and pace of instruction.

The study was designed to investigate, from an insider perspective, issues that arose using the reformed CPMP mathematics curriculum materials in secondary school classrooms. It was not designed to measure student achievement using reformed curriculum material, but to investigate what troubled teachers as they used the materials and to make recommendations for future implementation efforts.

Participants and Setting

This study of teachers implementing reform curriculum in a secondary school looked at six experienced teachers and their work during the first year of implementation of Core Plus Mathematics Project materials.

Northwest is a suburban Class A high school with a student population of approximately fourteen hundred students. The student body is a rich mix of culturally diverse students of moderate economic background. The majority of the student population is college intending.

Six, out of thirteen, teachers in the mathematics department at Northwest High School volunteered to teach the new curriculum. They made a commitment to work toward implementing the materials as the curriculum developers intended them. These teachers were personally and professionally motivated to make the move to reformed mathematics curriculum and instruction. An honest effort was made to follow suggested class structure and organization as well as the scope and sequence of the Course 1 curriculum materials.

All teachers had isolated experience using inquiry-oriented lessons, but no one had practiced continuous use of discovery mathematics. In our district we had reviewed and revised our course syllabi following the release of the NCTM Curriculum and Evaluation Standards (1989). We inserted standards-based lessons where topics were omitted; however, we had not had the opportunity to teach a whole curriculum that had been designed to conform to the NCTM Curriculum and Teaching Standards (1989, 1991). A summary of the participants' experience and credentials is in Table 2.1.

Table 2.1 Teacher Participants Experience and Preparation

Teachers	Lea	Kay	Tia	Ted	Ed	Ruth
Years of Experience	15	24	29	33	13	24
Degree	BA	BA, MEd	BA, MEd	BS, MS	BS, MS	BS, MEd
Major	Math	Math, Math Ed	Math, Math Ed	Math, Math	Math/ Physics Math	Math, Math Ed

During the 1995-1996 school year, the teachers who were using the CPMP curriculum were also granted one day of released time each month for professional development. On this day, we worked collaboratively on issues related to the implementation of this new curriculum and we were free to set the agenda according to our needs.

The motivation to change curriculum. The success rate of students in the high school curriculum at Northwest was much less than desirable. The students having trouble with secondary mathematics curriculum were found in a variety of other traditional mathematics courses offered at the school. The failure rate in Algebra 1 and in the Preparation for Algebra courses was the catalyst for curriculum improvement.

Previously, our plan to solve the "lack of success" problem had been to offer courses which revisited the prerequisites, to slow the pace of instruction, or both. We found textbooks readily available which provided the curriculum materials that suited those goals and we offered classes that stressed traditional prerequisites for algebra. We taught two courses, which divided the basic content, giving students several years to gain the requisite computation and number skills before attempting traditional Algebra.

This group of students saw little connection between mathematics and real life situations and had very little interest in mathematics. These classes had significant discipline problems, and were not prepared for the rigor and pace of a traditional algebra or Euclidean geometry course.

We added a basic, plane geometry course to the course offerings for students who attained marginal success in Algebra. This course slowed the pace of formal geometry, eliminated three-dimensional figures, and minimized the attention to proof and organizing mathematical evidence. Thus, we had created a track of mathematics courses that sorted students based on their computational ability when they entered high school. The high school graduation requirement, two credits in mathematics, could be satisfied by what was essentially two years of middle school mathematics.

In essence, students were studying pre-algebra and middle school mathematics topics in the two-year sequence. Even so, they were failing these classes at an alarming rate; sometimes as many as 60% of the students were unable to demonstrate a marginal level of proficiency in their respective courses.

A team of four (two teachers, a counselor, and the principal) from Northwest participated in the Algebra for All program during the 1994-1995 school year. In this program, we learned about alternate curriculum and instruction designed to provide all students the opportunity to learn algebra. We formulated a plan for our school to improve its mathematics program and student performance. Our plan included finding a standards and research based curriculum to replace traditional first year Algebra, and to continue in subsequent years adding courses which were consistent with the first course offering. The selection and implementation of new materials was part of the five-year plan presented to the Algebra for All groups in the early spring of 1995. Immediately following this presentation, we began a search for suitable curriculum materials.

<u>Selection of the Core Plus Mathematics Project materials.</u> A committee of teachers from Northwest investigated alternative curriculum options in our search to replace traditional Algebra with new and reformed math curriculum. Several textbooks, advertised as both integrated and NCTM standards-based, were considered in addition to the National Science Foundation funded Core Plus Mathematics Project materials.

We arranged a hands-on workshop to investigate further the CPMP materials, which was our first real encounter with the inquiry nature of the curriculum. The selection committee teachers participated in a half-day teacher in-service wherein we were provided with a copy of a sample lesson on slope, grouped in fours, and given a time limit to work together. We were asked to engage in the task as if we were students. Our instructor modeled the CPMP teacher role, by walking from group to group, observing our work, listening to questions and comments about the lesson, and reminded us of time limitations for the task. There was a progress-reporting portion of the lesson, which occurred following the investigation. This sample, a mid-year lesson from CPMP Course 1, gave us a concrete example of the inquiry model in action, an innovative approach to a familiar topic, and an image of how our mathematics classes might look.

We were favorably influenced. We were convinced that engaging students in an inquiry-based mathematical curriculum like this one, would lead to improved performance and interest in mathematics. We wanted the learning environment to change as well as the curriculum offerings. The committee wanted to adopt a curriculum in which computation skills would not be the filter used to keep students out of classes where meaningful mathematics was studied by all students. The selection of CPMP curriculum materials was made in the spring of 1995. We planned to place all students recommended for Algebra in CPMP Course 1. In addition, many students who were recommended for the low-level mathematics classes would be placed in CPMP. We believed the CPMP curriculum, designed for heterogeneous groups of students, would offer more of our students access to mathematics.

Northwest asked to be included as a field-test site in the Core Plus Mathematics Project. Near the end of May 1995, we were added to the study as a secondary site and given permission to purchase the field test version of the materials. In addition, we were offered the opportunity to send two teachers to an intensive two-week training session in the subject matter and pedagogy of the materials. We ordered the student and teacher materials for the fall opening of school and looked forward to launching our improvement plan.

Tia and Lea represented Northwest at the summer training institute at Western Michigan University. At this workshop, they received instruction on the subject matter included in Course 1, and information about the teaching techniques and classroom management styles needed to use the materials. These two teachers were our primary *human resource* as we began the school year. They continued to provide direction and offer suggestions throughout the year.

The six teachers in this study gathered together one day before the start of school. We intended to use this day in order to learn what we needed to know to begin our classes.[1] The four of us who had not attended the summer session listened as Tia and Lea described their learning experiences where they participated as students in the CPMP instructional model, an environment we attempted to recreate.

On this day, we determined we needed a clearly defined grading policy, one that would detail the important aspects of the new program for our students and explain how they would be assessed using this new model of instruction. Our initial planning was done with cooperative learning in mind as the keystone of class operation and our grading scale included holding students accountable for group participation, as well as the traditional homework, class work, quizzes and tests. Students who began school in the fall of 1995 expected a traditional algebra

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[1] In retrospect, we did not understand how much there was to learn about implementing this curriculum. A single day was scarcely enough to absorb the organization of the materials.

class but found the course and title changed to a new and unfamiliar class called Integrated Mathematics.

There were thirteen sections of CPMP Course 1 offered during the 1995-1996 school year. This included a population of approximately three hundred and fifty students in grades nine through twelve. However, the classes were comprised primarily of ninth grade students. The mathematics background of these upper class students in the program might have included either the Preparation for Algebra part 1 or 2, traditional Algebra, or all three courses.

Gaining Access

As one of the six teachers, I had the opportunity to initiate an ethnographic study of a curriculum improvement project as it evolved. Central administration in the district had a history of supporting of reflection and research. Consequently, the building principal readily gave permission for the study to take place. This was the perfect opportunity for a naturalist study of teachers at work. I expected there would be challenges when teachers attempted to make such a drastic change in both curriculum and pedagogy, but I had no preconceived notions of what might be the findings of the study. I went into the project with the intent of documenting the changes and challenges, knowing that I would be one of the teachers faced with making those changes and facing those challenges.

Hammersley and Atkinson (1983) caution researchers to design studies that avoid the researcher influencing the culture they study by their presence. In addition, they suggest that researchers learn the culture that they study. I was an established member of the community, had the good fortune to have a long standing collegial relationship with the other participants, and had been part of the subcommittee which designed the curriculum improvement plan we were implementing. I was an insider. Consequently, an important aspect of social research – reflexivity - was built into the study.

I am confident that my position and standing in the school did not compromise the data I gathered. I was an equal member of this group of teachers. I had no more or less experience with the curriculum materials than the others. We worked collaboratively to find solutions to our difficulties and I freely shared my classroom problems and possible solutions with the other teachers. There was no status or stigma attached to my position as a researcher taking notes; it was common practice for me to record the essential points at meetings in my role of department chairperson. I was not the principal teacher in the group and deferred to the designated lead teacher as moderator for the professional development sessions.

My position as researcher-observer-participant in this study might have been hampered by my role as the chairperson of the department if it had been defined differently. However, the position is not an administrative post in this school district, but a liaison between teachers and administration. As such, my primary function was to facilitate the teaching environment for the other members of the mathematics department. There were no teacher evaluation responsibilities attached to the department chair duties, therefore no concerns amongst the other participants that sharing classroom difficulties would result in any negative judgment or sanction.

Methods of Data Collection

Data for the study included:

- **Field notes**. I took field notes during the professional development sessions where all participant-teachers were present. The dates of these days are located in Appendix A.

- **Reflective journal**. I entered my reflections following informal conversations with small groups or individual teachers over lunch, in the hallway, in our classrooms or offices before or after school in a journal. This journal also contained my personal reflections and concerns, as well as patterns I noted as the year unfolded. I did not have a regular schedule to make journal entries, but instead did so when I had events or issues that seemed significant or confusing. Dates of journal entries are located in Appendix B.

- **Audiotaped discussions**. I audiotaped and transcribed three one-hour group discussions on April 16, May 7, and June 4, 1996 when all the participant teachers were present. My field notes served to provide an accurate record of our professional development meetings. However, I elected to tape the discussions to allow myself the freedom to participate in the discussions as we reflected on our work. Moreover, progress we were making in the curriculum and the success of the students were animated topics of discussion at this point in the year. I felt an audiotape would capture more of the discussion than I could manage by hand.

- **Chronological record**. I retained a teacher lesson plan book for the school year, which provided a chronological record of the assignments and activities in classes throughout the year.

- **The *Core Plus Mathematics Project Course 1*** curriculum materials, including student materials, teacher notes, and ancillary materials.

- ***Algebra 1:An Integrated Approach*** student text, teacher edition, ancillary materials. McDougal, Littell, 1991

Methods of Data Analysis

Analysis. Bogdan and Biklen (1982) offered data analysis suggestions, which I employed. I arranged the field notes, journal entries, and transcripts in chronological order and reviewed these side by side with the lesson plan-book in order to keep the data coordinated with the topics we were studying and our progress through the curriculum materials. I looked for words, phrases, and conversations that seemed to center around common themes or issues. There were also many references to classroom behavior problems, inordinate amounts of paper work, teachers overwhelmed by what was happening in and outside of class, and the lack of progress we were making in the curriculum. There were many references to the ever-increasing stack of papers to correct. Furthermore, there were references to students copying each other's work and cheating on tests.

After the initial review of the data, I coded separate artifacts with key words or phrases. I selected code words that attempted to capture the essence, such as *grading, making sense (of mathematics), behavior problems, curriculum conflict, traditional, no progress, teaching-telling, groups, technology, resistance, cheating.* The smaller topics seemed to funnel into clusters, which organized into categories (Bogdan, Biklen, 1982). After gaining a sense of how the issues aggregated, I attempted to determine the frequency of the many issues. I color coded and used file cards to record dates and categories.

Many aspects of our work were important to share. I struggled to select only a few to address; however, predominant themes emerged. The radical difference in the materials, the complete change of classroom protocol, and the fact that we had taught only slightly more than half of the curriculum in one school year became the critical points to consider. I focused on these areas, in search of a way that they might be connected.

Recurring comments regarding how different things were for students prompted me to look carefully at the ways the old and new curriculum differed. I analyzed the curriculum materials by comparing the explicit and implicit instructions for teachers and the organization of their classrooms and the learning goals for students inherent in the two curricula. To take a snapshot of specific differences I isolated similar content and compared the tasks for students within similar assignments. Finally, I compared student expectations via assessments from each curriculum. The differences became clear when the same standards were applied to each.

The instructional model had cooperative learning as a central feature. There were problems with the size, selection, roles, and productivity of groups. I considered when these difficulties occurred chronologically and referenced those dates with the lesson plans to connect a particular difficulty with a specific classroom activity.

I examined the problems we had making progress in the curriculum, and connected that to the countless references to how much time it took for students to carry out the investigations and the time it took us to read and grade their papers. Again, I considered the references to pace of instruction along side the chronological record of class and homework assignments.

As I began to construct the paper, I attempted to organize my thoughts and the paper in outline form as suggested by Booth, Colomb, and Williams (1995). I found it difficult to avoid the pitfalls about which they warned. It was difficult to attain a sense of distance from the events of the year and assemble appropriate evidence to support my assertions. It was hard to refrain from telling the story as it was because I lived it along with my colleagues. I went though the frustration, disappointment, and anxiety that the others experienced and it was hard to maintain the objective perspective a researcher needed. The evidence I presented in the first drafts of the paper was inappropriate. It occasionally represented my personal experiences and beliefs, but I had experienced it and my belief were part of the data. The conflict between the experience and objective observation was the essence of the dilemma that I had presenting the story of the teachers and their work. I had the advantage of being an insider and an accepted member of the community. I gained access to the day by day efforts of the teachers. I learned what they actually felt about their work – its successes and failures. I gained insight that an outside researcher might not have been able to obtain. However, it was difficult to obtain distance from the data and maintain the objectivity needed to analyze it. I had lived the year with the challenges, excitement, successes, and failures. My researcher-participant role was a double-edged sword which cut two ways through the gathered data.

I used teacher perspective as a framework to structure the writing. I examined and compared the reformed and the traditional algebra materials the way a teacher would view them. Next, I considered how the learning environment would be organized around cooperative learning. What would the teacher and students be doing? Third, what determined the pace at which teachers moved from one topic to another? Accessing understanding via students' written and oral work was difficult and time consuming to execute with this new curriculum. The paper presents a teacher's perspective on the challenges of implementing reformed curriculum.

A Preview of the Dissertation

In the first chapter, I outlined the problem of implementing reformed curriculum that differs radically from the instructional culture mathematics teachers and learners had previously known.

In this chapter, I positioned this study within the context of implementation of reformed curriculum in a secondary school and described the ethnographic nature and specifics of the study. I oriented the reader to our problem, my colleagues and their workplace, the design and methodology of the study, and the challenges of analyzing the data.

In Chapter 3, I illustrate just how different the standards-based, inquiry-oriented CPMP materials were from what the teachers had used for the majority of their experience. The fundamental differences between the two types of curriculum set the stage for understanding the problems and concerns we faced using them. Three NCTM documents on curriculum, teaching and assessment (1989, 1991, 1995), and the new Principles and Standards for School Mathematics (2000) guided my thinking about what curriculum materials ought to provide for all students in mathematics classes.

The structure of the lessons, the way students would interact with the mathematics in their classes, and the different expectations for teacher and learner are presented. Hawkins (1974) addressed the triad, teacher – student – subject matter, and the important relationship that exists between the three. Belenky, Clinchy, Goldberger, and Tarule (1986) described different ways of knowing and offered a way to think about how students gain knowledge connected to the ways students and teachers interact. These individuals helped me present the subject matter, the students, and their teachers in the context of the radical differences.

The NCTM Professional Standards for Teaching (1991) characterized worthwhile mathematical tasks. The Standards did not provide a means by which to objectively classify and compare the tasks. I needed an impartial set of categories to place the tasks of the two curricula side by side and objectively compare the types of tasks for students. The Balanced Assessment for the Mathematics Curriculum (1999) provided vocabulary to identify categories that characterized the tasks and facilitated sorting. The balance among the mathematical processes and important ideas is presented in this chapter. These task dimensions provided a lens through which to organize and compare the activities in which students would engage and to illustrate more clearly how the types of tasks for students in the two curricula diverged. Jackson's (1986) perspective on mimetic and transformative learning further crystallized the difference between the expectations for learners in ALG and CPMP.

Meaningful and worthwhile mathematics tasks translate into authentic tasks (Lajoie, 1995) where knowing math implies being able to do math. She speaks of knowledge evolving out of the opportunity to engage in tasks that are challenging yet solvable. I looked at the curriculum printed materials for students and teachers, and was mindful of the worthwhile nature of the tasks. In Chapter 3, I represent altered teacher role, the new learning goals for students, and the radically different learning environment. The changes we attempted to implement seemed challenging, yet doable.

Were some aspects of the CPMP instructional model more problematic than others? In Chapter 4, I explore the issues and problems we encountered in implementing the specific cooperative learning model prescribed by the CPMP materials. I explored cooperative learning theories and found there is much to support the positive effects of collaboration by students as they learn. Early scholars like Dewey and Piaget informed the learning communities about the connection learners make to prior knowledge and the ability of children to construct knowledge as they work with tasks and challenges. Later scholars such as Vygotsky (1978) and Lakatos (1976) addressed the social nature of constructing knowledge through conversation and arguments with peers, and the need to justify and prove via interaction. I describe the problems we encountered as we were thrust into cooperative learning for all class activities.

What was it about the CPMP curriculum that demanded so much time? We all worked very hard but found it very difficult to feel that we had made much progress. In Chapter 5, I explore the problems teachers had with knowing what students had learned and with the pace of instruction. Here, I found Lampert's (1985, 1990) writing helpful to identify the dilemmas we encountered as we tried to manage classrooms and students. Her examples helped me to depict the difficulty we encountered related to problems and questions, solutions and answers. I describe the conflict between what we expected and actually accomplished and obstacles which hampered our progress.

In Chapter 6, I use the findings of this study to lay out some suggestions for other teachers who might embark on implementation of standards-based, inquiry-oriented curriculum. I address what teachers need to know in order to achieve greater success with inquiry-based instruction. I offer suggestions to scaffold and support the efforts of teachers and schools who undertake implementation of standards-based curriculum. I also share the status of the five-year curriculum improvement plan of Northwest High School. In conclusion, I identify questions and areas for further research and study related to implementing reformed curriculum in mathematics classrooms.

Appendices and references follow the final chapter.

CHAPTER 3

JUST HOW WAS IT DIFFERENT?

Introduction

At first glance the textbooks looked very different. The CPMP materials were organized and presented in a way that differed from traditional textbooks. No boxes for important examples and no end of unit content summaries were evident. The typical answers to odd-numbered exercises in the back of the book were missing. Instead of carefully explained development of big ideas in the text accompanied by worked examples, there were investigations for students which embedded those big ideas in the context of real world situations and left the development and formulation of the mathematics to the students.

This radical difference of the CPMP materials presented challenges for us as we used the materials with students. To better understand the challenges, it is necessary to look closely at what was so different about the materials that shaped our work.

To illustrate how fundamentally different the two were, I describe and compare the printed materials which we had employed since 1991, *Algebra 1: An Integrated Approach* (Benson, Dodge, Dodge, Hamberg, Milauskas, Rudkin. 1991) and the *Core Plus Mathematics Project: Course 1* (CPMP, 1994), hereafter known as ALG and CPMP, respectively.

Comparing The Curricula Content

To illustrate the differences between the content of curricula, I examine the organization of the materials, as well as the titles of chapters, units, and subsections, and discuss what this suggests about the differences in the two programs of study. I compare the goals for students as learners of mathematics and examine the structure of the lessons. I provide a general description of the format followed by two specific examples and go on to look into the nature of the tasks for students' daily assignments and assessments. To compare the tasks of the two curricula I have used a framework taken from the Balanced Assessment for the Mathematics Curriculum (1999) which illustrates the process, type, and length of the tasks.

Structure and Organization of Content

Chapter/Unit Titles and Section Titles. The first difference between the materials was simply the number of units of study: ALG contained twelve chapters and the CPMP had seven units. The chapters and units were divided into subsections. The titles of chapters, units, and subsections are displayed in Table 3.1.

The quantity of material included in each curriculum appears approximately equivalent: twelve chapters subdivided into eighty-four subsections and seven major units, broken into sixty-seven subsections, each taking the same amount of space on paper to present. The names of each of the ALG chapters clearly communicated what was to be taught. The specific topic or type of operation was clear from the title of each subsection. CPMP unit titles indicated students study two kinds of mathematics, patterns, and models. Some subsection titles indicated what would be studied but others were indeterminate. For example, in Unit 1, Lesson 2 Cars and Calories, the three investigations refer to the familiar statistics topics of distribution, display, and measures of central tendency of a set of single variable data. But the investigation titles of Unit 2, Lesson 2 "What's next?" would not inform a reader that the investigation dealt with recursive relations

Table 3.1 Table of Contents ALG and CPMP

ALG	CPMP

Chapter 1 A preview of algebra
• 1.1 Getting started
• 1.2 Expressing numbers
• 1.3 Beginning to work with algebraic expressions
• 1.4 Understanding equations and inequalities
• 1.5 Ways to represent data
• 1.6 Graphing
• 1.7 Translating between words and symbols
• 1.8 Probability
 	
Chapter 2 The rules of algebra
• 2.1 Algebraic basics
• 2.2 Solving equations
• 2.3 Properties of equality
• 2.4 The substitution and distributive properties
• 2.5 Applications of equation solving
• 2.6 Formal properties
 	
Chapter 3 Signed numbers
• 3.1 The number line
• 3.2 Comparing numbers on the number line
• 3.3 Addition of real numbers
• 3.4 Subtraction of real numbers
• 3.5 Multiplication and division of real numbers
• 3.6 Special relationships
• 3.7 More properties of equality and operations
• 3.8 Line graphs, bar graphs, and frequency polygons
	Unit 1 Patterns in data
	• Lesson 1 Mathematics as sense-making
	    • 1.1 Getting to know yourself and others
	    • 1.2 It makes sense to me, does it make sense to you?
	• Lesson 2 Cars and Calories
	    • 2.1 Exploring distributions of data
	    • 2.2 Histograms on your calculator
	    • 2.3 Measures of center
	• Lesson 3 How close is close?
	    • 3.1 Variability, percentiles, and the five-number summary
	    • 3.2 Using box plots to display variability
	    • 3.3 MAD about the mean
	• Lesson 4 Relationships and trends
	    • 4.1 Scatterplots
	    • 4.2 Plots over time
	• Lesson 5 Looking back
	
	Unit 2 Patterns of change
	• Lesson 1 Bungee business
	    • 1.1 Modeling bungee jumping
	• Lesson 2 What's next?
	    • 2.1 People watching
	    • 2.2 The whale tale
	• Lesson 3 Playing by the rules
	    • 3.1 Variables and rules in money matters
	    • 3.2 Quick tables and graphs

Chapter 4 Working with equations
• 4.1 Equations with variables on both sides
• 4.2 Special equations
• 4.3 The distributive property in equations
• 4.4 Rate problems
• 4.5 Equations with absolute values of squared quantities
• 4.6 More equations with absolute values or squared quantities
• 4.7 Survey projects
 	
Chapter 5 Working with inequalities
• 5.1 Solving Inequalities
• 5.2 Using inequalities
• 5.3 Compound inequalities
• 5.4 Absolute value and other inequalities
• 5.5 Properties of inequality
• 5.6 Circle graphs, pictographs, and artistic graphs
 	
Chapter 6 Graphing
• 6.1 Tables, Graphs and Equations
• 6.2 Slope-Intercept Form of an Equation
• 6.3 The Geometry of Slope
• 6.4 Other forms of linear equations
• 6.5 One more form of a linear equation
• 6.6 Nonlinear graphing
 	
Chapter 7 Formulas and functions
• 7.1 Working with formulas
• 7.2 Special formulas of Geometry
	• Lesson 4 Getting out of line
	  • 4.1 What goes up must come down
	  • 4.2 The shape of the rules
	• Lesson 5 Looking back
	
	Unit 3 Linear models
	• Lesson 1 Predicting from data
	  • 1.1 Where should the projector go?
	  • 1.2 The ratings game
	• Lesson 2 Linear graphs, tables, and rules
	  • Stretching things out
	  • Finding linear equations
	  • Lines all over the place
	• Lesson 3 Linear equations and inequalities
	  • 3.1 Using tables and graphs
	  • 3.2 Quick solutions
	  • 3.3 Equivalent rules and equations
	• Lesson 4 Looking back
	
	Unit 4 Graph models
	• Lesson 1 Careful planning
	  • 1.1 Planning efficient routes
	  • 1.2 Making the circuit
	  • 1.3 Tracing figures from one point to another
	  • 1.4 Graphs and matrices
	• Lesson 2 Managing conflicts
	  • 2.1 Building a model
	  • 2.2 Coloring, map making, and scheduling
	• Lesson 3 Scheduling large projects

- 7.3 Using the quadratic formula
- 7.4 Literal equations
- 7.5 Functions and relations
- 7.6 Function notation and graphing
- 7.7 Mean, mode, and median

Chapter 8 Systems of equations
- 8.1 Solving systems of equations by graphing
- 8.2 More about linear systems
- 8.3 Solving systems of equations using the substitution method
- 8.4 The multiplication-addition algorithm and the computer
- 8.5 Solving systems of inequalities by graphing

Chapter 9 Exponents and radicals
- 9.1 Large numbers
- 9.2 Multiplication properties of exponents
- 9.3 Division properties of exponents
- 9.4 Negative and zero exponents
- 9.5 Simplifying radicals
- 9.6 Rationalizing
- 9.7 Radical equations
- 9.8 Other roots and fractional exponents
- 9.9 Scattergrams

Chapter 10 Polynomials
- 10.1 Anatomy of a polynomial
- 10.2 Addition and subtraction of polynomials
- 10.3 Multiplication of polynomials

    - 3.1 Building a model
    - 3.2 Finding the earliest finish time
    - 3.3 Scheduling a project
    - 3.4 Uncertain task times
- Lesson 4 Looking back

Unit 5 Patterns in space and visualization
- Lesson 1 The shape of things
    - 1.1 Columns
    - 1.2 Space-shapes
    - 1.3 Constructing and sketching space shapes
    - 1.4 Rigid space-shapes
- Lesson 2 How big is it?
    - 2.1 Describing size
    - 2.2 Television screens and Pythagoras
    - 2.3 Size measure for space shapes
- Lesson 3 The shapes of plane figures
    - 3.1 Polygons and their properties
    - 3.2 Regular polygons: The designer's friend
    - 3.3 Symmetry patterns in strips
    - 3.4 Symmetry patterns in planes
- Lesson 4 Looking back

Unit 6 Exponential models
- Lesson 1 Exponential growth
    - 1.1 Have you heard about...?
    - 1.2 Shortcut calculations
    - 1.3 Getting started
- Lesson 2 Exponential decay

- 10.4 Special multiplications
- 10.5 Factoring
- 10.6 Factoring trinomials
- 10.7 More about factoring trinomials
- 10.8 Factoring special polynomials

Chapter 11 Quadratics
- 11.1 Graphing the parabola
- 11.2 Graphing other parabolas
- 11.3 Completing the square in quadratic functions
- 11.4 The parabola and the quadratic equations
- 11.5 Projectile motion
- 11.6 Measures of dispersion

Chapter 12 Proportion and rational expressions
- 12.1 Ration and proportion
- 12.2 Applications of proportion
- 12.3 Direct and inverse variation
- 12.4 Simplifying rational expressions
- 12.5 Multiplication and division of rational expressions
- 12.6 Solving rational equations
- 12.7 Addition and subtraction of rational expressions
- 12.8 Stem-and-leaf plots and box-and-whisker plots

    - 2.1 More bounce to the ounce
    - 2.2 Sierpinski carpets
    - 2.3 Medicine and mathematics
- Lesson 3 Compound growth
    - 3.1 Just like money in the bank
- Lesson 4 Modeling exponential patterns in data
    - 4.1 Popcorn and thumbtacks
    - 4.2 Another day older...and deeper in debt
- Lesson 5 Looking back

Unit 7 Simulation models
- Lesson 1 Simulating chance situations
    - 1.1 How many children?
- Lesson 2 Estimating expected values and probabilities
    - 2.1 Simulation using a table of random digits
    - 2.2 Simulation using a random number generator
- Lesson 3 Simulation and the Law of Large Numbers
    - 3.1 How many games should you play?
- Lesson 4 Looking back

Capstone Planning a Benefits Carnival

embedded in population growth in China and decline in over-hunted whale populations. It was not obvious from the CPMP titles where mathematics topics such as signed numbers, solving equations, factoring, or operations with polynomials would be found, or if they were addressed at all. Looking at the laundry list in the ALG table of contents, it was clear when and where the familiar concepts and skills of Algebra would be covered. An experienced teacher would be able to conjure up an image of each lesson just by looking at the title. Examples, important definitions, and appropriate practice problems would be in memory files of experienced high school teachers who had taught freshman mathematics several times. The CPMP titles used words that were intriguing, interesting, and in some instances were vernacular familiar to teenagers,[1] but it was not intuitively obvious what lessons were about and what a teacher needed to know in order to teach them.

The tables of contents continue to illustrate the differences between the two curricula. The titles of ALG chapters and sections describe the traditional scope and sequence of a first year high school mathematics class. The phrases were comfortable and evoked familiar memories of past lessons. In contrast, CPMP titles communicated that the curriculum was indeed new and different. While the CPMP table of contents made one wonder where the familiar topics and concepts had gone, it created some curiosity accompanied by a bit of uncertainty about what is included and what has been left out. There was a noticeable absence of units covering operations with signed numbers, polynomials, factoring, and solving linear, quadratic, and systems of equations. It begged the question: What knowledge and skills were needed to successfully teach using these materials? In the traditional ALG course, students practiced and learned algorithms and symbol

[1] Bungee jumping is a popular amusement park attraction. Students wonder what is coming up, are expected to play by rules, and, as teenagers, are often warned about "getting out of line."

manipulation. They were expected to master choosing the appropriate algorithm and correctly applying the procedures to problems. It was not clear from the table of contents, what to expect students to learn in CPMP.

It is worth noting the different emphasis on statistics topics. In the ALG curriculum, there are seven subsections devoted to elementary statistics and data representation topics. These are isolated lessons, located at the end of chapters 3, 4, 5, 7, 9, 11, and 12, rather than organized as a single unit of study. In CPMP, the first unit of the year concentrated on statistics topics – the collection, analysis, and display of data.[2]

At first glance, CPMP Unit 4, Graph Models, might be thought to be a unit which considers the graphic representations of the linear functions in Units 2 and 3. That would have followed logically in a traditional first year sequence. However, the unit presented new mathematics for high school curriculum. Graph Models explored existence and optimization problems and began with the study of vertex-edge graphs like those that those used in business and industry to make sense out of situations with relationships among a finite number of elements. The first task for students was to plan how to go about painting lockers up and down school hallways without retracing steps. Conflict resolution and prerequisite task requirements were studied in a variety of situations and were modeled using vertex-edge graphs. These new graphs continued the CPMP emphasis on using mathematical models to represent relationships between variables. In this unit, students investigated and applied Euler circuits and paths, vertex coloring, and critical paths. These were new variables, new graphs, and new relationships, not different forms of linear equations side by side with their graphs.

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[2] It was necessary for the statistics topics to be presented at the onset because throughout the course, CPMP students were required to organize, manage, and present data, as well as write mathematical models to fit data.

CPMP Unit 5, Patterns in Space and Visualization, brought geometry topics - shapes of things in space, measurement, and polygons - to a first year high school course rather than locate them in the second year, traditional plane and solid geometry. Unit 6 Exponential Models also added material to the first year course which would traditionally have been included in Intermediate Algebra, a third year high school course. Unit 7, Simulation Models, which covered probability and chance was another topic not generally given an entire chapter in secondary mathematics curriculum. [3] Probability was included in ALG as a single section in the introductory chapter.

Looking at the table of contents, it was clear there were differences. In CPMP, there were new and unfamiliar topics, there were topics that were out of place compared to a traditional sequence, and significant numbers of topics were missing from the list. What was not clear was whether the content of CPMP would be an acceptable replacement for the content of a traditional Algebra 1 course.

Goals for Students as Learners of Mathematics.

The NCTM Curriculum and Evaluation Standards for School Mathematics (1989) addressed the need for change in the teaching and learning of mathematics in order to meet the challenges of a technological and information-oriented society. The document articulated five general goals for all students. These goals focus instruction on developing students who value mathematics, who are confident in their ability to do mathematics, who become mathematical problem solvers, who are able to communicate mathematically, and who reason mathematically.

[3] The CPMP authors took a position on the arrangement of content in the program. They wanted each course to include the minimum curriculum they believed should be covered if a student stopped studying mathematics in high school after one, two, or three years. This accounted, in part, for the inclusion of the geometry topics found in the first course: shape and measurement, exponential models, and simulation of probability and chance situations in the first course.

NCTM goals serve as a lens through which to view the two curricula and help to illustrate the different expectations for students in each curriculum.

Chapter 6 (ALG) and Unit 2 (CPMP) address similar mathematical content. Each introduced multiple representation of linear relationships[4]. The learning goals and objectives illustrate the authors' different expectations for students. The goals for Chapter 6 in the Algebra text and Unit 2 in CPMP are presented in Table 3.2. The statements are taken from the introductory teacher commentary preceding ALG Chapter 6, and from the teacher material in the beginning of the CPMP Unit 2 teacher notes. There was a fundamental difference in the way the teaching and learning goals were communicated to teachers and students. In the ALG teacher edition, suggestions for teachers were located in the margins. These were things to **do** and **say** during the lesson to help students master the objectives. The students' objectives were phrased in the traditional behavioral objective vernacular and were printed at the beginning of each section in the ALG student text. The student objectives, in general, related to a specific skill or procedure the student was expected to master in each section. The CPMP unit objectives were stated in the introductory commentary for teachers at the beginning of each unit. This commentary communicated the general learning goals for the unit in a narrative that described the purpose of the activities in the unit, its reason for placement in the course, and described the aim of each lesson in the unit. More detailed objectives were located in the lesson planning guide which followed the narrative. The notes communicated to teachers, not students, the goal of individual parts of the activities.

I compare ALG Chapter 6 and CPMP Unit 2 learning aims in Table 3.2.

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[4] Other aspects of linear relationships are located in other places in the two curricula; however, at this point both introduce connections between the three representations,

Table 3.2 Comparing Learning Aims

ALG Chapter 6 Teacher Overview *Suggestions for teachers to do or say to help students:*	Student Objectives[1] *After studying this section you will be able to:*	CPMP Unit 2 Teacher Overview *Lessons of this unit are intended:*	CPMP Lesson Objectives[2] *Activities of the lesson will provide students the opportunity to:*
• These skills (point plotting) will be used to help students see patterns that appear when a linear function is graphed. • Graphing is used to find the solution for two linear equations with two variables and to explain other relationships between equations, and to solve problems. • Use point plotting so students can get an intuitive concept of slope by examining the patterns that emerge. • Introduce slope informally as a geometric concept. Emphasis is placed on different interpretations of the	• Write equations from tables. • Construct graphs using tables and patterns. • Identify the slope and y-intercept. • Interpret the slope of a line in three ways • Determine the slopes of different lines. • Use the slope formula. • Graph equations of the form $y=b$, $x=a$, $Ax+By=C$. • Write an equation of a line in point-slope form. • Choose the most	• To begin developing student sensitivity to the rich variety of situations in which quantities vary in relation to each other. • To develop student abilities to represent relations among variables in several ways-using tables of numerical data, coordinate graphs, symbolic rules, and verbal descriptions - and to interpret data presented in any one of these forms. • To develop student ability to recognize important patterns of change in single	• Identify key variables in the to-be-modeled situation. • Collect data that will suggest the pattern relating those variables. • Make a table and graph the data to look for patterns. • Make predictions that go beyond the data. • Identify patterns of change in variables. • Recognize iterative or recursive change • Recognize equations relating NOW and NEXT. • Utilize the iteration capabilities of the graphic calculator. • Summarize patterns relating variables using rules. • Utilize rules along with the graphics calculator. • Illustrate the power of a 'rule' and its capabilities when used with a graphing calculator or computer software. • Answer questions relating variables by using rules and technology.

[1] Printed at the beginning of each new section in the student text.
[2] Printed in the teacher lesson-planning guide for each unit.

slope formula and on different forms of the linear equation • Discuss nonlinear equations as an important part of understanding linear equations. • Help students understand that they need to decide which is the best form of a linear equation for a particular problem.	appropriate form of a linear equation. • Graph: inequalities, absolute value, and parabolas. in two variables	variables and related variables.	• Understand and appreciate the power of calculator-generated tables and graphs and the essential role of algebraic rules in providing directions to the calculator. • Express patterns of change relating variables using other forms of representation - tables, graphs symbolic rules and verbally stated conditions.

Goal analysis. The presentation of goals and objectives was different in the two curriculums. As I compare the learning objectives, I look first at the stated mission of the chapter, then the teacher role in the instruction, and finally at the objectives for students. ALG provided *Teaching Notes* in the margins of the teacher edition and presented student objectives quite clearly at the beginning of each new section in "*The student will be able to...*" format. CPMP outlined an instructional focus for the teacher, both for the unit as a whole and for each individual lesson. At the beginning of each unit, instructional aims were presented as part of a planning guide for the teacher. Each curriculum had a guiding statement about the purpose and focus of the unit. These *mission statements* appeared on the first page of the teacher material for each unit.

> This chapter develops a sound conceptual basis in graphing.
> (ALG, p. T244)
>
> One of the most important transitions from elementary to secondary school mathematics is the emergence of algebraic concepts and techniques for studying general numerical patterns, quantitative variables, and relationships between those variables, and important patterns of change in those relationships.
> (CPMP, Unit 2, p. 1)

From the above statements, it is reasonable to anticipate that the ALG chapter provided instruction and practice in the skills needed to accurately graph algebraic relationships. The materials could be expected to assist the students in establishing the connection between an equation and its graph. The CPMP unit could be expected to require students to learn to use the language and symbols of algebra to represent the quantities that change and to express the patterns that illustrated relationships between those quantities.

The teaching overview hinted at how teachers would be expected to accomplish the goals of the material. In ALG, it is implied that the teacher will demonstrate, explain, and introduce

topics and procedures. The teacher ensured that students performed the technical skills and saw relationships. The teacher or the text used point plotting to see patterns, graphed to find solutions, introduced ideas, emphasized differences, discussed important parts, and made sure students understood the importance of different forms of an equation. The explicit guidance in the margins of the teacher edition implied that instruction resembled the traditional and familiar teacher-centered model.

The CPMP teacher was charged with helping students to develop *sensitivity* to rich varieties of situations in mathematics. Such terminology could have been expected in a psychology text, but was foreign to traditional mathematics vocabulary. The instructional aims intimated students used several ways to represent relationships (e.g., tables, graphs, and equations), and wrote verbal or symbolic rules for relationships between variables. These were more familiar tasks and objectives for experienced teachers. However, the teacher role emphasized developing student ability to recognize and express relationships between quantities that varied with respect to each other, not on the teacher demonstrating or discussing varying quantities or patterns. Different pedagogy was implied but not articulated in the teacher notes. Teachers were expected to facilitate development of student abilities to recognize and represent relationships, but specific actions for teachers to accomplish this were unstated. In fact, the materials were designed to produce the desired results. The teachers needed to know the intent of the materials, and were not expected to take a *show-and-tell* part in the instruction, but that was not evident from the stated learning goals.

There was a noteworthy difference in what the objectives suggest students might be expected to do in the two courses. The language of the objectives illustrates what was different for students. I isolate some of the verbs from the student objectives to illustrate that they were used differently. Notice how the same verb in some instances implies quite different intellectual activity for students.

- **Identify** – ALG students *identify* the slope and y-intercept in an equation. CPMP students *identify* the important variables in a situation, and *identify* patterns of change in variables,

- **Write** – ALG students *write* equations from tables and *write* equations in point-slope form. CPMP students *summarize* patterns relating variables using rules and *express* patterns of change using other forms of representation.

- **Use** – ALG students *use* point plotting and *use* the slope formula. CPMP students *utilize* the iteration capability of the graphics calculator, *use* rules along with the graphics calculator, and answer questions *using* rules and technology.

- **Graph** – ALG students *construct graphs* using table and pattern, *graph* equations of particular form, and *graph* other relations in two variables. CPMP students make a table and a *graph* to look for patterns and *illustrate the power of a rule with a graphing* calculator

- **Choose/Recognize**– ALG students *choose* the appropriate form of a linear equation. CPMP students *recognize* iterative or recursive change and *recognize* Now and Next equations.

- **Construct** – ALG students *construct* graphs using tables and patterns. CPMP students *make a table and graph* using collected data and *make predictions* that go beyond the data.

The objectives and learning goals for students in ALG were very different from those in the CPMP course. ALG students were expected to learn to perform procedures, solve problems, and see relationships. The verbs in the ALG objectives described concrete measurable skills the students would be expected to master. Those same verbs in the CPMP curriculum represented different expectations and efforts from students. The differences illustrate a change from looking at mathematics as a set of procedures to be learned and applied to looking at mathematics as a way of thinking about situations, searching for patterns, and representing relationships between quantitative variables. Students were expected to go beyond finding ordered-pair solutions to explaining what solutions represented in the context of the problem situation. Students in CPMP engaged in tasks which presented mathematics as a powerful way to represent quantities and relationships. CPMP used technology as a tool to support using mathematics to solve problems.

The learning aims of CPMP were more closely aligned with the NCTM (1989) earlier-mentioned learning goals for students (e.g., students who value mathematics, are confident in their ability to do mathematics, who become mathematical problem solvers, who are able to communicate mathematically, and who are able to reason mathematically) and more challenging for teachers.

For CPMP teachers, it appeared merely checking answers on a homework paper would not be enough. Teachers would be expected to search students' papers for evidence that they had developed a sensitivity to and appreciation of the many ways two quantities were related. Students were expected to demonstrate their ability to represent, communicate, and make predictions from these relationships. For the teacher, this was completely different from checking short answers in class, walking around the room to see how many students had done their homework, and looking for equations written in the correct form.

Structure of the Lessons

Each section in the ALG text followed the same three part format: *Introduction, Sample Problems, Problems and Exercises*. The *Introduction* contained definitions and explanations for the topic of the section. The *Sample Problem* portion showed students how to work problems. The authors provided examples, accompanied by a narrative, which explained procedures systematically. *Problems and Exercises* began with a set of ten warm-up exercises and continued with pages of practice problems. Sections were intended to take one or two days to cover and comprised, on average six or eight pages of the text. It was implied that teacher-directed instruction would model the lesson developed in the text.

CPMP units were subdivided into lessons, which were further divided into investigations. Each lesson followed a *Launch, Investigate, Share, and Apply* model. A CPMP lesson was intended to take from three to ten days to complete. The launch of each lesson, *Think about this situation,* was a whole-class discussion centered on a real problem or situation. This discussion was used to inform the teacher about the previous knowledge which students brought to the investigations, and to establish and clarify the context for the upcoming investigation. Initially, one might think an investigation in the CPMP materials compared loosely to a section in ALG simply by the similarity of subdivisions of the unit of study. However, the tasks, the expectations for students and teachers, and the learning environments were radically different. In CPMP, after the *Launch* discussion, students began work on a long or extended task, followed by questions which prompted students to describe, explain, and/or justify results to other students in cooperative groups. Strategically placed *Checkpoints* provided opportunities for students to share what they had learned via a whole-class discussion and for teachers to check for understanding before students proceeded to the next investigation

Each investigation in CPMP concluded with a problem intended for independent work called *On Your Own.* Large sets of technical skill problems were not included in the CPMP materials. Each lesson had a multiple problem set at the end called MORE[5] which provided opportunity for students to use the concepts of the lesson to solve similar problems. Teacher notes clearly stated that the teacher should launch the discussion with the *Think about this*

[5] MORE: Modeling, Organizing, Reflecting, Extending

situation, students should work in cooperative learning groups on the investigations, teachers should gather the class together for discussion at *Checkpoints*, and finally, make assignments for independent work.

Two Comparative Lessons

I select materials from each curriculum which address the same subject matter - symbolic, geometric, and tabular representation of linear and nonlinear relationships - to illustrate how the approach to a topic was very different from ALG for both student and teacher in the CPMP curriculum. I choose lessons from the Chapter 6 of the ALG text and the Unit 2 in the CPMP materials in which students first encounter the connections between different representations of linear relationships. [6]

In the two lessons, which address the variety of ways to represent a relationship between variables, two obvious differences appeared. First, the materials supported different types of discourse. Second, tasks for students and the presentation of information related to the tasks were significantly different as the sample lesson illustrates.

A lesson from ALG. The pages of the student text simulated what a teacher might say and do in the classroom. A student could read the text and follow the examples or participate in a teacher-led discussion of the topic. The text read like a teacher script; the following example helps to paint the picture.

[6] Non-linear relationships were introduced in each text as a contrast to linear relationships, but were not a significant area of study in ALG Chapter 6 or CPMP Unit 2.

ALG 1: 6.1 Tables, Graphs, and Equations
After studying the section, the student will be able to:

- Construct graphs using tables and patterns.
- Write equations from tables.

Introduction

Graphing Using Tables and Patterns

Diagrams and pictures help build an understanding of relationships. You can study the picture of an equation, called a graph, to draw conclusions about that equation. Some equations can be graphed quickly using a pattern found in a table of values.

Example Make a table of values and graph y = 3x + 2. Let's try consecutive integer values for x and see whether we can find a pattern.

Table 3.3 ALG lesson 6.1 example.

x	-4	-3	-2	-1	0	1	2	3	4
y	-10	-7	-4	-1	2	5	8	11	14

Notice that as x increased by 1, y increases by 3. Also, 3 is the coefficient of x in the equation y = 3x + 2.

We can use this pattern to sketch the graph of y = 3x + 2. If we start at (-4, -10), we find another point on the graph by moving to the right 1 unit, increasing x by 1, and by moving up 3 units, increasing y by 3. (p. 246)

As the lesson continued, examples were given regarding how to graph an equation after a table represented it. Students were directed to a completed graph. A narrative described how the pattern of increases was used to move from one point on the graph to the next by using the pattern of change. A second example was provided with a negative change for y. *Re-teaching* notes in the margin told teachers what to say and do.

> If students have trouble finding the pattern in a table, give them a graph. Then tell students to set up an (x, y) table from the graph and look for the pattern in the relationship between the x- and y-coordinates (Benson, et. al. 1991,T247).

In a third example, the rate of change was a ratio of integers in which neither of the integers was 1. In the text, the rate of change and its position as *m*, in the equation y = *m*x + b was pointed out. This was followed with exercises to practice graphing using the algorithm illustrated in the sample problems. Teacher notes suggested pointing out a number of facts for students.

> Point out that m is always found by using change in y divided by the change in x, never the change in x divided by the change in y. Point out to students that the change in y can be either an increase or a decrease" (Benson, et. al. 1991,T248).

The guided practice tasks gave repeated practice in moving from one point to another on the graph given the equation, and writing the equation given the graph. There were forty-nine tasks in the assignment of this section, including the warm-up problems, which continued practice on the technical skills of the examples in the text. These tasks provided practice in making a graph, writing an equation, and re-presenting information in tabular, symbolic, and graphical form, following the examples in the lesson. The margins of the teacher edition instructed the teacher to prompt or redirect students' thinking if they were having difficulty giving the correct response. There were no open-ended questions, or questions open in the middle to allow for different solving strategies. Most of the problems were devoid of context and provided no activities or opportunities for students to explore the mathematics on their own.

The problem set provided practice exercises using the skills and concepts introduced in the section, some review exercises for skills introduced earlier in the text, and exercises whose solutions would be easier using a scientific calculator. In the introduction for teachers, the authors indicated that each set of exercises included activities intended to be used by students in cooperative-learning groups. Problem-solving exercises were included in each set and teachers were asked to encourage students to solve them in more than one way. However, there were no open investigation problems and the direction to teachers was confusing. Problems with a real-world context appeared in each set and offered students an opportunity to apply the skill of the section to a question connected to the real world. Some items were used to introduce a new topic or skill, which would be addressed later in the textbook. A closer look at the tasks assigned to students is provided in a later section of this chapter.

CPMP Course 1 Lesson 2.1 Bungee Business. Standard CPMP procedure specified that students worked on investigations in small groups during class. Homework assignments were comprised of *On Your Own (OYO)* tasks and tasks taken from a *MORE* set, located at the end of several investigations. In this lesson, the tasks introduced a mathematical idea in the context of a real-world bungee jump situation. This lesson presented a table of data for the predicted number of customers who would purchase tickets to bungee jump for different ticket prices and a graph of those points with a line connecting the points. The *Think about this situation* launch began with a question about what students expected the relationship to be between the number of participants and the price of the ticket. The discussion continued with questions about which they thought best represented that relationship - the table or the graph. The investigation tasks involved determining the relationship between the weight of the jumper and the distance the "bungee cord" would stretch.

The objectives of the Bungee Jump lesson, the student will have the opportunity to:

- Identify the essential variables in the modeled situation.
- Collect data suggesting a relationship between variables.
- Make a table and graph the collected data to look for patterns.
- Make predictions, which extend beyond the data.

These objectives were stated for the teacher in the teaching guide, but not for the students. The narrative in the text began the lesson as follows:

The distance that a bungee jumper falls before bouncing back upward seems likely to depend on the jumper's weight. In designing the jump apparatus, you need to know how far the elastic cord will stretch for different weights. It makes sense to do some testing before taking a real jump.

When engineers design a new product, they often experiment with scale models before building the real thing.

Task 1 A) In your group, make, and test a simple scale model of a bungee jump using some rubber bands and fishing weights. Loop together several rubber bands of the same size to make elastic rope and then attach a weight as shown[7].

B) Use your scale model to collect test data for at least five different weights and record your data in a table like this:

Weight	Amount of Stretch
______	______
______	______

(CPMP, 1994, Unit 2, p 2-4)

In this lesson, a model bungee jump was to be built (using meter sticks, linked rubber bands, and washers). As jumps were simulated, data was to be recorded (in a table) on how far the elastic cord stretched for jumpers of different weights. A graph of the data was to be made. The graph and a conjectured rule were to be used to estimate how much the bungee cord would stretch for other weights. The students were expected to discuss the activity in small groups and answer the questions about it together. They were to compare their results with others, answer questions, make predictions, and write explanations based on data they had gathered. Students were to formulate a mathematical model and test their predictions using the model bungee jump. This investigation included 12 tasks, many with multiple parts. These tasks provided students with the opportunity to discover a relationship between two variables and to use several different representations for that relationship.

[7] A diagram of looped rubber bands and a paper clip "hook" was shown.

Teacher notes directed teachers to bring closure to the lesson with questions like, "What are the important variables in this situation?" and "What are the pros and cons of describing patterns of change in related variables with a table, a graph, or words?"

The investigation tasks were non-routine (it was unlikely any student had ever conducted a bungee jump). The task was open and allowed students to discover relationships between the variables via different models (more or fewer rubber bands and different measurement strategies). The task called for students to design and build, plan for, and organize the efforts of their group members. They were expected to check and verify their data, represent it in a variety of ways, and use it to make predictions. Within the activity, students were given information about the reason for using different representations of a relationship (e.g., table, graph, and rule). The tasks for students in the investigation portion of the lesson offered students the opportunity to perform an experiment, which modeled a linear relationship. In this activity, students measured the increase in stretch of the cord as they increased the weight of the "jumper." The expectation was that, they would be able to see the change in y and the change x in a very real way. (Change in y was the change in stretch, and change in x, the weight difference between jumpers). They saw these variables as related quantities in this situation. They had the opportunity to see variables as quantities that changed, and to observe a relationship between two variables as more than a formula for the slope of a line or as the coefficient of x in the equation $y = mx + b$.

The Nature of the Tasks

Meaningful tasks provide the intellectual contexts for the mathematical development of the students (NCTM, 1991). The NCTM Professional Standards for Teaching provide guidelines for worthwhile mathematical tasks. The standards suggest that teachers pose tasks based on sound and significant mathematics, a knowledge of students' interests, previous understanding, experiences, and a knowledge of how students learn mathematics. The Standards specify that tasks should engage students' intellect, develop their understandings and skills, and stimulate them to make connections between mathematical ideas as well as develop a coherent framework for those ideas. Meaningful tasks should require problem formulation, problem solving, and mathematical reasoning. In addition, tasks should draw on students' experiences, illustrate that mathematics is a human endeavor, and support the students' disposition to do mathematics (pp. 20, 25).

A close look at the tasks for students in the two curricula will help to illustrate how different the classroom environment was for students and for teachers. It is worth noting that the overarching objective of the ALG text was for students to learn the concepts and skills of algebra and to become a problem solver. In a letter to students, the authors stated that each lesson introduced some algebraic concepts and skills, and the tasks provided opportunity to practice and learn those concepts and skills. Throughout the CPMP materials, mathematical modeling (e.g., verbal or symbolic rule, graph, and table of values) was a guiding principle. The materials were intended to facilitate using mathematics to make sense of life situations and problems, and seeing mathematics as a body of connected knowledge. Activities and tasks required students to use mathematical models to represent many different variables and relationships. Early expressions of the relationships were verbal, but moved quickly to symbolic and geometric.

Several carefully selected problems from each set of materials follow. I selected tasks that ask students to perform very similar mathematical procedures. However, there is a distinct contrast between the problem samples. The difference is evident from the ALG emphasis on computation, transformation, and manipulation versus CPMP tasks that provide students the opportunity to demonstrate how well they reason and communicate mathematically, how well they are able to formulate and draw inference from a mathematical model, as well as how well they perform routine procedures.

ALG Section 6.1 Tables, Graphs, and Equations

#14 Make a table of values and graph the equation $y = -2x - 5$.

Table 3.4 ALG sample problem # 17.

x	-5	-4	-3	-2	-1	0	1	2	3	4	5
y	65	57	49	41	33	25	17	9	1	-7	-15

#17 Write an equation for the above table of values.

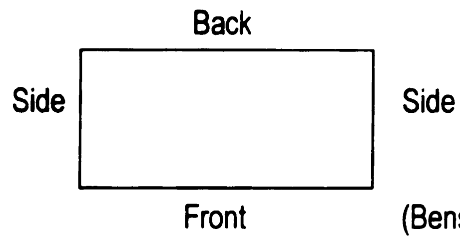
#42 An airplane at 30,333 feet begins to descend at 25 feet per second. Let x be the number of seconds of descent.

- Let h be the height of the plane above the ground after x seconds. Write an equation to describe the relationship between h and x.
- Sketch a graph of the airplane's height h above the ground for varying values of x in seconds.
- Find x when the plane is 5000 feet above the ground.
- Find the height of the plane 120 seconds after it starts its descent.

#45 Fencing for the sides and the back of a rectangular yard costs $1.50 per meter. Fencing for the front of the yard costs $2.00 per meter.

- Let W represent the width (sides) of the yard. Let L represent the length (front and back) of the yard. Write an equation for the cost; C. to fence a yard that is W meters by L meters.
- Copy and complete the width/length table for the total cost of the fence. Write your answer as a 5 x 5 matrix.
- Ian wants his yard to be in one of the rectangular shapes from the table and has only $220 to spend on fencing. What choices does Ian have for the dimensions of his yard?

Width Length —	20	25	30	35	40
10					
15					
20					
25					
30					



(Benson, et. al. 1991, pp. 251-255)

Unit 2 Investigation 1.1 Bungee Business CPMP

On Your Own: Now think about your own prospects in bungee jumping. Suppose the falling weight is your own weight and that the bungee cords of different lengths are to be tested.

- Do you think the amount of stretch in a bungee cord is a function of its length? If so, write an explanation of the change in stretch you would expect as cord length changes.
- Make a table like that below for (cord length, amount of stretch) data. Complete the table showing a pattern that you think might occur.

Table 3.5 CPMP sample problem On Your Own part c.

cord length (in meters)	5	10	15	20	25	30
amount of stretch (in meters)						

c) Sketch a graph of the (cord length, amount of stretch) data showing the pattern of change that you would expect to occur.
d) Describe an experiment similar to the one in the investigation to find the likely relation between cord length and amount of stretch for some fixed amount of weight.

Modeling #4 When new motion pictures are released, they first appear in theaters all over the country for about six months. Then they are sold to television stations or to video rental companies, which rent the movies to people for home viewing. Suppose that a rental store near you buys 30 copies of a new release and begins renting them.

- Stores keep records of the number of times that movies rent each week. How do you think the number of rentals per week of a new release will change over time?
- Make a table of (week, rentals) data showing what you believe is a reasonable pattern relating time, in weeks, since the video became available and number of rentals of that video per week for weeks 0 to 20.
- Sketch a graph of the relation between time since release and number of rentals per week that matches your data in part (b).

Reflecting #3 Think about variables that you notice around you every day, and how changes in one variable seem to cause changes in others or how changes in one variable occur as time passes in a day, week, month, or year. For example, as mealtime gets closer, most people get hungrier, but after a meal, the hunger decreases! Describe two variables that you notice every day that seem to be related. Explain how changes in one of those variables seem related to changes in the other. Sketch a graph or make up a table of possible values illustrating the pattern you notice. (CPMP, 1994, pp. 5-13)

I paired ALG Problems #14 and #17 with CPMP On Your Own parts a-d. These are examples of tasks that required students to construct a table of values and write an expression that represented the pattern in the table. First, ALG students computed dependent values, having been given independent ones, and then plotted and connected the points to form the graph. Given the table in #17, students were expected to write the symbolic rule for it. They had been taught an algorithm for writing equations in the lesson, and this task provided an opportunity to practice that procedure. Students were not asked to explain or discuss the relationship between the two variables in either task, only to re-present the given information.

The CPMP On Your Own task emphasized relationship. Students were asked to think about a relationship between two variables, weight, and length of elastic bungee cord. They were asked to fill in a table with values they thought would satisfy the situation wherein their own weight was used and the length of the bungee cord was varied. The numbers students placed in the table could not be judged right or wrong, unlike the responses in ALG task #14. The questions were open-ended, allowing students to bring their own experience (be it vicarious) and understanding of the situation to the task. Student responses to either the relationship (" ...change in stretch you would expect...") or table values ("...a pattern that you think might occur...") could not be judged incorrect. The "correctness" of their responses was related to the assumptions students made and the values they selected for the variables.

Task #42 and Modeling #4 gave students real world scenarios about a descending airplane and renting new release videos. Each task approached the mathematical model of the event differently. ALG students were told to write an equation to represent the relationship between the named variables height and time, h and x respectively. Students were to graph the equation using several points and find ordered pairs (x, 5000) and (120, h). In contrast, CPMP students are asked to describe how they think the number of rentals of a newly released movie will change over time and then to formulate a table to illustrate a pattern of rental over twenty weeks time, and to graph the relation that matches the data in their table.

Task #45 and Reflecting #3 continue real world context for mathematics. ALG identified a specific situation involving the cost to fence the perimeter of a rectangular yard. Given costs, students were expected to complete a table, which merely required computation. Students were expected to determine the size of a yard that satisfied cost constraints. They were not asked to model the mathematical relationship, or even consider what it was. There was only one entry in the 5 x 5 matrix of answers that would not satisfy the conditions, thereby eliminating the opportunity for the students to evaluate several acceptable solutions, select one as the best, and justify the answer. A task that could have been meaningful became trivial.

In sharp contrast to #45, Reflecting #3 allowed students to bring their own experience and knowledge of their world into the assignment. They were expected to describe a pair of related variables they noticed in the world around them, formulate a table of values, and graph the pattern they described. The task allowed student to bring mathematics from their world into the classroom and explain how the changes in one variable were connected to changes in the other. This task allowed students to communicate mathematically.

CPMP students' responses demonstrated their ability to make sense of relationships between variables and to express them as a rule, sketch them as a graph, or construct a table to show the relationship. In contrast, the ALG teacher could recognize if students had mastered plotting points, computation, and using an algorithm to write the equation of a line, but not know if the students understood the connection between the representations and the relationship of the variables to each other.

The emphasis in the ALG lesson was on the technical skills needed to graph lines, compute values for a table, and write an equation to represent either. The tasks provided students the opportunity to practice those skills. The CPMP emphasis was on learning to see variables as entities that change and finding the relationship between those quantities. CPMP tasks reinforced the idea that different representations of relationships were possible. Students were presented with situations wherein one representation might be more suitable to illustrate the pattern between the variables than another representation.

Task Analysis.

In the tables that follow, I compare the tasks in the two lessons described above[8]. The tables illustrate how the focus and balance of tasks for students in the two curricula were different. The assignment for students of average ability in ALG was comprised of forty-nine tasks from Exercise set 6.1 and for the CPMP students, forty-three from the Bungee Jump investigation.

The tables use Balanced Assessment (1999) categories, which address several different dimensions of mathematical tasks. Table 3.6 the Mathematical *Process* Category, Table 3.7 uses Tas*k Type* Category; and Table 3.8 compares the tasks by Task *Length* Category (p. vii). These categories help to sort the tasks, to analyze and compare the curricula, and to illustrate the distribution of tasks for students over the range of possible activities in a mathematics classroom. The tables make it easier to see the degree of balance of tasks achieved by the two curricula.

Table 3.6 Comparison of tasks using Balanced Assessment Mathematical *Process* Categories

Task Process	Tasks that:	ALG N = 49	CPMP N = 43
Modeling and Formulating	Require selecting appropriate representations and relationships to model the situation.	3 6%	13 30%
Transforming and Manipulating	Involve manipulation of the mathematical form in which the problem is expressed usually with the aim of transforming into an equivalent form.	44 90%	7 16%
Checking and Evaluating	Involve evaluating the quality of a solution as it relates to the problem situation.	2 4%	5 12%
Reporting	Involve communication to a specified audience of what has been learned about a situation.	0 0%	8 19%
Infer and Draw conclusions	Involve applying results to the original problem and interpreting results in that light.	3 6%	11 26%

[8] Each of the CPMP tasks had multiple parts, as did several of the ALG tasks. The total number of tasks for each curriculum is used in the comparison table.

Table 3.7 Comparison of tasks using Balanced Assessment *Task Type* Categories

Task Type	Tasks that:	ALG n=49	CPMP n=43
Open investigation	Invite exploration and aim to have students discover relationships and establish facts. Students will explore, generalize, justify, and explain.	0 0%	17 40%
Non-Routine	Presents an unfamiliar problem situation students probably have not analyzed previously.	1 2%	17 40%
Technical Exercise	Require only the application of a learned procedure, and can be judged for accuracy.	40 82%	10 23%
Re-Present Information	Require interpretation of information presented in one form and presenting it in a different form.	27 55%	13 30%
Review and Critique	Require reflection on curriculum materials and make a suggestion for revision or pose a further question.	2 4%	3 7%
Design	Require construction and use of an object and evaluation of results under various constraints.	0 0%	8 19 %
Evaluate and Recommend	Require students to collect and analyze information and make a recommendation based on the evidence.	1 2%	9 21%

Table 3.8 Comparison of tasks using Balanced Assessment *Task Length* Categories

Task Length	Tasks that:	ALG n=49	CPMP n=43[9]
Short	require 1-10 minutes to complete	49 100%	0
Medium	require 10-20 minutes to complete	0	7 75%
Long	require 20-45 minutes to complete	0	0
Extended	require several hours to complete	0	12 25%

[9] The first 12 CPMP tasks done in an in-class group investigation, the remaining 31 individual tasks grouped to form 7 larger tasks

Striking differences are apparent from the tables. First is the difference in the balance over the range of categories. All of the ALG tasks were short in duration. 90% involved one kind of mathematical process (transforming and manipulating information), and 82% were of one task type (technical exercise – where their work with numbers or symbols could be accomplished by applying a technical skill and could be checked quickly). There was only a token nod to modeling and formulating, checking and evaluating, and inferring and drawing conclusions.

The ALG emphasis on transforming, manipulating, and mastering technical skills made a statement about what mathematics is: procedures to perform, and what it is not: a tool for solving problems that require extended time, extensive thought, consideration of alternatives, or making conclusions based on mathematical evidence. The number of ALG tasks that took less than ten minutes to accomplish say something else about mathematics: it can be done quickly.

In contrast, CPMP students had the benefit of tackling tasks in each category. Students had no short tasks in this group: 75% of the tasks were of medium length and the remaining 25% required extended time. Given the emphasis on mathematical modeling in CPMP, it is not surprising to find 30% of the mathematical process tasks involve modeling and formulating and that 26% require students to draw conclusions and make inferences from their model. The remaining tasks were evenly distributed over the other process categories. Most of CPMP tasks in this investigation were open (40%) and non-routine (40%). Only one fourth of the tasks were technical exercises. Others were almost evenly distributed over the design, evaluate and recommend, and re-present information categories. CPMP tasks gave students the opportunity to use technical skills, select appropriate representations, and use representations to go beyond collected data. Students were expected to reason and communicate mathematically with each other and their teachers. The tasks they engaged in were, in general, extended tasks that necessitated a new view of mathematics, far different from a set of procedures. CPMP tasks offered mathematics as a way to make sense of real situations in which variables and relations exist, and a language to use to communicate with others about the patterns they observed.

Assessment

CPMP assessment followed the theme of the tasks for students in the text, as did ALG. The ALG 6 Quiz 1 and the quiz from the Bungee Jumping lesson follow:

Algebra 6 Graphing Quiz

1. Write an equation that describes the values in the table.

Table 3.9 ALG Quiz problem 1

x	-5	-4	-1	2	3
y	13	11	5	-1	-3

2. Write True or False
   The point at which the graph of an equation crossed the x-axis is called the change in x.
3. Find the slope and the y-intercept for the graph of y = - 6x - 5.

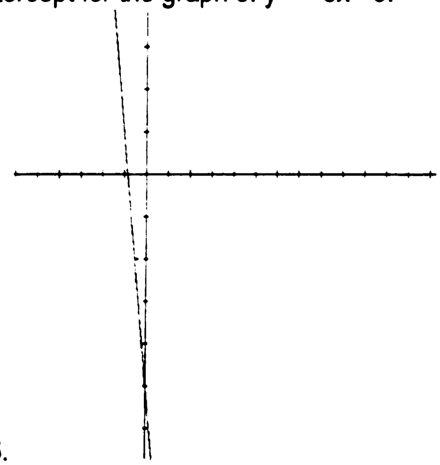


Figure 3.4 ALG Quiz problem 3.

4. Find the slope and the y-intercept and write an equation of the line.

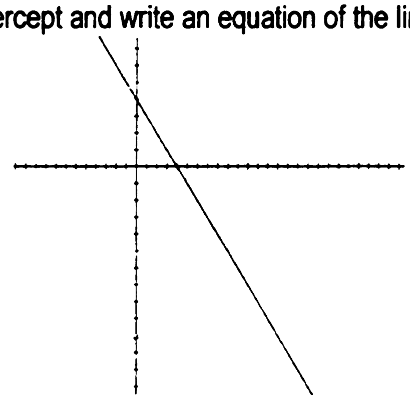


Figure 3.5 ALG Quiz problem 4

5. Find the slope of the line that passes through (2, 5) and (4, 9).
6. Write an equation of a line that passes through (0, 0) and is parallel to y =-1/2x + 1.
7. Graph the equation 3x + 4y = 8.
8. Graph the equation x = 10.

Lesson 1: Bungee Business Quiz

1 Room capacities for classrooms for Central City School District are set, in multiples of five students, by the district administration based on the floor space of the room. Following are floor spaces and capacities of some rooms at Kennedy High School.

Table 3.10 CPMP Quiz problem 1

Room number	101	105	110	201	220	308	320	340
Floor Space (sq.ft.)	380	418	306	750	345	440	460	260
Capacity (number students)	25	30	20	65	20	30	35	15

a) Plot these (floor space, room capacity) pairs on the axes below.

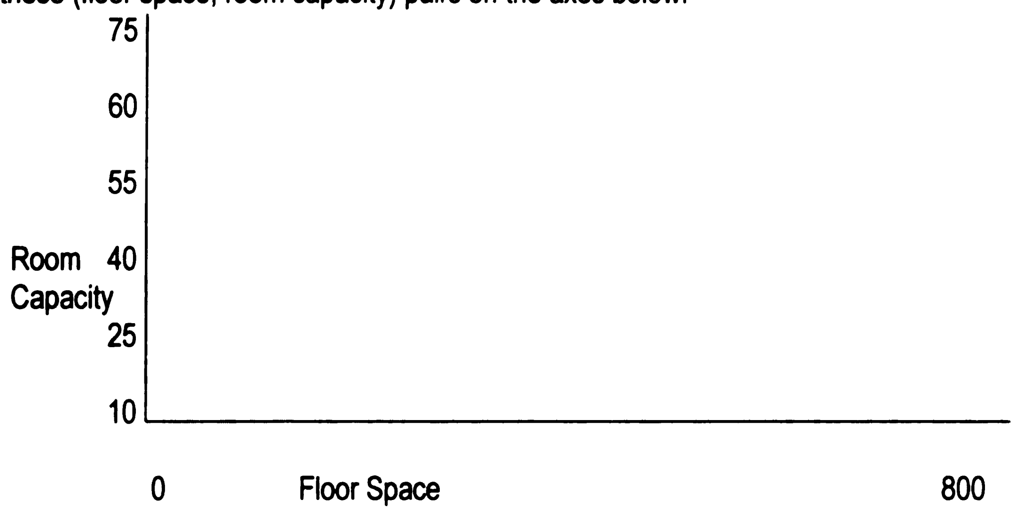


Figure 3.2 CPMP Quiz problem 1 part b

b) Using the pattern of the data and the graph, describe the pattern (or rule) that the district administration is using to determine room capacities.

c) Find the room capacities that would be assigned to the classrooms with the given floor spaces (in square feet) and enter them in the table below.

Table 3.11 CPMP Quiz problem 1 part c

Floor Space	320	370	417
Room capacity			

2. In a test of a new roller coaster by the Gooding Amusement Manufacturing Company, a test rider rode the roller coaster and used a radar-timing gun connected to a computer to produce this graph.

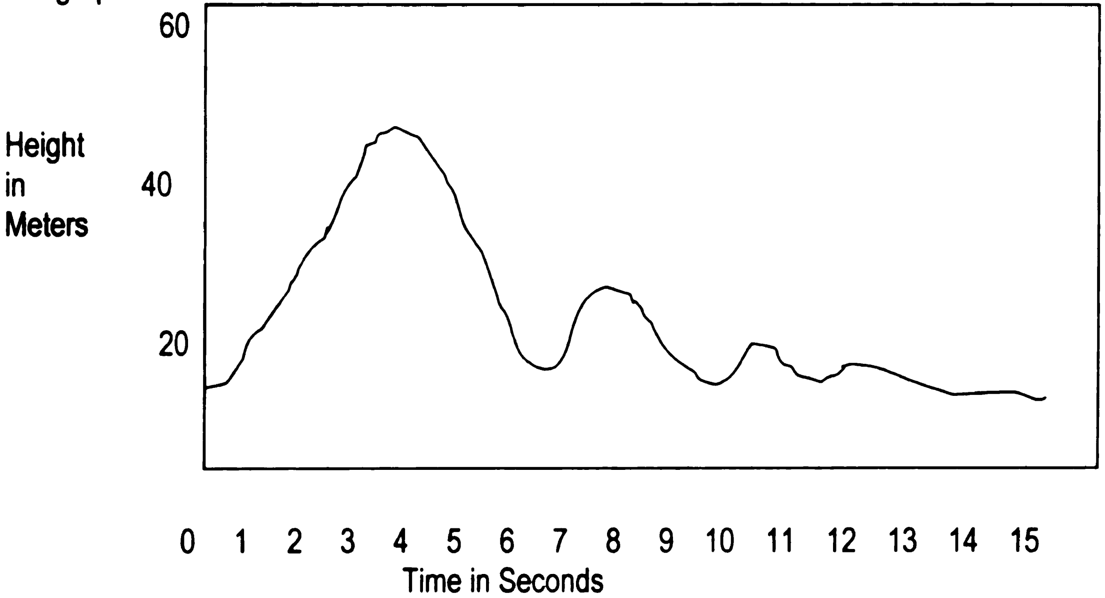


Figure 3.3 CPMP Quiz Problem 2

a) What does the pattern of the graph tell you about the roller coaster's shape?

b) According to the graph, approximately what was the test rider's height above the ground one second into the ride? Six seconds into the ride?

c) After getting started, when did the test rider come closest to the ground?
When did the rider reach the maximum height?

d) Describe what was happening to the test rider between 1 and 8 seconds.

Table 3.11 Summary of the quiz tasks using the Balanced Assessment categories.

Category Math Process / Task Type	CPMP n = 7[10]	ALG n=8
Model / Formulate (Process)	2	0
Transform / Manipulate (Process)	3	6
Draw Conclusion / Infer (Process)	2	0
Re-present Information (Task)	2	5
Open Investigation (Task)	2	0
Non-routine (Task)	2	0
Technical Exercise (Task)	3	8

The tasks on the CPMP quiz required the students to engage in each of the mathematical processes of modeling, drawing conclusions, and transforming the expressions. The kinds of tasks and the processes that were needed to solve the tasks of the quiz were equally distributed over the categories. The emphasis on skill and procedure as well as the lack of attention to higher order thinking needed to model and make inference in the ALG assessment is evident. Comparing the ALG quiz to the CPMP quiz, the difference in balance over the categories is very clear.

Table 3.12 presents a side by side comparison of the principle differences between the two curriculum materials. Using CPMP meant moving away from the position that studying mathematics meant learning a set of procedures and skills, practicing them

[10] I separated the two major tasks into their respective smaller tasks for purpose of analysis.

Table 3.12 Summary of differences

ALG	CPMP
• Familiar Scope and sequence of a first year high school course. • Traditional topics • Traditional order	• Some familiar topics but scope and sequence not traditional. Statistics and Probability as a stand alone units Exponential functions (traditional 3rd year content) Geometry topics (traditional 2nd year content) Graph Models (a completely new topic for high school curriculum) • Traditional units deleted as stand alone units.
• Mathematics as technical skills, symbol manipulation procedures, applications.	• Mathematics as sense making, ways of thinking and communicating about patterns and relationships between variables
• Teacher-centered instruction Teachers: Introduce, Explain, Demonstrate Students: Practice	• Student-centered cooperative learning Launch, Investigate, Share, Apply
• Major emphasis on developing technical skills	• Major emphasis on mathematical modeling
• Technology to manage computation	• Technology as a powerful tool for processing information and learning
• Pre-Dominant mathematical process – Transform and manipulate	• Balance over mathematical processes
• Pre-Dominant task type –Technical exercise	• Balance over task types
• Pre-Dominant task length – Short	• Minimal short tasks, predominant – Medium 75% Extended 25%
• Emphasis - student ability to perform procedures quickly and accurately	• Emphasis – student ability to reason and communicate mathematically; formulate mathematical model of event and draw inference from said model

until they could be performed quickly and accurately, and demonstrating how to apply them to appropriate but often routine problems. Instead, the materials would hopefully reshape instruction into inquiry, teachers into facilitators, and students into budding mathematicians. Mathematical activity would be defined by the challenge to formulate mathematical models that accurately represented situations and to justify how and why particular models were useful and meaningful. Classrooms would look and sound different as the voice of the teacher moved to the background and the "noise" of the classroom became students engaging in energetic conversations to defend and debate their solutions and their reasoning on a mathematical task.

It is reasonable to expect that leaving behind the traditional model of classroom instruction and management to embrace the new content and its accompanying pedagogy would leave us vulnerable to problems. The classroom environment would change, as would the role of the teacher and the student as we moved to cooperative learning. The students might need different or additional instruction to assume the new investigative role. In addition, there could be conflicts between what was suggested by the ancillary material as appropriate teacher input and the needs of the students as they tried to make sense of their new role in the learning process. The situation could become more complicated if students resisted taking on responsibility for learning and working in cooperative learning groups with other students all the time. Some mathematics was new and completely different from what had been taught previously and presented students with challenges for which they felt unprepared.

Learning new content was not expected to be problematic for the teachers. However, the use of a graphing calculator on a regular basis in class would be different for us. We needed to learn to use this machine as a teaching tool. In addition, it might be a problem for all students to have it available at school and at home. Furthermore, learning the graphing calculator might get in the way of learning the mathematics as combination and sequence of keystrokes to produce mathematical results were sometimes difficult to recall. The variety of tasks - type, mathematical process, and length – could be a challenge for teachers to manage materials, time, and students' papers. There would have to be different ways of knowing what students had learned because the tasks were different. Checking homework papers, quizzes and tests would likely be altogether different, as would calculating letter grades for report cards. Parents would not understand this to be mathematics – it would be nothing like the Algebra they remembered.

As it turned out, all of the above occurred at some time during the first year of implementation of the CPMP curriculum. The non-traditional instructional model, the new tasks, and the accompanying new roles for teacher and student had an impact on many areas of our work.

The teachers realized early in the year that we were taking an inordinate amount of time to move through the material. The lessons took much longer than described in the guiding notes. At semester we had completed only two units, and by the end of the year just slightly more than four.

In the next two chapters, I focus on the difficulties we encountered with the cooperative learning model and the uncertainty we faced as we attempted to determine what students had learned and when we were ready to move on to the next unit or topic. I examine how the changes in content and pedagogy had an impact on our decisions to move forward in the curriculum. In chapter four, I address the issues we had with cooperative learning as the standard for classroom instruction. In chapter five, I explore the factors that hampered our efforts to determine what students had learned and handicapped our decisions to move forward.

CHAPTER 4

INSTRUCTIONAL PROBLEMS WITH THE CPMP MODEL OF COOPERATIVE LEARNING

Introduction

Of the seven units that comprised CPMP Course 1, we had completed four and part of a fifth by the end of the school year. In addition, we had not considered using the two-week capstone activity to draw the units together because of shortness of instructional time. We felt bad that we had not been able to complete as much mathematics as we believed we should have taught and, in fact, we had not been able to implement the program, as we understood it was designed to be taught. In several ways, we felt we failed in our mission. Not just because we had not been able to teach the entire course, but we had not been able to use the CPMP cooperative learning model consistently or effectively. Late in the school year, one of the teachers reflected, "This program is predicated on cooperative learning. Not all of us have been able to facilitate that in our classrooms." I try to ascertain why.

At first, the data seemed to tell a story about time - the amount of time teachers needed to prepare for class, the time management of class activities, and the inordinate amount of time we needed to read and process student papers. Teachers consistently expressed the concern that we felt we were behind where we should have been in the curriculum. It seemed we could never catch up with the mountains of paper students created using CPMP, and ultimately, there was not enough time in the school year to "uncover"[1] the entire curriculum.

It seemed unlikely that implementing an innovative, curriculum simply took more time. The tasks and expectations for students were very different, as described in Chapter 3. We were asking students to accept responsibility for learning and to demonstrate knowledge of mathematics in a much different way. We were spending more time in class on projects than teacher guidelines suggested and using a great deal of time to process students' written work. Student papers were longer; they took longer to read, and we found ourselves taking more time to correct them. We wrote comments on student work. Rather than just mark them with X's and C's, we suggested alternatives and wrote questions in the margins. Certainly, it was about more than just the paperwork. Yet, every time we gathered to discuss our work and its challenges, teachers raised the time issue.

Graphing calculator technology was central to the CPMP curriculum and was required on a daily basis. The first lesson of the year had students gathering data, entering it into lists, and using TI-82 graphing calculators to find measures of central tendency. In contrast, technology use in our ALG classrooms was minimal and primarily used to manage large numbers in tasks.

Given the emphasis on graphic calculator use, it was necessary for each CPMP classroom to place an overhead projector and screen in a central position. It was used regularly for projection of the graphing calculator view-screen and for gathering and sharing class data on transparencies. Students needed their own calculator for work outside of class, but we provided them with one for use in class if they did not have their own. Teachers had classroom sets of twenty-eight calculators for students to use in class.

CPMP proved to be a time consuming curriculum in many ways. Unfortunately, calculator borrowing[2] took at least five minutes at the beginning and end of each period. Distribution and collection of materials took additional time at the beginning and end of each period. The tasks for

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[1] In contrast to covering the material in the textbook, we hoped to allow students to discover and make sense of the mathematics. Hence, my choice of the word uncover.

[2] Calculators were numbered and students were assigned a specific calculator to borrow each day. At the end of each class period, teachers needed to account for all calculators to avoid theft.

students were time consuming, and some tasks provided students the opportunity for students to mask time-off-task minutes.

Cooperative learning was the exception in the traditional classroom, but the standard in the CPMP classroom. CPMP materials were intended to be used by students, in groups of four, investigating interesting problems in which mathematical concepts were embedded. Consequently, desks were not arranged in parallel rows and were moved to accommodate groups and active investigations.

I narrowed my analysis to aspects of implementing the curriculum that I saw as central to the ever-present time issue. Cooperative learning was intended to be the standard for classroom activity and our attempts to implement the materials according to that instructional model challenged us to organize our classrooms in different ways, to use the materials as they were written, and to make effective use of time.

In this chapter, I describe dilemmas faced by the teachers and the adaptations we made in our effort to ensure that students had the best opportunity to learn. I trace issues that were problematic in the beginning and subsequently decreased in importance, issues that remained constant through the year, and others which appeared later and were dominant as the school year came to a close. Cooperative learning, as the modus operandi was the keystone of difficulties we encountered and had significant impact on the pace of instruction.

Cooperative Learning for All Class Activities

The CPMP stance on cooperative learning was to use groups of four for all in-class investigations. The rationale behind organizing a curriculum around cooperative learning groups was that it would promote student engagement and provide an active learning environment in which students worked together in heterogeneous groupings, where group findings were intended to be shared, evaluated, and summarized by the entire class (Hirsch, Coxford, 1997). The authors advocated using a very specific model of cooperative learning, one where students were assigned particular roles, titles, and duties in the early lessons. The shift away from teacher-centered instruction was difficult for everyone. The problems we encountered were more than merely adjusting to a different classroom style, although that change was a huge factor. I focus on the impact that this model of cooperative learning had on our work.

The CPMP Model of Cooperative Learning

CPMP cooperative learning roles for students. CPMP materials used a very specific model of cooperative learning, wherein each member of the group was assigned a clearly defined role. In the very first lesson, the roles were outlined for teachers and students. The titles and specific responsibilities for each student in a group were as follows:

Coordinator

- Obtains necessary recourses.
- Recommends data gathering methods and units of measure appropriate for the situation.

Measurement specialist

- Performs the actual measurements as needed.

Recorder

- Records measurements taken and shares information with other groups.

Quality controller

- Carefully observes the measuring and recording processes
- Suggests when measurements should be doubled-checked for accuracy.

(CPMP, 1994, Course 1, Unit 1, p. 2)

After the first lesson, the roles were modified to reflect more generic functions for the remainder of the year. The roles and responsibilities were outlined in the text as follows:

Coordinator

- Keeps the group on track and makes sure everyone is participating.
- Communicates with the teacher on behalf of the group.

Reader

- Reads and explains the questions or problems on which the group will be work.

Recorder

- Writes a summary of the group's decisions and ideas, and reads them back to the group to ensure agreement and accuracy.
- Shares group's summary with other groups or the entire class.

Quality Controller

- Monitors the group's results and makes sure that the group produces high quality work of which they can be proud.

(CPMP, 1994, Course 1, Unit 1, p. 6)

We had used small learning groups in our classrooms on occasion in the past and had not taken the position that each student needed a specific role. We had allowed students to determine the needs of the task and to decide on the best way to accomplish it on their own. In CPMP, there was a great deal of emphasis on students having specific titles and responsibilities within each group. I believe the emphasis was intended to ensure that students participated and took ownership in the tasks; however, the students did not assume the roles and perform the duties. In some instances, the role assignment gave students permission to sit back from the activity and participate in only one aspect of a lesson. From a student perspective, only one student was assigned to be the Recorder, therefore only that student was required to write anything down.

Throughout the year, we observed and complained that one member of the group worked and the others copied. It seemed that the role assignment fostered that behavior. Similarly, the responsibility for measuring was designated to one student, others sat back and watched, relieved of the responsibility by their title. The Quality Controller was assigned the job of watching the others work. Once the Reader had read the task aloud, there was nothing to do but sit and observe. The Coordinator was to be the designated speaker for the group when there was a need to communicate with the teacher; however, students were unable to make the switch to leaving that responsibility to one student. If students had questions, they asked them and in most instances, the teachers attempted to answer them. In many ways, the role assignments were counter-productive to the cooperative learning goal. The following vignette illustrates this problem.

Lesson 1, Project 1: Objective: students measure the height and arm span of each group member, then combine the measurements to obtain a class data set. The task was designed to gather a set of data quickly, that could be used as context for exploring measures of central tendency and variance. Ultimately, students were expected to determine a relationship between the two measurements. The task required students to determine the height and arm span of the average group member and of the average class member, to consider how *varied the* class was, and finally to determine a relationship between the two measurements.[3]

In my classroom, there was much confusion about what to do and how to do it. For this typical group, Kate (grade 10), Leon (10), Justin (12), and Nikita (9), overcoming inertia was half the problem. Kate (the Coordinator) was sent for the needed measuring stick and tape. Leon was the Recorder, but he did not have paper and pencil to record the measurements. Nikita was the Quality Controller, while Justin was the Measurement Specialist. After some discussion about whom was the tallest, (which I overheard digress into a description of a pick-up basketball game the previous night) I suggested they begin measuring. Niki stood against the wall and Justin placed the measuring stick approximately at the top of her head. He did not make a mark on the wall, but kept her standing there while he began to measure the distance to the floor next to where she was standing. He moved the meter stick down the wall without marking where the end had been positioned. When he moved the stick so that the end was on the floor, he stopped, looked confused, and in typical senior style, announced she was really short and handed off the meter stick to Kate and looked around the room. Justin was mentally checking out of the activity. I did not know if I should step in and take charge, giving directions about how to measure and get this activity moving or just stand by. I stood by, watched, and listened.

Kate (who in the meantime had taken out a sheet of paper and pen and given it to Leon) took over measuring Niki. I suggested using a book on top of her head to locate a place on the wall for a mark to measure her height distance. As I watched, Kate started measuring from the floor, held her finger to the spot on the wall at the end of the meter stick and correctly found the mark on the wall for Niki's height. She added the two separate measures together, and reported to Leon the height for Nikita. Next, Kate measured Leon. I continued around the room and did not hear the group discuss which units to use: inches or centimeters. I believe they used centimeters because Kate measured with centimeters. After the three members were measured and recorded, they called Justin from another corner of the room where he had wandered to talk with friends. Kate measured his height and started the group on measurement of their arm span.

This group and others had difficulty with the measurement aspects of the task. They had difficulty (a) marking and measuring height, (b) consistently stretching arm span to its greatest length, and (c) using a measuring stick accurately. Once the groups began to write class members' measurements on the overhead, they noticed the difference in measuring units used by groups. Some groups gave measurement in inches, others in feet and inches, and one group used centimeters. I pointed out a need to have the class decide on a unit of measure for all the data. The class quickly made a decision to use inches because only one group had used metric units. Those who needed to report in inches were not enthusiastic about re-measuring using a different scale, and the groups who needed to convert to inch measurements set to work.

It had taken an inordinate amount of time for students to accomplish what seemed like a simple task. It took nearly the entire fifty-five minute class period for the measurement and

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[3] The desired conclusion - height approximately equals arm span.

recording to be accomplished. There was no time remaining in the period for them to find the average member in each group, or to determine the average class member. I collected materials and held off the discussion of variance. I would attempt to have the class determine a relationship between the two numbers later. That discussion occurred during the first part of the next class meeting. Essentially, I had assumed students would be familiar with measuring and that the task would go quickly. That was an error.

The next day I moved the class on to Project 2, changing the roles within the groups as instructed. Students continued to measure and gather group and class data. The measurement of thumb and wrist was less challenging than height and arm span. However, Project 3 - Stride length - was another measurement dilemma. I watched students trying to take the longest step possible and then remain "frozen" while group members measured their stride length. They did not know what to measure as the length of one stride. Was it to be measured from toe to toe, heel to toe, one step, or two steps?

I tried to keep students on task (answer questions when I felt I was supposed to) but tried to refrain from providing directions and offering information. I conducted a class discussion after the third project was completed. I intended to gather students' attention and focus their thinking on the relationship between pairs of measurements. We had three data sets: height and arm span, wrist and thumb circumference, and shoe and stride length. However, the measurements were so diverse and inaccurate they were not useful to illustrate a relationship between variables. It was difficult for me to see a relationship between the variables. Students were such novices looking for patterns in data that they were mystified about what was expected of them.

This example of one group working on the first task illustrates some of the initial difficulties we encountered using the cooperative learning model. My colleagues described similar situations that did not work well. It took each of us several days with our respective classes to accomplish the entire data gathering. Students of varied ages did not work well together.[4] The juniors and seniors in our freshmen level classes had not had success in prior mathematics courses. Their age status was sometimes apparent from their behavior. Many did not have good reading, writing, or reasoning skills and had taken our two-year pre-algebra sequence before this course. Behavior or attendance problems were the reason students were placed in lower level courses or repeated a course for the second time. For whatever reason, these students were several years behind grade level in mathematics. The population of the classes spanned a wide range of abilities and personalities. My colleagues encountered students similarly disengaged from the activities and described the familiar scene of materials not brought to class.

Students worked on the measurement data-gathering task. This group illustrates some of the problems we had from the onset enacting the CPMP cooperative learning stance. It was difficult keep students engaged in the activity and to be confident that all students were learning. In my class, the desired mathematical outcome (to determine variance and a relationship between the two data variables) and the cooperative learning outcome (establish the format and dynamic which would be used in class) were not accomplished. The data gathering portion of the investigation stretched over several days and the checkpoint discussion was not fruitful. Students' lack of measuring skill made this task challenging. More importantly, the students were not captivated by the task itself. Their measuring skill deficiencies and lack of investment in the task hindered them from benefiting from the positive part that cooperation could have played in efficiently accomplishing a task. The mathematical relationships were missed and the specific roles for students were often ignored. The students needed a great deal of time to measure each other. When they were finished; the results were grossly inaccurate and hence not useful in illustrating a relationship between two variables.

[4] The classes were heterogeneous by age and included students in 9th, 10th, 11th, and 12th grades.

CPMP cooperative role for teachers. The first lesson instructed students that they needed to learn to depend on each other for help and teachers that we were no longer the only source of knowledge in the room. Investigations were to be kept student-directed and teachers were advised to interrupt only when absolutely necessary. Teachers were further instructed to communicate only with the student who assumed the role of Coordinator in each group of four. The primary function of class time was for group work. We were instructed to conclude investigations with whole-class discussions, wherein students shared what they had learned in the investigations and teachers determined to what extent students had a common understanding of the concepts of the lesson (CPMP, 1994, p 4).

As traditional algebra teachers, we had walked around the room as classes began while students worked on a *bell work* problem or two. As we walked among the students, we surveyed homework papers to determine what needed further explanation before proceeding with the new lesson.

In contrast, the CPMP class began with a teacher-launched discussion that was not intended to be teacher-talk. The launch activity, called *Think About This Situation,* presented a setting or scenario and questions for discussion. The purpose of these discussions was to help teachers determine what students brought to the learning situation, how they were making sense of the tasks, and where they were confused. The student-teacher dialog was intended to elicit student ideas and inform teachers as to where clarification was needed. A sample of discussion questions taken from the bungee jump lesson described in Chapter 3 follow. The questions referred to a table and graph containing the price of bungee ticket and the number of jumpers who could be expected to purchase at a given price.

> Suppose that you were asked for an opinion about the prospects
> for a bungee jump business.

- What relation between price charged and number of jumpers is shown in the table and the graph?
- Is this relation what **you** would expect?

(CPMP, Course 1, Unit 2, p. 2)

This launch activity illustrates how the teacher role in the beginning of a lesson in CPMP was different from that in the ALG classroom. Teachers were expected to gather information regarding what students understood about relationships between two variables. In addition, we were to determine what students understood about representing the data in a graph or in a table. From this discussion, we assessed students' informal knowledge of related variables. Note the emphasis on **you** in the second question; it was important to convey to students that what **they** thought about a situation was important.

Table 4.1 examines some of the teacher "suggestions" taken from the Teacher Notes of the ALG and CPMP texts side by side to illustrate the entirely different aim of teacher talk in the two classrooms. Table entries are taken from teacher notes for the first unit of the curriculum. This unit served to establish the type of classroom discourse and daily routines that would predominate for the remainder of the school year. I selected instructions for teachers, which told us how to interact with students.

Table 4.1 Comparing teacher instructions and prompts.

ALG	CPMP
• Explain how to find the lowest common denominator for a pair of fractions with denominators 18 and 24. • Suggest two methods for adding a fraction and a decimal then use each method. • Remind students that neither 1 nor zero is a prime number. • Try to convince your class that willingness to try a problem and learning from one's mistakes is critical to problem solving. • Here is a problem to share with your students to show them that it makes sense to multiply before adding. • Point out that an inequality is read from left to right. • Stress the importance of making a list. (Benson, et. al., 1991, pp. T2-T43)	• These discussions give students a chance to 'make sense' of mathematics by bringing their own background knowledge (Think about this situation). Use the discussion to assess students' informal knowledge. • It is important for students to realize their thoughts are valued. • Encourage creativity and accept a variety of answers. • This would be an appropriate time to start discussing the idea of multiple answers. • Again, students may need to be encouraged that their previous answers were not necessarily "right" or "wrong." Sometimes we need to change our thinking when presented with new or improved data. • If students do not understand the term "variation," link it to their understanding of "variety" or "vary." • It is important to only interrupt group work when necessary; try to keep the investigations student-directed. (CPMP, Unit 1, pp. 2-4. 1994)

Teacher actions helped to set the tone in classrooms. As ALG teachers we were explicitly instructed to do and say things that ensured that students use procedures correctly and arrive at correct answers and that was consistent with our history as students and experience as teachers (Lortie, 1975). In contrast, CPMP materials suggested that teachers encourage and support students as they learn to think differently about what it means to do mathematics.

Consider the difference between multiple methods and multiple answers. In the ALG class, the teacher's task was to demonstrate using two methods to arrive at the same correct answer to an arithmetic problem. CPMP instructed teachers to encourage and accept a variety of answers from students, and in the process discuss the idea that problems might have more than one correct answer.

Another difference – the role played by wrong answers. The ALG teacher was expected to convince students that mistakes could be learning experiences and play an important role in the problem solving process. In contrast, CPMP teachers should encourage students to recognize that answers previously thought correct may need to be revised in the light of new information or additional data. ALG teachers communicated an implicit message to students about solutions. There was indeed a right way to do math, things might be done incorrectly, but knowing about the mistakes could improve the learning process and ultimately help arrive at that one correct answer. The contrasting CPMP position was that students were both entitled and expected to revisit and rethink problems and solutions. The CPMP implicit message: it is okay to change your mind when you learn more about the problem. This perspective would lead us to difficulties assessing student work and moving forward, a topic I investigate in the next chapter.

Yet, another significant difference in the role of the teacher is how teachers made sure that students had information they needed. The ALG teacher was instructed to provide specific information; conversely, CPMP teachers were expected to find a way to link new ideas to previous knowledge (Dewey, 1938).

The role of the teacher needed to undergo a dramatic transformation to successfully implement the program as it was outlined in the teacher guide. The instructions for teachers in the CPMP materials advised teachers to say and do things in the classroom that focused attention on the learner and away from the teacher as the pivotal person in the room. In simplistic terms, the predominant difference was the difference between having students listen to teacher-talk about what students ought to be thinking about, and teachers prompting students to talk about what they were thinking. The CPMP teacher was expected to provide opportunities for students to learn that doing mathematics was more than executing procedures and finding correct answers. In CPMP, the teachers were expected to both challenge and enable students to think and reason mathematically.

Establishing the modus operandi. The first assignment was intended to establish the way cooperative learning would be practiced in CPMP classes. The class needed to be divided into groups. We decided to assign students to groups rather than allow them to self-select. In the text, students were told to "Work with your teacher to get into groups of four." (CPMP, 1994, p 4) In our case, teachers made the group assignments and made sure each student was assigned a role before they began the task of collecting data.

We believed we should try to ensure that groups of students were heterogeneous with a range of ability reflected in each group. We wanted to avoid homogenous grouping by grade level, gender, or social status. Although we had only known the students a few days, we thought we could arrange the students randomly and avoid socialization problems that might occur if students grouped themselves with their friends.

Teachers were instructed to use 3 x 5 index cards folded in half to make stand-up role identifier cards for each group. The titles *Coordinator, Measurement Specialist, Recorder,* and *Quality Controller* were printed on the cards. Teachers launched the investigation with the group discussion, students moved into groups, and the first investigation began.

Each group member placed the correct identifier on his/her desk so other group members and the teacher were reminded of the role each student currently held. It felt artificial to place the stand-up 'Role Cards' on students' desks and insist that each student take responsibility for the specifics of each role. The teacher notes were very specific about the group size (four) and the defined roles for each student, and in the beginning, we tried very hard to follow the program.

The newly defined role of the teacher was challenging; it was difficult to refrain from the timesaving technique of telling students what to do. It was hard to know what each person brought to the task, and harder to gauge what each understood about the mathematics. Pacing the lesson was challenging because the students lacked some of the skills needed for the task, and because they socialized while making it look like they were engaged in the work. I allowed much more time for the measuring than was outlined in the teacher notes. In some groups, only one person did the work of the investigation. In some instances, that was the most "senior" member of a group but in other group combinations, the youngest student was the person most enthusiastic about the accepting responsibility student. In addition, the students showed little evidence of performing the roles on the identifier cards.

It was difficult to know how much class time to allocate to the tasks and how to determine when it was time to move on. I had questions as I watched the process: Did they really need more time to complete the measurements? Were they manipulating the task to avoid more work? If I allowed more time, would they accomplish the goal of the lesson? I did not know the answers to any of my questions. The assignment guide/time table in the teacher materials suggested the entire lesson would take four days, including two class investigations, *OYO problems*, and *MORE* homework assignments.[5] So many things were different about what we were doing that it was difficult to determine exactly what the problem was. It was clear that things were not going as we had expected. Instinct and experience told me something needed to be done differently if we were

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[5] It took us sixteen days to complete two class investigations, process the homework, and administer the quiz over the first lesson. Teacher instructions were to spend no more than five class hours on this lesson.

going to feel good about what was happening in our classrooms. Nevertheless, we attempted to continue using the specific directions related to groups and teacher behaviors.

Similar scenes were repeated in all our classrooms. The lack of success reported by teachers following this lesson produced the first of many dilemmas for us. We wanted to keep as many students as possible involved in working on the tasks and to eliminate disruptive behavior as quickly as possible. We had made the commitment to implementation as described by the authors; however, we were struggling to make it work the way we envisioned it. The students, configured in groups of four, were not doing the work and we feared they were not learning. Consequently, the first aspect of the curriculum to be modified was the configuration of groups. This was not an attempt to return to teacher-centered instruction, however this act directly and indirectly affected other aspects of the CPMP model.

Exploring the relationship between tasks and ways to organize students.

The teachers had concerns about the extent of students' participation in the cooperative learning groups and students' off task behavior. Some tasks were not engaging enough to keep a group of four students working together for a class period. Furthermore, some activities were more suited to individual work. Insisting that students work together on these activities was a factor in some of the problems we experienced with cooperative learning.

I consider several CPMP tasks to illustrate how some were more appropriate for groups of four and others better suited for individual student work. I consider the mathematical elements of the tasks, strengths and weakness of the tasks as group activity. I contrast the Bungee Jump activity discussed in Chapter 3 with a lesson from Unit 1 Patterns in Data.

First – a description of the two tasks. The Mean Absolute Deviation (MAD) task asked students to revisit the height and arm span data gathered in the beginning of the year. In each group, students were expected to find a) the mean height of the group, b) the deviation from that mean for each member of the group, c) the average of that deviation and finally, d) to explain how they determined that average height deviation from the mean. The bungee jump task required each group of students to design and build a model to gather cord stretch data for "jumpers" of varying weights. Once the data was gathered, students were to present it in tabular form, plot it as ordered pairs on graph paper, and determine a rule which modeled the relationship between the weight of the jumper and the amount of stretch in the cord. Students then were expected to use the model to predict how much the cord would stretch for other jumpers.

I use the task categories of Balanced Assessment (1999) seen first in Chapter 3 to isolate the mathematical aspects of these tasks.

Table 4.2 Comparing mathematical attributes of two tasks.

Bungee Jump Business	Mean Absolute Deviation (MAD)
Mathematical processes • Modeling and Formulating • Transforming and Manipulating • Reporting • Inferring and Drawing Conclusions Task types • Open investigation • Non-Routine • Technical Exercise • Re-Present Information • Design • Evaluate and Recommend Task length • Extended (several hours)	Mathematical processes • Transforming and Manipulating • Reporting Task types • Non-Routine • Technical Exercise Task length • Medium (10-20 minutes)

It is clear from the table of attributes that the Bungee task was more complex than the MAD task. As I compared these two activities, some questions helped to organize my thinking about the tasks and cooperative learning: How would working in a group be helpful in learning the concept/skill? Will the cooperative learning requirements of the activity contrived or necessary for completion? Is the task challenging or engaging enough to keep students' attention for the time allotted?

Appropriate task for cooperative groups. Recall the bungee jump task: a) Make and test a scale model of a bungee jump using some rubber bands and fishing weights. b) Use your scale model to collect test data for at least five different weights and record your data in a table. c) Make a graph of the data in the table. d) Formulate a rule that describes how far the cord stretches for a given weight. e) Use the rule to estimate how much the bungee cord would stretch for other weights.

The Coordinator needed to collect a meter stick, rubber bands, some assorted metal washers, a large sheet of graph paper, and colored markers. The Reader read the directions several times aloud so that the Quality Controller and the Coordinator could assemble the model bungee jump. All four members of the group offered ideas about the number of rubber bands to use, how to hook the weights to the cord, and how to measure the amount of stretch. One member of the group needed to hold the meter stick steady while dropping the "jumper" from the top. Several different members watched to see how far the jumper fell and repeated each jump several times to confirm the amount of stretch they measured. The recorder carefully noted the number of washer-weights and the amount of stretch in a table. Once the jump experiment was completed, the group used the large sheet of graph paper and colored markers to make a large graph of the data. Next, students drew a straight line to go through as many of the points as possible. They made a conjecture as to a rule that would represent the data and used the rule to make a guess about the stretch for a weight they had not used in the experiment. Each member had some responsibility for completing the task. The data gathering for this experiment was completed in one class period. Making the graph and conjecture took place in the opening part of the next class. Then, students taped their graphs up on the wall and shared the rule they formulated with the remainder of the class.

The bungee jump task was more complex and required cooperation and collaboration. The mathematics was intellectually more demanding than the computation of the MAD task. Students needed to design and build the model jump and conduct the experiment. In the MAD task, students performed technical exercises and manipulated symbols, reported results, and made comparisons with other groups, relatively low-level thinking skills. In contrast, the bungee task required students to simulate an event, to model a relationship between the variables, and use the model to make inference about an additional event, report the results of their investigation, as well as perform several technical exercises.

The students were interested and engaged in the bungee jump task. The task itself required students to collaborate and cooperate in order to accomplish it. They needed to be on their feet, holding, measuring, watching, and commenting on the scenario. The specific roles were ignored when students did this task; students wanted to take part – to measure the stretch, drop the "jumper", and to build and hold the apparatus. In fact, the roles were insignificant.

When the weights hit the floor or desk top following a jump the students could be heard to comment on the "death" of jumper as they reset the apparatus for the next customer. These were simulations of very real events that were familiar to students via amusement parks, television, and movies. The students were absorbed in the task of determining the relationship between the weight and amount of stretch. They were interested to find the answer to the "life or death" question.

The bungee task is an example of a task that was appropriate for groups of students working cooperatively. This task required higher level thinking skills, was complex, in addition, it required more than one person to execute it and to collaborate with about the results.

The next task was the intended to follow the Bungee Jump investigation and was assigned to students as homework.

> On Your Own: (Bungee task) Now think about your own prospects in bungee jumping. Suppose the falling weight is your own weight and that bungee cords of different lengths are to be tested.
> a) Do you think the amount of stretch in a bungee cord is a function of its length? If so, write an explanation of the change in stretch you would expect as cord length changes.
> b) Make a table for (cord length, amount of stretch) data. Complete the table showing the pattern you think might occur. Cord length in meters = {5, 10, 15, 20, 25, 30}
> c) Sketch a graph of the (cord length, amount of stretch) data showing the pattern of change that you would expect to occur.
> d) Describe an experiment similar to the one in the investigation to find the likely relation between cord length and amount of stretch for some fixed amount of weight.
> (CPMP, 1994, Unit 2, p. 5)

The bungee lesson assignment paralleled the work that students had done collaboratively in class. The homework task students was similar and the experience gained in the lesson prepared students to be successful on this task.

<u>A task better suited for individuals.</u> MAD task 3 (the activity planned for the day in conjunction with some TI-82 graphing calculator instruction) asked students to revisit the table which contained the data on height and arm span for all members of the class. After students were arranged in groups of four, teachers gave each a photocopy of the data. The task: a) Calculate the mean height of your group. b) How much does each member of your group vary from the mean height? c) On average, how much did the members of your group differ from the mean? How did

you find this average? d) Compare your results with each of the other groups. Which group had the greatest variability among its members? Which one had the least?

Students were arranged in groups that differed from when the data was gathered. Reconfigured groups also reconfigured the data for computation, which was the most positive result of grouping for this activity. Calculating the mean took only one student; the others waited while computation was completed by the Quality Controller and noted by the Recorder. Since students learned to find the mean of a set of numbers in late elementary or middle school, it would not be expected that high school students needed to confer before proceeding with mean computation, or determining how much each group member differed from the mean. The subtraction was elementary and did not require collaborative work to accomplish it. The third part of the problem, asked students to find an average and to tell how they had found it. The task required students use the answers to four subtraction problems in part b, and find the average of those answers. Again, it was unnecessary to require students to depend on a group to accomplish the task. The final part of the problem required communication and comparison with other members of the class.

In my classroom group members moved about the room or shouted to others across the room while making the comparison of the average difference from the mean, a task that led to chaos. It was hard to know if the students had made comparisons to all the other groups and members of each group had reached a conclusion as to which group had the greatest variability. There was so much conversation it was difficult to determine when it was time to bring the groups back together for processing. Teachers were directed to ask which groups had the largest and the smallest difference from the mean. Teacher notes suggested having groups with the largest and smallest variability stand in front of the class to provide a visual image of variability. Teachers reported that classes never got that far before the bell rang and students began to move on to their next class. This was another frustrating example of a cooperative learning activity that used far more classroom time with too little benefit from the activity.

If each student had been required to find the mean of his or her measuring-lesson group, every student would have been required do the calculation. Every student would have been required to do each part of the task, not merely write down the answer after the computation was completed. If all students had done the computations on this assignment individually, the lesson might have looked much different and taken less time.

We used the transparency of class data and asked students to provide the mean and the average difference from the mean for of the Lesson 1 groups, as well as the amount each individual student deviated from the mean of the class. The teacher recorded the number answers given by volunteer students on the overhead. As this transpired, the calculated and recorded means provided feedback for the students who had not replied to teacher questioning. Other students could check their work because at least two or three other students in class would have done the same calculations. The teacher in traditional walk-about monitored the time used for the calculations, thus avoiding time off -task waiting for groups to appear finished. The focus remained on variability by having the individuals with the greatest and least differences come to the front of the room.

This problem, done in class by groups of four, illustrates why students resisted the forced grouping. This task was not challenging; it was not complex or lengthy enough need collaboration in order to accomplish it. There was no real need for all students to be engaged in the computation; the specific roles deemed that students would defer to one member to do the real work of the task. It appeared that one member of the group worked while the others copied; however, the role assignments were conducive to one person doing the computation and sharing the answers. Neither the subject nor the elements of the task were challenging enough to engage four students.

It is reasonable to expect students to have a greater interest in working with data about themselves rather than data from a census table or almanac. "Which group [in this room] has the greatest variability?" This question did not stimulate student interest simply because it was data about themselves. The mathematics was trivial, and the use of groups in this exercise was counterproductive. Students used the opportunity to engage in off-task activities that were difficult to detect as being off-task.

The MAD activity illustrates a task that was not engaging or challenging enough to use with cooperative learning. Each student would have benefited from hands-on participation in learning to use the graphic calculator's capabilities to find the mean and to process data organized in lists.

> The tasks that follow were intended to be assigned after the MAD investigation. These illustrate how effective the cooperative learning activity was in preparing the students for the individual assignment.
> On Your Own (MAD task): At exactly the same time, Tony and Jenny checked the time on the clocks and watches at their houses. The times on Tony's ten clocks were 8:16, 8:10, 8:14, 8:16, 8:12, 8:15, 8:13, 8:17, 8:15, and 8:22.
> a) Calculate the mean time on Tony's clocks (What is tricky about computing the mean?) Calculate the mean absolute deviation.
> b) Jenny had the same mean on the ten clocks, but her mean deviation was 10 minutes. Find an example of ten times that could be the times on Jenny's clocks.
> c) What do these numbers tell you about how useful it is to look at a clock at Tony's house and at Jenny's house?
> (CPMP, 1994, Course 1, pp. 67-68, 70)

To do the 'tricky' part of the assignment students needed to notice 8 o'clock was the zero point and the only the number of minutes past the zero point were needed to find a mean time past eight o'clock. Once that took place, part (a) was not difficult to find the MAD. The in-class activity did not address interpretation of deviation from the mean and part (b) and (c) of the assignment went beyond the skills needed to be successful with the problems students had done in class. These required different thinking skills, students could have benefited from collaborative work on these questions had they been the ones we assigned to work on in cooperative groups.

The teacher guide stated OYO problems should be assigned for individual work and Investigations were to be done by students in class in groups. We followed the curriculum guides without doing the kind of planning and thinking we might have done if we had not made the initial commitment to implement the curriculum as intended.

Adapting the CPMP Cooperative Learning Model

Group size, selection, and roles. When we began, we followed the instructions in the teacher materials to the letter. We placed students in groups of four, assigned each a role, gave them an identifier card for their desk, and informed them they would remain with the same group of students until they completed a lesson and then groups would be reassigned. Productivity of the group was an immediate issue. The size of the group and the selection of members were problems. We had made a collective decision that teacher selection was preferable to allowing students to self- select groups. We had no specific guidelines regarding ability grouping, but assumed that because the curriculum was designed for heterogeneous groups, we should assign students of varied abilities to work together. The size of the groups did not vary now. However, we quickly changed procedures after our initial contact with students and the materials. In some instances, four members per group did not seem workable. We changed the group sizes, and the selection method in our individual classes to suit the needs of the personalities involved.

We had Professional Development days on September 19, October 17, and November 28, and at each session we expressed problems with group size. Our September 19 professional development session was our first formal meeting following classroom experience with the curriculum and students. The first item on the agenda was *Concerns*, and the first item to be mentioned was size of groups and participation in cooperative learning groups.

> Ted: When one student is absent a role isn't filled, and not all students were willing to accept responsibility for a portion of the work.
> Tia: Groups that have students with chronic absentee problems are having trouble moving forward.
> Ed: I n most of my groups, one person works - the others don't.
> Ted: Some of my classes need groups of three, not four. {PD, 9.19}

We were seeing evidence that the roles were not serving the purpose for which they were intended. Students in a certain sense were given permission by the descriptions of the responsibilities of the roles to limit their activity to that role. Roles placed students in charge of one aspect of a task; if they accepted role responsibility, they did no more than that job entailed, then sat back, and waited for the other group members to do their assigned parts.

In October, after more experience in class with the curriculum, other issues about cooperative learning surfaced. We were seeing groups of students who worked much differently than Tia and Lea had described from their summer session. Real students, as opposed to teachers roll-playing students, had different reactions to cooperative learning. Individual personalities and willingness to participate in the process played a role in the dynamics and productivity of our groups. We were having problems, which were unresolved by the teacher's guide. Not all groups worked well. Student behavior problems hindered the effectiveness of the group model. Salomon and Globerson (1989) described some "effects" which we saw in our groups. The free rider effect, where one group member allows the others to do all the work aptly described Justin in the measurement task. Other patterns of behavior we observed included the sucker, the status differential, and the ganging-up-on-the-task effect. In these group behavior patterns, one higher ability member does not want to be used by the others, the highest social status members take control, and members decide they want to exert the least amount of effort to accomplish the task, respectively.

Most questions remained unanswered. We had agreed on four students per group, selected by the teacher, and heterogeneous groups; however, there still seemed to be inconsistencies in the way we operated our classes and uncertainty about enacting the agreed upon policies.

> Lea: Groups are resisting certain members of my class.
> Ted: I think pair assignments need to be an option.
> Ed: Pairs then sometimes meld into fours.
> Kay: What about choosing partners versus assigning them?
> Ruth: I am uncertain of the criteria we should use to make assignments into a group. Do we use same ability levels? On the other hand, do we mix levels so there will be a good student in each group?
> Ted: What can we do about removing problem students from a group once the groups are all working? That changes the balance and leaves one of those roles unfilled. {PD, October}

Some of the difficulties were evident in this exchange about the way that students worked or did not work in their groups. Note that teachers had comments and questions but were not sharing solutions.

I shared with the others that in early October, I had attended a meeting of teachers from other field test sites. Art Coxford, one of the authors of the materials attended. I communicated what he had advised concerning pair assignments.

> You don't have to use groups of four all the time. If it's a problem, do what you would normally do when you start something new. Start with pairs and work up to groups of four.

Although this was the antithesis of the teacher manual and our instructions from our summer institute attendees, it planted a seed of flexibility.

By November, most of the teachers had settled into their own pattern of using groups in their classes. Our classes had become amalgams of different sized cooperative learning groups and students working independently. The group's decision to make teacher selection the preferred way of choosing group members was not unilaterally implemented. The autonomy of the classroom prevailed. We had not discussed the merits of changing our selection method; however, teachers had done what they felt they needed to do in individual classes. Therefore, some teachers assigned students to groups of four, while others allowed students to form groups, pairs, or work on their own. Students changed groups at will in some classes. Moreover, in some cases, the clearly defined roles for groups of four students were disregarded.

When we began the November 28 professional development day, the teachers had more to say about the problems they encountered with groups of four, teacher selection of group members, and the changes they had made in the class format. We were beginning to be reflective regarding how the pedagogy was affecting our progress and had taken steps to remedy problem situations in our classrooms. However, some of us felt much more comfortable making modifications than others did. The tension between the agreement to implement and professional judgement was evident,

> Ed: My initial response or observation on the groups -- one works. The others copy. I found choose a partner worked better. Quiet, non-aggressive personalities and similar levels of ability, like A-B-C students, will group themselves and work together. The kids have different abilities and styles. If they group themselves, they choose someone they can work with. {PD, November}

This went counter to the heterogeneous-nature-of-group-selection, but avoided one of the negative effects, which might occur with students working in cooperative groups. When students grouped themselves with peers of similar ability no one student stood out as the smartest one. When students with like ability were grouped together they avoided the one of the negative aspects of heterogeneous groups, the "sucker effect" wherein one higher ability student does not want to be used by other members of the group (Salomon and Globerson, 1989). Ed and Ted were much more willing to trust their judgement and experience when it came to handling classroom situations when CPMP procedure did not fit with their instincts.

Lea described difficulties she had in class with students who wanted to work alone. She also did not know what to do when members of the class refused to work with a particular student. Ted and Ed offered her suggestions, which would have changed the way groups were configured in her classroom. However, Lea had a problem with changing the established cooperative group position of the CPMP materials. The changes some of us made in the cooperative learning stance of the curriculum were more objectionable for Tia and Lea than for the other teachers. These two expressed strong feelings regarding modifying groups of four in class. Lea's comments made me think that she felt she had violated a sacred promise rather than an informal commitment to the implementation plan. Her comments were confusing, but it was clear she was firm in her resolve to use cooperative learning groups in her classroom. Tia expressed her sense of the conflict between the ideal and practical at the end of this exchange.

> Lea: What about the kid who wants to work alone? And what about Katie Smith? *Nobody* wants to work with her.
> Ed: Let it go. (Students working in groups.)
> Ted: Try having the kids who can't or won't work with anyone else work alone. Start everyone, then work with those kids. Be part of their group.
> Lea: I need to make a confession. I'd rather do this [use cooperative groups]. I'm tired of fighting. If I give up on groups, it's quitting; it's wrong. I'm feeling like it's wrong to do this, to let students work outside of groups.
> Tia: I got an important message from the people at Western this summer. It is mandatory (groups), but that reality is disconcerting. I feel like a failure by not doing all group work. {PD, November}

The teachers had made the commitment to using the program; they had not expected that doing so would mean abandoning professional judgement and experience. The feeling of failure that Tia expressed verified her strong commitment to the agreement, in spite of what was happening in her and others classrooms. When she saw it was not working in her own classes she still felt compelled to continue with the program and deny her experience and training.

Tia and Lea had experienced the program first hand in the summer. They knew how it was supposed to look and they were more committed to working to make their classrooms look like their summer classes. The contrast between their summer experience and our classrooms was unsettling for them. They had been in a class of teacher-students who were willing to use new classroom procedures, who already knew the mathematics, and who were excited about a new way to learn and teach. Their summer classes were examples of the best possible combination of learner and subject matter. In contrast, we were dealing with teenagers who had varied degrees of mathematical ability and willingness to learn. Moreover, many students had probably never experienced mathematics instruction that was not teacher centered. They saw school as the opportune place to socialize. Group learning gave them plenty of opportunity.

It appeared that we had tacitly decided it was necessary and acceptable to modify the four-person group policy. We adapted ways of grouping students barely five weeks into the school year and continued to change it throughout the first semester. It followed that we needed to adapt the student roles. This had an effect on the *Checkpoint* discussions. We used pairs, triples, groups of four, and allowed some students to work independently. The variety of group configurations negated the specific roles students assumed in the investigations. Hearing reports by the group recorder at the end of investigations was unmanageable; there were too many sectors to be heard. Therefore, *Checkpoint* discussions were omitted and we had to devise another strategy to check for understanding. We resorted to having students write out their responses to the Checkpoint questions and we collected them. We thought this would hold all students responsible for participating in the investigations so they could answer the checkpoint questions.

We had a difficult time keeping students occupied and engaged in the cooperative learning activities while maintaining what we believed to be a learning environment. Our experiential pool of knowledge about teaching mathematics equipped us with ways and means to keep students engaged in class activity in a traditional classroom. However, we felt we were supposed to avoid traditional teaching and we did not have a new set of techniques in place to orchestrate these lessons. We felt constrained by the instruction to communicate only with the Coordinator in each group, and encouraging groups to utilize their classmates to solve problems meant lessons took longer while we waited for students to figure out things in their groups. From the first lesson that was intended to take no more than five class hours (for us sixteen class periods) to the quizzes which were supposed to take twenty-five minutes and our students demanded fifty - everything took longer than it the teacher guide suggested.

In our meeting to plan for the mid-year exam, we came face to face with the lack of progress that we had made by that point in the year. We constructed a mid-exam that covered significantly less then half of the material designed to comprise a year of study. Out of seven units, our exam would assess students knowledge of less than two: *Unit 1: Patterns in Data* and part, but not all of *Unit 2: Patterns of Change*. It seemed we were treading water more than we suspected. The realization that we had covered so little of the material had an effect on the way we conducted class for the second semester of the year as well on our attitude about maintaining the format of CPMP.

Modifying the teacher role. We struggled to be consistent with the role of teacher as facilitator and coach. We were falling further behind where we believed we ought to be in the curriculum and we were unsure of what students were learning. A lesson on linear functions and their graphs spawned an animated lunch discussion about teaching on January 25 about the success of the lessons of the past few days. We seemed to be moving back to teacher-telling and feeling excited and comfortable with the familiar role. The assignment consisted of four groups of equations in which students were to determine the shape of respective graphs and to identify common graph characteristics and common properties of the equations. Students had been assigned a group of equations and were to determine characteristics of the graphs by using their graphing calculator.

Students were interested in the "experiments" and had asked to be allowed to do more than one. Ultimately, the students were to make a connection between the nature of the equation and the shape of its graph. We were enthusiastic as we described the part we had taken in class sessions and I suspected something was different. In my notes, I reflected on what we had to say about teaching the lesson.

> Teachers seem to have an enthusiasm about teaching this lesson that has not been present so far. There were smiles and laughter as the discussion went on. I suspect that the old and comfortable ways of teaching crept back into the classroom. Lecture and example with concrete algorithmic steps let teachers and students fall back into comfort zone teaching and learning styles.
> {RN, January 25}

Lea was excited to share details of her class and confirmed what I had thought might have occurred in classes.

> Ed: There is some meat in this one!
> Kay: There is something they can get interested in.
> Lea: This is the best lesson I have had so far. I think I went beyond what the authors intended. I am so used to teaching pre-calculus that I went into talking about the shape and slope and y-intercepts without it being part of the lesson plan. Students were participating like they never have; we had a great discussion.
> {Lunch January 25}

That same January day I recorded in my journal a recap of a conversation in the hallway just after lunch. I noticed enthusiasm and energy about teaching this lesson and suspected Tia would be in front of the class teaching in a much more traditional manner for this lesson.

> Talked briefly with Tia in the hall. She was on her way to class and was to begin this lesson for the second time today. She was excited about doing this with here 6th period class. Maybe it would be something that they would cooperate with and do with her. Her third period class had had a great lesson, by her description and she has had problems all year with her sixth period group. These students are discipline problems and she is in need of more control with them. She showed the same kind of positive body language as the others. Quickness of step and smiling as she headed off down the hall to class following lunch. {RN, January 25}

This shape-of-the-graph lesson and the very familiar slope and y-intercept lessons that followed it were memorable for the participants. We returned to the slope lesson our conversations several times. In our April professional development day, a conversation that began with a discussion of the students doing quality work on the MORE problems which had been assigned. When we discussed the need to demonstrate for students how a completed problem should look, the conversation turned to traditional teaching. We were aware of how we slipped back into traditional method when things were either familiar or difficult. We did slip back, even when we did not intend to do so. We were under the impression that we were not to move back to teacher-centered classrooms. The way we interpreted the CPMP model did not include teacher telling. However, going over a problem in class sometimes turned into a traditional lecture.

> Lea: ...You were saying, you model something, That's almost like the old tradition, we're talking about sometimes where you jump back in to your old ways because its easier for us. That's almost the way we get back or we can get back into our old ways, yet it may not be an old way. [We say things like] *Lets go over some of these MORE exercises that you did as homework* and model it. Yet, it's a MORE exercise. Something they had to do not

a new thing. Something that they are attuned to and that's probably all the lecture you are really going to give them and it's not really a lecture. Do you understand what I'm saying?

Ruth: Back into the old comfort zone with the way we used to teach. I found myself, when we got to the linear models unit, shifting over. The material was really doing slope and y-intercept, and it was changing y and changing x, and I thought. *Oh! I feel so much better!* Then I really stopped to try to analyze. What was I doing that was making me feel better in the classroom? I looked at what I was doing and I just went right back to my comfort zone. *I'm going to talk to you about how you do this formula.*

Ed: I think I did the least, but I did some of it. Most of us, when we got to the slope and intercept, we went right back or at least a ways back to traditional algebra presentation. I mean rise over run was one of the first things out of my mouth even though it wasn't in the text

Lea: I went the traditional way because I'm used to it. And I tried so hard not to go back to it. They learn anyway, so I guess I didn't need to stand there and lecture all that time.

{PD April}

The conflict teachers were feeling was evident in what was almost an apology for teaching a lesson that included a formula and a catchy phrase. The phrase "comfort zone" seemed to denote something negative that one should be learning to leave behind, even though that comfort was gained through years of teaching experience. The commitment to try this new program had somehow made teachers feel there was something wrong if they used methods that had worked well in the past.

We had been so convinced by our early exposure to the CPMP instructional model. When we were the students in that slope investigation the teacher who modeled the program for us did not slip into teacher telling, Tia and Lea came back from summer math camp with descriptions of classes where all of the investigation was inquiry bases. They reported that their teachers never reverted to providing information and were always able to orchestrate the discovery of the appropriate mathematics. The CPMP teacher notes reinforced that we were not the source of knowledge in the classroom. We thought we were not supposed to revert to lecture under any circumstances. Nevertheless, it felt like the right thing to do in this instance. Is it any wonder that we were feeling guilty for taking on the old role? Moreover, I felt guilty for enjoying it!

Finding ways to make the cooperative learning model work was a constant quest. We recognized that things were not working as well as expected and in an effort to increase student productivity, we employed greater teacher control

The familiar linear equation y = mx + b as well as traditional teaching came back into the conversation again in our May meeting. We were again feeling we had fallen far short of the amount of mathematics we should have covered as we saw the year ending. Teacher responsibility for covering the curriculum was firmly planted in our minds.

> Ed: I don't feel good about the amount of mathematics we have covered.
>
> ...
>
> Ruth: I've been doing the curriculum as it was, at least the assignments, just plowing right through the book, one page right after another. We're getting to the point [in the year], like Ed said, I always feel a little strange when I talk about how much mathematics I've covered. In addition, that takes me back to my days of traditional: I *will stand up in front of the room and do the mathematics.*
>
> Ed As long as I have given notes on pages one to three hundred; I've done my job.
>
> Ruth: Exactly! I've covered the curriculum, and I'm absolved from the responsibility. If they don't know it, it's not my fault because I did my job. I've gone through this just like they said. Not everything the way you're supposed to do it, but I have gone through the assignments the way I was supposed to. I keep thinking to myself...I remember when we were doing the linear equations. Back to the mx + b form, and I thought *I can do this.* Then I trotted happily off to class thinking I was going to have this really great lesson. I had it in my head there was going to be this wonderful synthesis of this material and what I knew how to do from before. And, it was a disaster!

Everything I wanted to do from before was in conflict with what this was trying to do now. But, I couldn't identify, standing on my feet, what the conflict was. ... I just continued marching right on through telling them all the important stuff. I just had to save time. I just thought, I couldn't spend this much time on this topic because here it is the end of February and before we know it, it's going to be June. I won't have done my job the way I saw my job. ... I'm not comfortable with what my job is.

...

Ed: Almost all of us, whenever we felt uncomfortable with trying to do the curriculum the way it's written, our response was to fall back on ways that we did things in the past, rather than work through those issues. I don't know, but to a degree, you gotta do what you gotta do. You have to survive from day to day. Maybe our advice to the people of the future to look at way if things aren't going as well as we like, try not to solve them by going back to the tried and true.

The other thing was, I tried real hard to present that slope stuff the way the book had it, but I slipped back a little bit a couple of times. But, I walked up in the halls and I saw an awful lot of rises over runs and delta X's and delta Y's.

Ruth: I had a problem with trying to do the program like it was outlined and then running into the slope formula handed to them in a MORE problem. It was out of the blue $x_2 - x_1$. Where did that come from? My kids hit it on a day there was a sub, the sub tried to teach it the way she remembered it and she didn't remember it right. The kids were really confused. They had it backwards and upside down. I don't think my kids ever got it straight. They weren't used to a formula just dropping in from nowhere.

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Ed: The other thing is, that's a MORE problem. That should tell you something, it's not a core piece of knowledge. Hey, we taught you to look at lines and rates of change, and by the way, here's this antique formula, see if you can match it up with anything you've learned so far.

Lea: Another thing, what if I didn't pick that MORE to assign? Would they never see the slope formula? Is that right or wrong, good or bad? Do the MORE's mean that it's not necessary for their livelihood? Or do we make sure that we pick out those kinds of problems so they meet it again later on? {PD May}

We were experiencing tension between doing what we had learned over years of experience and the leaving the development of a big idea to students in cooperative groups. We found the slope formula relegated to an exercise, one, which might not be assigned. We lacked confidence that students would discover the importance of the rate of change in the world of mathematics. The need to take control of the classes was strong. However, just as strong was the need to apologize for acting on professional judgment and teaching experience. They were unsure these materials would produce the kind of mathematical knowledge we expected.

In the second half of the year, we settled in to a pattern of classroom operation that was workable for each of us. The standard group of four with assigned roles was rarely used. In the following collection of comments from professional development days in March, April, and May we reflected on what happened in our classes. We described groups of our students acting out the free rider, and ganging-up-on-the-task effects. We shared how we modified the cooperative learning model in order to make it workable in classrooms and provided rationales for changing class procedures. The wake up call at mid-year had provided the catalyst for us to use our experience and our professional judgement in class. Not all the teachers were comfortable yielding to the temptation to be traditional teachers. in the end each of us moved from complete commitment to the new program to a hybrid form of instruction.

Ted: I remember when we first started out. We followed the rules in the book, get the kids in groups, have them work together - one person recording, one person would hand in a sheet of paper with all the results on it. Then - not to long ago I said - Man! You get a group of four people and two people are doing all the work, two are riding the fence - this isn't working, so I went back to the lecture.

So, I go to the head of the class and start talking and pointing out concepts, things I thought the kids should know. And then, I found out it didn't make that much difference in performance. Honest to God! {PD April}

Recently, we started this last book, I said, No! It's better to have the kids work it out for themselves. The ones that ride the fence, let them ride the fence - they're not going to do the work whether you are up there bossing them around or if they are working in a group. They're just not going to perform. {PD April}

Ed: I kind of feel the same way. The difference is what you hold yourself responsible for. If you stand up there and do it, you can say, well at least I did my job. And if they don't learn it they haven't' done theirs. But if you stand back and say, okay you've got to do it, but then what am I doing? If they're not doing it, and I'm not doing it for them, then it must be my fault because I didn't do anything. Even when I knew no one was listening and I was standing up there, in the past I could say, well I'm doing what I'm supposed to do. {PD April}

Lea: This summer that came up many times. You're going to feel that way, that you want to go back to the old traditional way of teaching, but try to fight it. Don't do it! Kids are going to learn in spite of you or not learn in spite of you so you really have to learn to fight that. {PD April}

Ed: The biggest problem I have is wen I'm standing up front running the show, it is easier for me to keep the ones who have no intention of participating quiet and from interfering with other people. When I put them together it is harder to control that sort of thing. {PD April}

...

Lea: It's easier to be in front of the class and teach like we used to because we are used to it. It's a lot harder on us and on them [students] probably, to be ingenious enough to not say so much. {PD April}

Ted did not have any trouble making adjustments in the class format to suit what he believed the students needed. He decided to return to traditional lecture format but that did not solve the problem or produce better results than students working in cooperative groups. At this point in the year, he did not hesitate to use his professional judgement and experience to try to improve on the situation but returned to groups when he determined that the students had made decision to be involved or not. An interesting side benefit of the collaboration days was how teachers became more reflective about their practice and the impact of their teaching methods on the learning and behavior of their students. Ted was aware of his decision to change technique and that his position and status in the classroom changed little about some students' behavior.

Ed was conditioned to be held accountable for his students' learning. He felt obligated to be pro-active to ensure students learned. If students learned, then teaching must have taken place, and traditional teaching was defined by teacher telling. The feeling was that if a teacher did his/her part, then the teacher no longer had to own responsibility for failure. Lea provided negative reinforcement for falling back on trusted teaching practices and attitudes, compounding the myriad feelings that were lurking among the teachers.

The pressure of time and its constructive use motivated teachers to alter class procedures. Teachers developed styles of managing class activities that had stricter time constraints on students as they worked. The students were in groups, were without the strict role assignments, and were given the daily assignment in bits and pieces rather than for a week's time.

> Tia: I found that giving a lengthy investigation for the kids to do lends itself to kids getting into socializing. But if I assign one problem within an investigation and assign 5 minutes - *You have 5 minutes and you have to come up with something!* - Worked a lot better for myself. I'm see-sawing in and out of the leadership role all of the time. This process lately has been working as far as kids keeping on task. First semester I did a lot of the group teaching, a lengthy one, or two day assignment, and an investigation. In twenty minutes they were all talking about basketball, cars, and playing computer calculator games, and I was putting out brush fires all over the room trying to get [them] back on task. This is better, assign one or two problems, ten minutes later we discuss it, here is some more, now we're going to discuss it.

Ruth: ...it's like we also ended up teaching these kids some time management skills. They are, for the most part, ninth grade, fourteen- fifteen year olds, and we expect them to take on a task that requires connecting one class period, an evening, another class period and another evening without some direction. They don't have those kinds of skills. I think maybe if we had started in the beginning of the year doing some of that we would have been better off. They would have learned a bit more about how to manage time and be productive.

Kay: I think that's how we got into the pattern of taking so long to do things-this is our first time with the curriculum- that's one thing. I watched the kids that seemed to be working and they would say, *Oh, we're only on number two. Can we have another day?* Okay you can have another day. And before you know it, you are giving them 5 days to do seven questions and even then, when you get them together to talk about it you have kids that haven't done it.

...

Kay: Their time management skills are very poor.

Ted: I'm thinking that's probably something you should work on next year - this time management thing that Tia is talking about - time management, where she is the manager. If we had started out the way that Tia is talking about and then wean them off a little bit at time...we'll do it my way this time, next time we'll do it their way.

Lea: It sounds like it would work better but...we are really asking them to do a lot. I don't mean the amount of work; I mean the quality of work, the type of work. We're asking them to be responsible in a group. I mean, we're really asking them a lot.

Ted: We are asking them a lot more than they ever got before.

Lea: Yeah! And we are expecting them to be good students by staying on task in a group of their peers. It's like impossible; you got to be kidding. *I want to talk about this weekend.* They almost need to be taught that and I don't think we thought about taking the time to teach that.

Ed: I almost don't know how.

Kay: There isn't a way to teach it other than to model it by things, you know, 'you have five minutes to do this one and then lets talk about it. Now you have fifteen minutes to do the three in your group and then we'll stop and talk about it.' Maybe we don't give them enough time to model it then. I was real loosy goosey on how to time that.

Ed I think the answer is that it isn't so much that it's going to give more success with more students, I think the advantage is that it stops the students who are interfering with other students from interfering as much. Because they don't get a chance to get rolling and the kids who are prone to be pulled away are more willing to go where you want, that their easily influenced. The influence doesn't have much time to sink in or take effect. So I think by managing the time a little bit better is a way of dealing with that faction that I don't think any of us know how to get to right now. . {PD May}

Adapting to Change

The combination of new material and new pedagogy startled everybody. The students established a pattern of behavior early in the year when the teachers were making their most serious attempt to orchestrate the specific model of cooperative learning. Coupled with some tasks that were not challenging enough to require cooperation and collaboration and roles for group members that were contrived and at times trivial this classroom pattern served to extend and delay progress. Teachers assumed students would accept and enact the roles and that the all tasks would be challenging and engaging for groups of four. Nevertheless, they did not and they were not, respectively. As the end of the year was on the horizon the need to take charge overcame the desire to enact the program exactly as prescribed and structure class in order that the students learned to operate in an inquiry environment. We believed the mathematics to be sound and well presented, but the cooperative learning model fell short of student and teacher needs.

<u>Student resistance.</u> Students were as set in their ways to do math class as the teachers. Students were familiar with the standard format of class, which consisted of a bell work problem, new lesson, practice problems, and a homework assignment to be started in class and finished at home. They were equally accustomed to the teacher-as-expert both in subject matter and in

methods to communicate knowledge to students. We were trying to overcome the momentum of that model and were having limited of success.

> Lea: I think that one of the reasons the kids were showing resistance was not knowing. Not knowing how to behave in a group or maybe it was too much freedom and they didn't know exactly what to do with that freedom. They weren't used to that, they weren't used to not doing whatever they wanted whenever they wanted to do it. As long as they finished the activities in class, they wanted to do the homework in class. So, they didn't know what was expected of them and they hung on to the old ways. *Okay, lets appease her, let's get it done as fast as we can.* So they divided up the work. You take part number one, you take part number two, and you take part number three. And then we'll all put it together and we'll be done really quickly and then we can get back to what happened this weekend. They'll do what they need to do to appease you, to get you off their back for a while. Then they go back to their old ways. They were conditioned for so long to do it this way, and now we expect a big responsibility from them in this new course, yet they don't' know how to react to that. {PD May}

Students were able to complete an assignment when they ganged-up-on-the-task, especially when the task was not complex enough to require collaboration and cooperation. Students found a way to fulfill the classroom obligations while doing very little thinking about mathematics. Many times the teachers lamented, "One student works, the others copy!" The original roles made that much easier. Lea continued with a possible explanation related to the role assignments, but Tia clearly disagreed with her about student intentions.

> Lea: You know what I think? At the beginning of the year, remember how they had a person that wrote all the things down as people were saying them and then everybody copied them. Maybe that's some of the stuff that's being reinforced. Let's talk, he writes it down, let's copy it... The reason for them copying as much as they do is maybe by virtue of those cards, where somebody's the recorder and somebody's coordinator, and somebody's whatever.

Tia: I think kids know darn well when they are copying.
{PD May}

Tia continued with her observations of students in the cooperative learning groups and their reluctance to accept the specific roles. Her observations on her students were consistent with the pattern we all saw in our rooms. Students found the roles insignificant to the task and although we assigned them, they did not perform the specific aspects of the role.

Tia: I also found some resistance to this new curriculum because of the group learning situation. They were not very comfortable with it; they were unclear as to what their expectations were. Even though we carefully set up roles within a group - you'll be doing the recording job, and you'll be doing the coordinating job, etc. They found this to be very awkward – contrived - we definitely left their comfort zone for a learning situation, so there was resistance to performing the jobs that they had been assigned, or that they had agreed to take on. Therefore, they weren't doing what they were supposed to be doing.

Ted: I think one of the things we should have done in the groups right away is reorganize them as fast as we saw the dysfunctional problems. I hung on too long to that whole thing. Kids not working in a group, if your not going to work, then we'll find something else - anything to motivate these kids to get involved in the group process. I think the group process would be wonderful the way we are talking about it. The problem is reading skills. Kids that work together and if a reader or two in the class are in their group, they are going to benefit both in reading skills and understanding. It would help. That way one person's weakness and the other person's strengths work together – that is what I think the group is all about.

Tia: But I don't think the kids perceive it that way. I would notice something when I assigned several activities or an investigation that had several activities within the one problem. Than, I would visit some groups and they would have divided up the activities, so that they were not all participating and gaining the experience we were trying to provide for them. Just so that they can get it done.
{PD May}

Teacher reflection on our efforts. The students were able to manipulate the system to their advantage because we ignored our professional instincts. We now knew we had stayed too long with the authors' position on class procedures. In addition, it had been detrimental to the learning process. We were quite the "reflective practitioners" at our final professional day in June. I asked the teachers to share things that stuck out in their minds as they thought about the year. One central theme was that we tried to hard to stick to the program and ignored our instincts and experience.

> Ted: I think the biggest thing that came up was that we tried too do too good a job We tried to follow the curriculum too close. We did not really rely on some of our instincts that we felt over the years as teachers to modify and fit to our particular ways of doing things. All those things that you learned over the years went out the window when we got the new curriculum. We tried too hard to follow the curriculum.
>
> Ruth: I don't think that any one of us would have been too comfortable with not following exactly what they had written down including the groups of four. If Lea and Tia had come back from the summer and said so.... It sounded like we had to get in there, assign this role, do groups of four, and don't deviate from that.
>
> Kay: Maybe the guidelines in the book should have been different. You might want to start with pairs.
>
> Lea: Obviously you learn from your mistakes. But not once did the Core Plus people change.... This summer, when we were taught the material, it was very, very important to get into groups of four and go through all the material.
>
> Kay: Next year, I'm pretty much going to throw out the formality of it.... I may not have the little tags going around. I will try to get them to take on responsibility. Maybe not have them in groups of four; just choose a partner to start ...walk around to see that they aren't copying, and then ease into groups of four.
>
> Ed: I found the whole construct they gave us to be artificial...To me it was stupid and artificial and I think it seemed that way to most of the kids too, "You get to be the recorder." you know?
>
> Ruth: I think one of the things that slowed us down in the beginning – we really were spending an inordinate amount of time trying to get kids to cooperate and go with

> the program. We were spending half our time in discipline and trying to get them to sit down and keep on task...A lot of time was lost and I think it frustrated all of us because we knew we were getting further and further behind and we couldn't help but compare with what we had done in years past – even though it was a different curriculum. We all have a sense of how we pace and how much can happen in a class period, what's reasonable to expect in a homework assignment. So, we messed ourselves up. {PD June}

Summary

As the year closed, the teachers reflections confirmed that groups or four for all class activities had not been a viable model and that considerable time had been wasted attempting to establish the cooperative learning model with its accompanying roles. Some students worked better with partners and others balked at the forced matches. The roles with specific responsibilities were considered contrived and trivial by both teachers and students and were rarely utilized to advantage. Teachers had a difficult time insisting that students participate in a process they did not actually support. The time students spent off-task contributed to the snail's pace at which we were able to proceed in class, however student misbehavior was not responsible for all the delays. Some tasks were counter productive when done by groups of students and would have been handled more efficiently by individuals. We spent the better part of a school year denying our professional experience and expertise deferring to the constraints of the new curriculum. It was not until the last quarter of the year that we consistently took a proactive role in managing the activities in the classroom.

At the end of the year, the teachers were frustrated. We had been committed to the methods and materials of reform and were disappointed in the results. We felt we had failed to provide the desired amount of instruction and that we had not successfully implemented the materials in the manner we thought they should have been used.

In the next chapter, I examine why we had such a difficult time moving forward in the curriculum. It was hard for us to make the decision to move on to the next topic. It was hard to know what students had learned and in retrospect, it was easier to understand factors that contributed to our difficulty. I examine how the cooperative learning model and the radical difference in the materials contributed to the problem of assessment and decisions to move forward.

CHAPTER 5

IT'S ABOUT TIME
....OR IS IT?

Introduction

As stated in chapter four, we had not been able to complete the full course of study for CPMP Course 1. In fact, we only finished slightly more than four entire units out of seven. In itself, this was not unusual as many mathematics courses include more material than can be reasonably covered in one school year. However, the teachers felt we had failed in our mission to implement the new curriculum on several counts. We had not been able to teach what we thought was a reasonable amount of the curriculum and student performance did not improve as we had hoped.

In this chapter, I focus on the issue of time and I consider factors related to the amount of time we needed to teach the CPMP content and the amount of time students needed to learn it. I discuss how assessing student learning and grading student work consumed teacher time and take note of how we adapted the instructional model to manage classroom difficulties and save time as we became increasingly aware of the shortfall in both quantity and quality of students' accomplishments. However, was it simply a matter of time? There were other issues that were masked as time consuming tasks. The primary issues revolved around how difficult it was for us to determine if students had learned enough to move on to the next topic.

Regardless of content or curriculum, the classroom teacher makes decisions that control the pace of instruction. The teacher's role includes offering activities designed to facilitate learning, determining what students have learned, and deciding when it is appropriate to move to the next topic or concept. These decisions rest heavily on what teachers are able to discern that students understand and on what students need to know in order to move on to the next challenge. In general, teachers scaffold new learning on the shoulders of concepts students have a firm grasp of and experiences with which they are familiar. Cooperative learning as the standard classroom protocol and the radical difference in the CPMP materials played a significant role in the difficulty we had gauging what students understood and making decisions to move on in the curriculum. Instructional decisions to move on were affected by several factors: lack of participation of students in the learning process, the reliability of student work as accurate representation of their mathematical knowledge, and low student achievement. The concrete measures of success that we used were students' report card grades and the portion of the curriculum we were able to teach in one school year. Assessing these standards left us feeling that we had fallen short of our school improvement goal. Student performance was far from satisfactory and each lesson took us nearly twice much time to cover as the teaching guide suggested. If we were spending twice as much time investigating the mathematics as the curriculum developers anticipated, then why were our students performing so poorly? Moreover, why was it so hard for us to feel our students were ready to move on? In this chapter, I look at some of the reasons our endeavors and difficulties with the innovative curriculum appeared to be hinged on issues of time, but in fact, were related to knowing what students needed to know and what they had learned.

How Do We Measure Progress and Determine Pace?

How do teachers know when students are ready to move on to the next chapter or unit? Acceptable student performance, coupled with our experience about what and how well students need to know current concepts in order to be successful in upcoming lessons, were typical indicators we used to decide when it was appropriate to proceed to the next unit of study.

In our first year using the CPMP curriculum, we lacked the knowledge of and experience with the curriculum materials to make decisions about the pace of classroom activities with the same confidence as we had made them in the past. We simply did not know exactly what topics the curriculum contained or which ones would be most critical for future concepts.

<u>Prerequisite knowledge.</u> When we embarked on the CPMP mission, the materials were in various stages of development and revision, and not all units were available to us at the beginning of the school year. The scope and sequence of the course was merely sketched out for us. We had a list of titles and a brief description of the substance of the seven units. The individual booklets arrived one at a time throughout the year and consequently, we were teaching each unit without knowing very much about the substance or prerequisites of the units which followed.

However, it might not have made much difference if we had been in possession of a complete set of course materials anyway. We would likely have felt we did not have the luxury of time to study units in advance of the one we were currently teaching. CPMP is an integrated program that weaves algebra, geometry, probability, and data analysis strands together throughout the year. We all had experience with both Algebra and Geometry as separate courses and were familiar with the structure and prerequisites in each. But, with this new curriculum, we did not know what was important to ensure students had a firm grasp of before moving on. Years of experience pacing instruction based on known sequence of important essential ideas did not serve us well now. In retrospect, it seems almost irresponsible that we were teaching a course of which we actually knew so little.

It was challenging to keep the class involved and moving as the students engaged in the new tasks. We were unsure of when to intervene and move students on to the next task. We were not confident enacting our new role and questioned when it was appropriate to engage in teacher-talk. There was a tension between the time available and the time it took for students to reach some level of comfort with the mathematics. The curriculum guide for teachers regarding the pace at which students could be expected to move through the topics and activities did not fit what we saw in our classes. The signs we knew so well were absent. Students were asked to think and act differently and we were frustrated by not knowing what to expect students to say or be able to do that would tell us to move on. At our October meeting, Ted expressed what we were all feeling:

> I'm frustrated! Can all the parts come together? In all my years of teaching, I knew what to throw out to keep pace. This is not the same as planning for a traditional lesson. I try to make sure I don't cut any kids off. I am treading water more than in the past. {PD October}

Ted was not sure what was critical to teach before moving on. He expressed what most of us witnessed students doing in our classes: fumbling with the material, looking for direction, sometimes taking advantage of the new format to socialize, and being somewhat unsure of how to proceed in a new kind of math class. We were taking more time to listen to students explain, then asking questions to probe for more detail, and making an effort to elicit multiple responses. All this took much more time than we would have traditionally spent in class discussion and it felt like we were not making progress.

Our own sense of important mathematics told us some topics were more critical for students to master than others. There are some processes and concepts that students should not move past without having a firm grasp of the technical skill and the conceptual understanding. Solving equations is one such topic. We found the innovative CPMP approach to this topic interesting and intriguing, but we were uncomfortable that the familiar properties of equality were held back, waiting for students to figure them out for themselves. We were not confident that students were gaining the *basic* knowledge that our experience told us they needed to have. My journal reflected my own discomfort and worry that the materials might not be serving our students or us well:

> We are coming up on the introduction to solving of equations, but there are no strategies. The teachers' guide says we are not to give instructions as to detailed properties to be applied. What do we do here? We move on to the distributive property problems and the *Looking Back* set of tasks. These are advised as very valuable by the authors. We are running out of time to do all of this work with students before the end of marking period four.
> {RN February 2}

Others expressed concern that students were not grasping the concepts.

> Lea: With this equation solving and the importance – how much time do we spend before we interject and correct the students who don't get it?
> Ed: The students don't seem to be able to discover the idea. Cut to the chase and tell them.
> Lea: I guess we do whatever it takes to get the point across.
> {PD March}

By this time in the year, our impatience with inquiry as a mode of learning was growing. We were overly concerned with the limited quantity of material we had covered and were making attempts in class to speed things along and make sure students at least were exposed to some of what we believed they needed to know.

<u>Student performance.</u> In our traditional classrooms, when the majority of our students performed satisfactorily on homework assignments, quizzes, and tests, we knew it was appropriate to move on to the next unit. As we gathered in our monthly professional development sessions, we shared information about student progress, questions, and difficulties. As the year progressed, the students' performances as measured by marking period grades declined.

We did not attempt to do a statistical analysis or carefully monitor all students' progress throughout the year. However, we did share informal results in our meetings as the year passed. Students were not the only ones under pressure to do well. Teachers felt pressured to have student performance improve. At the end of the first section, we were optimistic that grades would improve when students adjusted to the new class format, the new type of tasks, and the different approach to learning mathematics.

The teachers shared distributions of the grades in their classes. For the first marking period, Lea's sections had 13% E's, 22% D's, and 39% C's. There were far too many students performing poorly, and I was alarmed. Others echoed similar results as we discussed their lack of achievement. We noted that the distribution was lower than what we had historically seen in Algebra classes, but we reminded ourselves that these classes included students who would not usually have been placed in Algebra. They would have been in the pre-algebra courses had we not initiated this course change.

We saw some improvement in the second marking period, but not for all students and not for all teachers. Some teachers added an easy quiz just before the end of the marking period to boost grades and others calculated the grade as a separated entity rather that computing the grade cumulatively from the beginning of the school year, as we had originally agreed. For some students, this improved their grades if the marks from the first portion of the year were not included. The teachers involved stated that they wanted to reward students who had turned things around from a poor beginning. We had many parents who were upset with their children's' performance and low grades.

At the end of Semester 1, not only did we realize that we had covered merely two units but there were very few A's and B's among the student population. In addition, there had been some adjusting of the scores on the mid-year exam to raise exam grades and consequently semester marks.

At the end of Marking Period 4, we shared that we had many failures. Kay related that she had 50% E's in some of her classes and Lea said that in her three sections there were 10, 8, and

10 E's respectively and only one A in all of her three classes. She stated that many of her failures were the result of not doing the work and not coming to school.

Student performances continued to decline and by the end of the fifth marking period, 43% of the students in Course 1 were failing. Failure rates over 13 classes ranged from a low of 12% to a high of 59%. Computer queries were run on the student data bank. The results were sorted by teacher and by grade level and presented to the principal. Each of us received a report of our own students and as department chair, I received the complete set of data. Following his examination of the data on student performance, the principal questioned us about this apparent lack of success. We did not have good reasons why students were failing other than they were not doing the work, and in some instances, had high absentee rates. I elected not to mention to the principal how little of the total curriculum we had taught.

Student performance failed to get better following the first marking period. After report cards were processed at the end of the first semester, we discussed the less than desirable results and realized that not only had we covered merely two units out of seven, but very few of our students were getting A's and B's. The downward spiral of performance continued as we neared year's end. There was a tension between the need to pick up the pace in order to cover more material against the need to spend more time with a topic. Student performance indicated the latter. This tension began early in the school year when we realized each assignment took our students twice as many days as the teacher guide suggested. At semester, we were acutely aware of our lack of progress and as the year ended, we had taught only four complete units. Although we knew we were moving very slowly, we were unable to pick up the pace. The disheartening performance of our students and our desire for students and the new program to be a success kept us from moving more quickly.

How Do We Know Students Are Learning?

CPMP took multiple approaches to assessment. Teachers were expected to evaluate students informally at the beginning of a lesson to determine what students brought to the investigation and how they understood the tasks. Both oral and written work were to be used to determine how students made sense of the mathematics. Class discussions following an investigation were designed around questions that allowed teachers to determine the level of understanding groups had been able to attain. Written work allowed teachers to ascertain individual levels of understanding and included On Your Own (OYO) and Modeling, Organizing, Reflecting, and Extending (MORE) tasks, and the formal quizzes and tests supplied by the publisher. Certainly, assessment was more than merely grading work. It was intended to inform the teachers of how students were thinking as groups and as individuals, how students were making sense of the mathematical activities, and where misunderstanding existed. Listening to how they articulated their findings and reading how they explained and justified their reasoning were intended to inform the teacher about the progress students were making. But CPMP assessment was difficult for us to implement as it was intended. The discussions took large blocks of class time. Students generally did not cooperate; either they did not listen or they did not contribute. Consequently, the discussions were often not productive or informative. It took a great deal of time to process student written work. Both the written and oral work of students was challenging for us to assess and use in a meaningful way to make instructional decisions. We had a difficult time moving into new avenues of evaluation. We were overwhelmed by the need to grade student work and assign marks.

Assessing, Reading, and Providing Feedback on Students' Written Work

The nature of the CPMP tasks made it difficult for us to assess the students' work on them. The tasks required students to make hunches, construct arguments, provide evidence, and explain reasoning. There were multiple answers to questions posed within the tasks. [1] All these required careful reading to determine if students were making sense of the concepts. We couldn't merely read off answers and have them check their own work during class, or collect and scan papers looking for key steps and circled answers. We asked ourselves traditional questions. Would they be able to perform procedures? Could they solve an equation? Could they find the slope and y-intercept? Would they know how to combine like terms?

The authors did not ask those familiar questions. For example, they provided the population of India, its birth and death rates, and the approximate numbers of people that left the country each year, and then asked: What combinations of growth rate and number of people leaving the country could lead to zero population growth? The familiar short answer-numerical solutions were almost non-existent. As educators who were convinced that the reforms in mathematics education and curriculum were necessary and positive, we were in favor of the new tasks.

In the above problem, it was not a matter of a quick check to see if the students correctly solved a simple equation. Instead, there were several ways students could correctly answer the question. They could argue that if the emigration rate equaled the difference between birth and death, then zero growth occurred. Alternatively, they could argue that if the emigration remained constant, then the difference between birth and death rates would be the percentage of the population that emigrated. We needed to read their responses carefully to decide if students

[1] Students sometimes peeked at the instructor notes and copied solutions. More than once, students submitted assignments with the response "answers will vary."

understood the relationship between birth rate, death rate, emigration, and total population, and in addition, to determine if students understood how zero population growth would be represented mathematically.

Keeping up with grading student assignments was difficult for us. First, the tasks had multiple parts, were written in narrative, and took a great deal of time to read thoroughly in order to comprehend what students actually understood and were able to do. Second, student papers took a lot of time to process because there were a lot of them. The teachers taught one, two or three sections of this course, which meant between twenty and ninety students per teacher. The numbers of papers mounted up quickly. The time it took to read so many papers was a major issue. Third, the feedback we provided students as we read their papers was a problem. We were aware that the demands on students were very different and tried to consider how the program was as new to them as it was to us. We felt we needed to do more than write mere C's and X's as we graded papers.

For example, a task which asked students to write a rule using words and letters for the cost of meals (*T*otal for a burger, fries, soft drink and sundae per student) for any number of students (*D*iners), had the following response from a student. *To find your bill total, take the number of diners and multiply it by the price of each item, after you have all 4 totals, add them together to get your bill total.* Teacher comment: **Good!** The student continued with the second part of the task *T + DxT; T= Drink, Fries, Burger, Sundae; D = # diners.* Teacher response: circled the two T's in the expression and wrote in the margin: **T is used twice. What does that mean?** The task required students to make a table showing the cost of meals for 1 to 10 students and then to make a graph of those ordered pairs. We looked to see that graphs were drawn to scale and axes correctly labeled. One student response listed the amounts in cents not dollars and cents, which prompted: **The numbers are too big.** In addition, when students confused placement of variables on horizontal and vertical axes, we wrote: **The axes are backwards and have no labels.** Clearly, reading and making similar comments on sixty of these papers took hours.

Initially, we wrote comments and questions, such as those above, on students' papers to prompt further explanation or clarification. It seemed the fair thing to do. Students were unfamiliar with how to answer the questions and often needed a prompt or additional probing question to help them think of another perspective. We did not write lengthy explanations, suggestions, and corrections on every paper for every student; however, it was demanding to read each student's work thoroughly enough to identify the errors similar to those in the above example. Writing comments added considerable time to grading sets of papers. In addition, when students received their papers with teacher comments, some wanted to revise their work and resubmit it for an improved grade. Early in the year, we accepted students' edited and revised work and graded it again. Ultimately, those papers added to the time to read, assess, and record student progress.

One tension we faced was between our need to be supportive teachers who provided students with additional information concerning the expectations of this new curriculum and the amount of time it took to provide this kind of learning support. Soon after we began, the revision of student work became a problem. Some students wanted to submit a paper many times to obtain even better scores. While this created more work for teachers, the students seemed to be taking advantage of additional information, directions, and time to improve their grades. The issue came up in our September professional day.

> Kay: How many times do we let them revise their work?
> Ted: The students are manipulating the leeway to rework.
> They deserve the right to fail.

We stopped taking papers for second and third times and tried to provide feedback and guidance for the whole class by modeling solutions to MORE tasks on the chalkboard or the overhead projector. Our comments shortened to question marks in the margins when we could not decipher what students were trying to communicate. As might be expected, grades on papers fell when teacher feedback no longer included commentary and suggestions and students were no longer allowed to revise their work.

In our November meeting, we discussed our concerns regarding how we were grading student papers. After assigning and collecting papers for several months, we knew that the paperwork was more time consuming than we had ever anticipated. We were in search of an efficient way to assess the work, to put meaningful grades in our record books, and to hold students accountable for doing the assignments, all while remaining true to the stance of the CPMP curriculum. This was a daunting goal, to be sure. Traditional assessment scales did not serve the CPMP tasks well, but the time it took to thoroughly consider student work and apply new rubrics was incommensurate with the time we had available. We were not finding a system that worked well.

> Lea: How do you grade the MOREs?
> Ed: I am using the grade scale A, B, C, D, E.
> Kay: But, reasoning counts even though they may come up with two different answers.
> Ed: Look for completeness, scan the page.
> Ted: Don't read it. There is just too much! There are mountains of paper. I look for the graphs. If they're not there, I mark off.
> Tia: I'm having trouble backing off the detail.
> Lea: I can't do it all. I don't have time to talk to anybody.
> Tia: Why don't we just pick a night and just get together and do MOREs? We choose one that will be graded. {PD October}

We had not reached an effective way to manage reading and grading student papers but were searching for a system that would work to ease the time demands. Ed was using a traditional scale to assess the problems he graded. It appeared neither he nor Ted were carefully reading each problem. Tia was caught between attending to the many details of each problem and the quantity of student papers to process. Her suggestion was to have the group decide on a representative problem for each set. At the time, we let Tia's suggestion pass without comment. Nevertheless, later conversations revealed that most of us adopted Tia's idea. We selected and graded only a task or two from each assignment. We chose tasks that we believed best represented the central idea of the lesson and considered those few tasks as representative of what students knew. In reality, we were not reading enough of what students wrote to have a total picture of how they made sense of the concepts or the source of their partial or complete misunderstandings.

Assessing, Listening, and Learning from Student Oral Contributions

The authors created two group discussion opportunities in each lesson, a launch and a closure discussion. Student inquiry was to begin with a discussion centered on *Think About These Situations* wherein prompts focused attention on the mathematical aspects of the task's context. Teacher notes directed us to the role we might play in these discussions, their purposes, and possible input from students. In these discussions it was important for teachers to listen to what students brought to the discussion in order to help them realize that their thoughts were valued and to encourage creative thinking. The first launch discussion provided the following information for teachers:

> Each unit and investigation will begin with several "Think About" questions. These are intended for use in entire-class discussions which will launch the upcoming material. These discussions give students a chance to "make sense" of mathematics by bringing to it their own background knowledge. The discussions should also be used by teachers to assess their students' informal knowledge of the topic. (CPMP, 1994, Unit 1, p. 1(a).)

Checkpoints, located at the conclusion of each investigation, were meant to generate a class discussion of the important concepts of the lesson. This discussion was a critical assessment tool for teachers to determine how students understood the central concepts of an investigation. The directions with the first *Checkpoint* in the teacher notes told us:

> Throughout the CPMP materials, the purpose of the Checkpoints is to gather the class back together for an entire-class discussion and to ensure that you have a common class understanding of the concept investigated. By random selection of students to respond to the Checkpoint items, you can assess whether each person has "made sense" of the material, and has understood the essential objectives for the investigation. It is vitally important that you use these Checkpoints to help bring closure to the concepts taught in the investigation, so that all students can be successful in the upcoming individual work. (CPMP, 1994, Course 1:Unit 1, p. 4)

The directions in the teacher notes indicated a class discussion, orchestrated by the teacher. However, this was quite different from the description Tia and Lea gave from their summer classes. In the summer, the Checkpoint questions were prompts for each group to report their findings. They described a reporting exercise rather than a discussion. They described how each group stood together in front of the class while the Recorder reported the group's findings. That was quite different from the printed teacher notes, but we yielded to their direction and their summer experience. We had incorporated group participation into students' grades and had planned to use the reporting sessions as the way to assess individual contributions to the group process. We agreed to use the format whereby students would come to the front of the room and "report out" at the conclusion of each lesson.

We did not have much difficulty with the discussions that launched an investigation. Students readily offered suggestions and asked questions if they were unsure of what the situation described. We had the notes from the teacher materials to inform us of what students could be expected to bring to the discussions. When we found students did not understand, we clarified and explained so that the investigation could proceed. Teacher telling seemed appropriate on occasion. The discussions were useful to gather the class together before students began work on the lesson.

But from the start, we had problems with the *Checkpoints* used as a reporting format. The discussion was not working the way it was described in the teacher notes. In fact, it was not a discussion at all. Students were not contributing to the discussion. They were not listening to other groups' report findings, and they were using the "up front" position of the reporting group as an opportunity to show off for their classmates.

Teachers brought concerns to the September meeting regarding the Checkpoint discussions and the need to hold students accountable for the responses. One of us suggested that instead of holding the whole-class discussion, we require all students to write the answers to the checkpoint questions and then either collect one from each group or collect all the papers from each group. We anticipated we could read the responses and return them to the group recorder. Another suggested that students write out the answers to the Checkpoint questions and include them in their notebooks. We could then check for their inclusion during a notebook check. The first of these options produced more paper for the teachers to process and we had plenty; the second created the unrealistic administrative task of checking thirty student notebooks during a class period while students were engaged in an investigation.

There was a critical disparity between the discussions the teacher notes described and the reporting sessions the summer participants related to us. These were two entirely different kinds of class activity. We were unable to orchestrate the kind of class discussions described by the authors because we were trying to reproduce the reporting sessions our summer school representatives described.

Our students did not respond positively to the questions or the discussion format. Ultimately we lost the benefit of information that could have been gleaned from students' responses to the *Checkpoint* questions either orally or in writing. We stopped holding the reporting session/discussions and omitted the reading of the written responses to the *Checkpoint* prompts in addition to the OYOs and MOREs.

The next month, Kay's comment accurately described our experience with the oral presentations and pointed out that if students were seated in rows – in traditional classroom style, to listen to their classmates – things might have been better. However, because we were committed to the cooperative learning format, we had them seated in groups. To have them face the reporting group required changing the arrangement of the desks, and this was a source of disruption and additional unproductive time:

> Kay: The oral presentations – others don't pay attention. If the students were in a normal class setting, it might help. {PD, October}

At our January meeting, there was discussion of the group grade and the general lack of success of the Checkpoint discussions. Kay had several comments about her students and the lack of success of the reporting sessions.

> Kay: The group work grade is not possible. It never worked when groups reported out. I am moving away from groups of four, so it doesn't make sense anymore. Kids can pass without doing the work. {PD, January}

In June, we reflected on many aspects of our year's work and the Checkpoint discussion was one we had not been able to use effectively. We echoed Kay's concern with the groups reporting out; however, our concerns went beyond the difficulty in assessing student participation. They went to the purpose and effectiveness of the discussions. For us, *Checkpoints* had never actually been discussions. In general, we had abandoned the reporting session early in the year and shared our reflections about doing so. This was another instance of a change we made in the instructional design of the materials without realizing how it would affect the overall plan of the authors. We were not aware that from the onset we had changed the intent of the authors by using the *Checkpoints* as a reporting rather than discussion time. We had interpreted the discussion differently. We had taken direction from our colleagues rather than strictly following the teacher guide. In general, the teachers found our interpretation of the *Checkpoint* discussion counterproductive.

> Tia: One thing I'm going to ease off differently at the beginning of the year is the reporting of the results of their investigations. I got towards the middle of the first semester where I was not even reacting to a lot of the investigations because I fell so far behind time-wise. So, I blew that off. I know that's not good, because the kids needed closure on some of these concepts, but I was getting one or two, three groups of reporting – days just dragged by.
>
> Ted: I don't think kids got that much out of it either.
>
> Tia: I did get a lot better giving up the reporting and asking the kids questions to prod them into discussion.
>
> Ted: I mean the kids in the rest of the room are not getting much out of it. If they were on stage, they were involved, and the rest of the kids were waiting.
>
> Ruth: I found that the kids that are reporting are paying attention, trying to make sure they are saying things right, but the rest of the class isn't listening. I asked another student to paraphrase and it was very evident that they weren't listening. I felt like I was a vindictive person, picking on the kid who wasn't listening, but I'd call on anyone and they weren't listening.
>
> Ed: I find the whole construct they gave us very artificial. This is supposed to do this, it's all connected to that, but it's not reality.
>
> Tia: If you are doing a team project for a company and you come back and make a presentation to your bosses, what happens if nobody is paying attention?
>
> Ed: In that case, the people who were listening, didn't do the same job you did.
>
> Lea: Didn't it almost get to the point where [a student might think] so-and-so is going to answer it anyway? I'll just wait until they make their speech and then I'll write it in

my notebook, since all she checks is notebooks. That is one of the reasons I stopped the follow-though with the questions.

Ed: Say you have ten kids in the classroom that are really doing good work – they're all done with it – why would they listen to a reiteration of what they've already done and understand? I asked them to be patient, but it seemed like beating it to death.

Lea: I know that I did it too much at the beginning of the year. I stopped asking them to bring their group to the front of the room to tell what went on. It didn't have a lot to do with the kids not wanting to hear this over and over again. **I didn't want to hear it over and over again.** I didn't want to battle with the other kids in the classroom to listen, to pay attention. Stop until it's quiet. It got to be a pain in the neck – so I stopped, and that was kind of sad.

Ruth: I think that's one of the things that slowed us down in the beginning- we were spending inordinate amounts of time trying to get kids to cooperate and go with the program.... We lost a lot of time and I think it frustrated all of us because we knew we were getting further and further behind and we couldn't help but compare with what we had done in the past, even though it was a different curriculum.

{PD, June}

The Checkpoint discussion, which was intended to inform teachers of what students had learned in the investigation, was for all practical purposes eliminated. The authors' goal for *Checkpoint* discussions was never effectively realized in our classes. In retrospect, it is understandable why it had not been a source of information about how students understood the mathematics. The authors stated it was important. However, the way it took place in our classes, it had not been valuable to us.

Some of us viewed the discussion as a way to bring closure to a lesson, a traditional teacher summary of key ideas instead of using the discussion as an opportunity to hear students' conceptions of the central ideas. The students failed to cooperate with the sharing of learned ideas, and took advantage of the few students who had been successful in the lesson objective.

When students reported the findings of a group, it was difficult to know if he/she expressed what the whole group understood. Often, successive groups repeated what those before had said, making us wonder what groups had actually managed to learn. We were using valuable class time to listen to students repeat previous groups' findings and felt the time could have been better used. The unintended consequence of our decision to try to correct unproductive classroom time was that we removed an assessment source the authors intended to be valuable and important.

Obstacles to Determining What Students Had Learned

Awarding grades and attempting to find a balance between the work we needed to do and the time we had available had taken precedence. Students' concerns about their grades contributed to problems we had in coping with the written work. In an effort to improve their scores and avoid zeros for unfinished assignments, students copied work from others and handed in assignments well past the deadline dates. Some students stretched investigation time allowances while others simply did not participate. Students' written work was unreliable as an accurate gauge of what they had learned. In some instances, we saw multiple copies of one student's work; in others, student work was completed long after the unit was concluded and they had missed meaningful discussion of it. Still other students did not attempt the written work at all. Original, not copied, work completed and submitted on time was the exception, not the rule, in our classes.

Copied work. It was difficult to determine what students knew from their written work because they copied excessively. Copying another's work was one way that students avoided engaging in the tasks and seriously attempting to construct mathematical knowledge. Students looked merely to satisfy the requirements of the course.

We found it difficult to put a stop to copying when the students worked in groups during class. Student performance on formal assessment was poor and zero grades given for blatantly copied assignments had an effect on their overall marks in the course. A short list of teacher comments on student deception throughout the year follows:

Lea: Copying is running rampant.
October

Ed: My initial observation: One works – all copy! November

Ted: The ones who are copying – are not doing anything.
November

Ruth: One student actually did the work of hand copying three papers for others in her group.
December

Ted: Photocopies of homework papers were handed in with student names simply added their names to the page.
January

Kay: Students seem to be waiting things out and copying.
January

Tia: Next year we are going to have to recreate all the tests and quizzes because of the cheating network.
February

Lea: Make-up work is just copied.
March

Ed: They are failing because now they can't just copy numbers from someone else's paper and hand it in. They have to present something more thorough and they are angry about it. April

Ruth: The students continue to try to find ways to bypass learning.
May

Tia: Students who copy are under the impression that they are doing the work needed to pass. They don't see what they do as not working. May

Tia: I'm still trying to take my good students and differentiate between cooperation and copying. They are used to copying, not cooperative learning.
June

The above litany chronicles our yearlong battle with copied work. We wanted students to take responsibility for learning but instead they attempted to deceive themselves and us into believing they had done so. It was frustrating for us; however, we came to believe that this practice had been occurring undetected in our classes for years. But because we were working so closely on planning and grading student work, we were now much more aware of how often it happened.

Cheating on formal assessment. It was difficult to determine what students learned based on their scores on formal tests and quizzes. The students continued to challenge us with situations which made managing our classrooms on assessment days and implementing the program as it was designed very difficult. Students blatantly cheated on tests and quizzes. They were moderately creative in doing so but cheated just the same. When confronted with evidence of cheating, students often did not protest. We used alternate versions of the tests and quizzes as retest instruments. We suspected that there was some sort of a cheating network, wherein students attempted to take blank tests and quizzes from the room and distribute them (solved or blank) to other students in advance of later class periods. Consequently, security of testing instruments was suspect.

> Lea: One student did not turn in a quiz. I went to find him in his next class and he said he had turned it in. When I required him to take another quiz in its place, he had no objections. {RN December 13}
>
> Kay: One student did two tests, one for himself, and one for another student. Both were handed in with the same handwriting, just with different names on the top of the page. When confronted with the handwriting issue and grades of zero, there was no battle. {RN December 14}
>
> Ted: I had a student tell me she didn't get a test when I passed them out. When I went back to give her one, I noticed the edge of a paper in her purse. I asked her to take it out and explain. It was a blank copy of the test. She said she had no idea how it got there. {RN December 14}
>
> Ruth: While students were taking the test, I saw a calculator passed from one student to another. When I questioned the receiver of the calculator, she said she couldn't get hers to work so her friend agreed to trade. {RN December 14}

Kay: I watched as one student went to the pencil sharpener and dropped off a folded piece of paper on another student's desk. I walked over and picked up the folded paper. It had all the answers to the test on it. The student who had it placed on her desk never opened it. I don't know who should be punished. {PD April}

We saw students pass answers via calculators and crib notes, do the work for other students, and attempt to sneak tests out of our classrooms. We were afraid the instances we uncovered were only a fractional part of those that actually occurred. Students were aware that all six teachers used the same tests and quizzes. Their efforts to compromise the security of the tests were sometimes novel, but still discouraging. We could not be sure that test scores accurately reflected student learning.

Ted: Absence on quiz days is incredible.
Kay: Make-ups are one of the problems that keep us from using tests as learning activities. It is really hard to do – to decide what to do.
Lea: A student handed in a quiz the next day, she took it home. I don't know what to do. Do I accept it? Grade it? The students are under such pressure to do well, and we have a negative history with parents. It makes us look like the bad guys. {PD, March}

These are samples of why we did not trust the formal tests and quizzes as accurate representations of student learning. We suspected there was a network of students sharing answers, but did not have the resources to investigate further. We just tried to be more vigilant.

<u>Assessments not challenging.</u> We believed many of the authors' tests and quizzes were not challenging enough to represent accurately what students had learned. We thought that students could pass without having a firm grasp of the main concepts in the lessons. We also were uncomfortable because students were not asked to demonstrate technical skills within the context

of the investigations or on the formal evaluations. I suspect we still believed some of those traditional skills and procedure were important and were missed by CPMP materials.

> Kay: I'm having a hard time making the leap from class activity to the tests and quizzes that gloss over the topics. I don't know how to assess how much they should know before moving on. The hardest part is to determine what is the important mathematical knowledge to teach - to make sure they have before we move on. {PD, February}

Kay expressed another problem we were having. We were unsure of the big mathematical ideas that ought to be firmly in place before we moved on, and we were not sure that the tests and quizzes were providing the necessary information about those big mathematical ideas. By this time in the year, we had modified several of the ways the curriculum developers intended for us to assess student understanding. We were unconvinced that we did not need to modify what they were learning. Some of the familiar algebra concepts failed to appear in the curriculum to date, and the question about the traditional skills remained unanswered. A lunchtime conversation on March 29 turned to the most recent test on solving equations.

> Ted: I don't like the quizzes. The way they ask the questions isn't good. The kids don't know what they are asking. I think they really don't know what they're doing.
>
> Ed: I'm not sure they test what the kids are learning in class.
>
> Ruth: I fear that we, or maybe just me, are not teaching what is being tested. ... I find this so different than the way that I have always taught solving of simple equations, that I think I may be slipping back into my old teaching method without even knowing it and the kids are suffering as a result.
> (Ed nods in agreement.)
>
> Ted: I have given some matching exercises – equivalent expressions – and they did great, but I don't think they had a clue what they were doing.
>
> Ed: I know. I find myself teaching how to do $3x + 4 = 9$ on the board, and then giving them $2x + 3 = 11$ to do themselves. I go around and give them a point just for doing something, writing it down off the board. I hate teaching like that, but the kids love it. They can get

> something right and at least they get a point in the book.
> {IC, March 29}

That afternoon, after thinking about the lunch conversation and the relative failure of our improvement plan, I reflected on the traditional instruction that was creeping back into our classrooms. Our frustration level had reached a high after we marked report cards and we realized just how few students were excelling in this program. There was a tension between the commitment to the program we had in the beginning of the year and the uneasiness with continuing that commitment in the face of marginal student involvement and success. What were students learning of traditional algebra? What did we need them to know? My notes from that afternoon echoed my own concerns about what was happening in our classes and the ways we were determining what students learned:

> The teachers are resisting the changes to using the curriculum materials as developed. They are changing instruction and evaluation materials as well as the system of evaluating what kids know. The "point per problem" and something entered in the record book falls right back to the standards and methods we have all used to keep kids on task and doing what we want them to do in class.
>
> Our ways of knowing what they know are traditional and now we ask them to demonstrate in ways that are unfamiliar to us. We don't quite know what it is they know. {RN March 29}

The early questions regarding students' ability to solve equations, factor, and operate with radicals remained. Students had complained about the traditional math skills, claiming that no one would ever use it in real life. But we could not understand why students were not willing to investigate and conjecture about topics that were related to life situations. Teachers were frustrated with the lack of student participation, the lack of success measured by report card grades, and our inability to prompt significant change in either. We tried to gain control over student behavior in class. We revisited traditional methods to try to entice them to participate. We used short skill demonstrations and practice problems to provide instant feedback and rewards.

Delayed timelines. In January, we designed a mid-year exam that would reflect material we had taught in semester one. We were forced to look at how little of the curriculum we had covered, in that we were constructing an exam to cover only the first two units in the course. It was evident that we had been unable to adhere to the time guidelines given in the teacher notes.

We shared classroom situations that had effected our decisions and found a common theme. Students manipulated the time lines to give themselves more time than they really needed for class and homework assignments. We had used far too much time for lessons for a few basic reasons. Students requested more time to work on investigations in class, explaining for instance, that they were only on the second task, there were five, and the end of the period was near. We saw students who used class time to engage in off-task conversations, avoided honest attempts to tackle tasks, and made it look as if they were involved only when the teacher was looking over their shoulders.

For many reasons, we reduced the size of the assignments and extended the due dates. The lack of prerequisite skills sometimes was a legitimate excuse as was limited skill at using the hands-on aspects of the tasks. Nevertheless, we wanted students to complete the investigations and do the homework assignments and we mistakenly decided that giving them more time would accomplish this goal. Class assignments that should have been possible in one class period stretched over days. Kay described what we had all done:

> I've been lax with time lines. I allow extra time for slow groups
> and I have reduced my expectations.
> {PD January}

We consistently took more days than the teacher guide suggested we would need for units. Notes from Kay's plan book indicated that she had spent eight days on the second lesson in Unit 2. The pacing guide suggested four, including administering the in-class quiz. Kay's plan book was representative of the pace in the classes of all six teachers. We worked together and communicated with each other in order to coordinate the time spent on each section and the days on which we gave the quizzes and tests. We had adjusted our pace to the pace at which the students were willing (not able) to work and it had taken twice the suggested amount of time for the material.

It was difficult to know when students had successfully made sense of the mathematics because they claimed they needed more class time and handed in homework days late. Students avoided taking responsibility by taking advantage of the cooperative learning environment, our unfamiliarity with the time guidelines, and the newness of the instructional model. They appeared to be engaged in the task of the day. However, when the teacher was out of earshot, they carried on conversations on many other topics. Basketball games, weekend parties, and gossip were topics of conversation that ceased when we approached. Students used unfinished class work as a reason to extend timelines. As Tia said in frustration, referring to homework excuses and students taking responsibility for participation and effort:

> *I don't understand* is not a reason to not do homework. The real message is shift responsibility to the teacher. {PD September}

Students manipulated time simply by not doing the work in a timely manner. Our original class organizational policy stated that weekly assignment sheets were given and deadline dates established, usually one week after the assignment page was handed out. Students often waited until the last night to do a week's worth of homework and could not complete it all in time. As a result, they both asked for and received new deadlines, or simply handed in the assignments one, two, or three days late accepting a percentage penalty for each day it was late. This created a bookkeeping nightmare. We had to make decisions about accepting late homework assignments. We changed this policy and procedure several times throughout the year because accepting late assignments and computing the late penalty added more time to processing student papers.

We faced a dilemma. CPMP instructional model eliminated explanation of concepts and demonstration of procedures. The tasks in the text were designed to engage students in activities that allowed them to *discover* the concepts. We believed that if the students did not do the work in the book, then they would not encounter the concepts at all. Ultimately, we believed it would be advantageous to allow the students to turn in the work after the deadlines or move the deadlines to accommodate the pace at which students worked. (Better late than never!) We thought participation and performance would improve if we allowed students more time to work.

That was not the case. The students handed in work weeks after it was due and when it was no longer relevant to class activity. In many instances, the late work was simply copied from a paper returned to another student. By April, one by one, frustrated teachers had established a policy wherein they refused to accept any work past the deadline unless students were seriously ill. Teachers truly felt that late assignments did not accurately reflect what students knew and were able to do. Many students received no credit for assignments when this policy took effect.

One holdout, who allowed late or made up assignments, was Tia. She was most patient with her students and their tardy assignments. Instead of refusing to accept late work, she offered students the opportunity to hand in work past the due date, with one condition. Students were required to come in after school, sit in her room while she was present, and do the work on site. She was unwilling to accept late work "sight unseen" and she wanted to ensure that they worked on the tasks on their own. Tia's effort to have students participate and engage in the tasks required still more of her time, although she claimed she could work on reading and grading student papers while they worked in her room. She was the only teacher willing to extend herself in that manner. Her classroom was often filled with students making up late work after school. She provided students the opportunity to be successful, but tacitly gave them permission to not use class time wisely.

There were many reasons we were unable to carry out the time guidelines of the CPMP materials. Student manipulation of the class and homework deadlines was only one. We were unsure of many aspects of the program and failed to take an assertive position with students. We attempted to collaborate and coordinate assignments; thus we hindered the progress of the most advanced classes and held all to the pace of the slowest. Students used a variety of strategies to delay engaging in the investigations and to avoid diligent efforts to learn. By yielding to their maneuvering, we had created another obstacle to forward progress.

Summary

The pace at which we moved through the material was one area where we felt we had fallen short of our goal. The quantity of mathematics that students had learned was significantly less than what we believed we might have completed using traditional curriculum and pedagogy. The combination of poor student performance and quantity of material we had taught over the course of the school year indicated we had worked very hard to achieve such a small margin of success.

We expected students to learn more and to be engaged by the real life context in which the problems were based, but that was not the case. Why didn't our students embrace this curriculum when it was so far removed from the traditional technical skills and procedures that they so often called boring? Students were failing in large percentages, which contradicted our motivation to change from traditional curriculum to this one. We had a spent a great deal of time and energy attempting to implement the CPMP curriculum. We were critical of our work and the lack of positive student performance. We knew we had not implemented the curriculum as it was intended, although we began the year with honest intentions to follow the format.

We did not have confidence or reliable evidence that students had learned meaningful mathematics. I believe that had we felt confident students had learned the few concepts we covered well, we would have finished the year with a more positive attitude. However, we did not have convincing evidence that students learned meaningful mathematics. It had been difficult to overcome the traditional teaching and learning experience of both teachers and students. CPMP required different pedagogy, different subject matter knowledge, different assessment rubrics, and the evidence of knowing mathematics was very different from what we had known.

The radical changes in the materials and the requisite changes in pedagogy combined to produce challenges and dilemmas we had not anticipated. It was difficult to assess student work first, because it was so different from traditional technical skill and procedural knowledge and second, because it took large amounts of time to read and synthesize. The work on CPMP tasks that students submitted required careful reading and thinking to gain a firm grasp on what the student understood. It was difficult for us to discern what individual students had learned when they worked in groups because we were not sure each member of the group understood the concepts, especially when the responses were nearly identical. Teachers lacked confidence that the work students submitted accurately reflected what they knew and were able to do. The amount of copying and cheating we detected made us suspect that a few students were conducting the investigations and many students were plagiarizing their work. When groups reported their findings orally, it was difficult to determine if all members of the group had the same understanding. We did not believe that tests and quizzes provided the students sufficient mathematical challenges to determine their grasp of the concepts. Hence, we did not have confidence that performance on these assessments reflected strong mathematical understanding.

We adjusted the CPMP instructional model to fit the demands of our students and our schedules. We adapted the cooperative learning model as described in Chapter 4. We modified individual aspects of the Launch-Investigate-Share-Apply model. We found whole-group discussions unproductive and disruptive to classroom operation. *Checkpoint* group discussions were interpreted as student reporting times and hence, mismanaged. Accordingly, they were ineffective as sources of accurate information about the mathematics that students understood. Without the *Checkpoint* discussions, we had one less source of assessment the developers had intended us to use to determine how groups of students understood the concepts. That was one less piece of information that would have helped us make decisions to move on.

We adapted the *Apply* portion of the model by changing the suggested assignments. We reduced the number of tasks we assigned and selected those with short answers in order to manage the time required to read and assign grades to student papers. This adaptation narrowed the lens through which we could view the students' understanding of the mathematics. Our assessment emphasis continued to be grading student work and assigning grades to report cards. We had not changed our perception of assessment to fit the design of the reformed curriculum.

The issue of time seemed to be omnipresent; however it was more a symptom of the problems we experienced rather than the source. It did not just take more time to do the investigations and correct the papers. It took us longer because we were unsure of many aspects of the curriculum. We did not have a total picture of the curriculum and did not know the critical concepts that should be firmly in place before students moved on to the next topic or concept. We were unfamiliar with multiple perspectives on assessment instead, were accustomed to grading student work as a measure of progress. We did not find an effective way to process student written work that quickly and thoroughly informed us of their mathematical knowledge. Assessing student work required careful reading, which necessitated much more time than checking for correct short answers. Students manipulated time constraints in several ways. They took the opportunity to move slowly by convincing us that they needed more time and we granted it hoping that additional time would produce better results. They delayed deadlines and cheated, making timely and accurate assessment challenging. The radical difference in both the content and pedagogy of the CPMP materials was difficult for students and teachers to accommodate. Those difficulties and the modifications we made to the instructional model obscured information we needed to make decisions to move forward. Altogether, it just took too much time.

CHAPTER 6

WHAT WILL HELP REFORM EFFORTS?

Introduction

After reading Chapters 3, 4, and 5 it would be reasonable to ask, *Why would anyone want to attempt to implement reform in a mathematics classroom?* The obstacles and challenges we faced were certainly enough to deter teachers and school systems from adopting reformed curriculum. Nevertheless, we did not throw in the towel. In fact, the following year we added Course 2, then Course 3 the year after, and to complete the sequence, we added Course 4 in 1998.

What was it that motivated us to persist? Why did we persevere in the face of many discouraging outcomes and frustrated endeavors? What can be learned from the experience that might facilitate other's efforts at reform implementation?

This study illuminates some of what happened when seasoned teachers made a sincere effort to use radically different curriculum materials. CPMP was so different from anything we had ever used in classrooms that it was more work and more frustrating than simply implementing a new textbook. In hindsight, we could have benefited from more of lots of things: more research-based information about cooperative learning; more time for planning and more time in class for students to work on mathematics; more time to correct students' papers; more realistic expectations for us and our students; and more faith in our own professional experience and judgement.

Perseverance in the Face of Adversity

Certainly, there must have been something that encouraged or inspired us to continue when common sense told us to give up and return to the traditional curriculum and methods. First, we knew that our students had not been successful when we used traditional materials although our work had been easier. Our primary motivation for making the change had been to improve student performance and we believed that using these materials and methods was the right thing do. Second, when we participated in the sample lesson, we were impressed with the way the concepts were presented in the text. We believed that the students would benefit from discovering and making sense of the mathematics on their own as opposed to us telling them everything. Third, our sincere and honest commitment to the developers and to each other to use the materials as our standard curriculum kept us from abandoning the program mid-year. In addition, we had invested considerable funds to purchase the field-test materials and it would have been difficult to justify abandoning the project mid-year. From a pragmatic perspective, what would we have done if we had decided to return to the traditional Algebra text? We would have needed to issue textbooks and begin with Chapter 1. That was not even considered at any point in the school year. Had we opted to change course mid-year, we would have taught very little of either curriculum.

Again, one might ask *Why didn't you just do a little bit of each. Couldn't you just mix in the traditional topics with the investigations?*

The task of writing curriculum while teaching five classes a day was a daunting challenge. We were not prepared or equipped to do that. In some lessons, we added technical skill problems to assignments by making them up and writing them on the chalkboard. However, creating an amalgam of traditional algebra and reformed integrated curriculum was something we did not even attempt.

Why did you keep going, when it seemed to be failing?

Every now and again, we saw students gain insight and success and we were encouraged by what we interpreted as small victories. We witnessed students having success that might never have had success in a traditional Algebra I course. In November, we discussed how frustrating it was to change so much about what we were doing as teachers and how very different it was for students. Two of the teachers shared the essence of what it was that made it worthwhile.

> Tia: What keeps me going is every once in a while my third hour class does exactly what the program says they should do.
>
> Lea: I'm amazed at some of the kid's papers and what they remember. They remember stuff that blows my mind. The dumbest kids do the most amazing things!

We had searched for ways to provide real world context for the mathematics we taught. In the past, we had created a few lessons that represented mathematics as useful and applicable to the world our students recognized. This curriculum gave us a full year of those lessons. We considered the presentation of mathematics to be relevant, and if students took it seriously quite rigorous. In general, the students no longer asked us "*When are we ever going to use this?*" and by that, we were encouraged.

As professionals, we were growing. Toward the end of the school year, we had a conversation concerning a lesson on rigid figures in geometry. In this dialog, we used terminology that had not been present in our early sessions. We discussed the need to prove or disprove the conjectures. In our May full day meeting, one comment about our growth as professionals stood out from the others.

> Kay: Teacher learning is a powerful piece of participation in this project. We have adopted the teaching and learning style of the program as our own. I don't think that this is usual in professional development and teacher learning activities.

The type of change implicit in the recommendations for reform requires support. Materials continue to be an important mainstay of instruction. If teachers are to make significant change in practices, they need concrete materials in their hands, materials that help to structure the activities of classrooms. Having comprehensive materials in our hands was one component, which worked well for us and made it possible to continue. Ed summed up what was necessary for him to make changes:

> Ed: To make changes, to move in a new direction, I need materials. I can't do it without something to direct the effort.

We had selected the CPMP materials and we had collegial support firmly in place. We believed we had selected materials that presented mathematics as a connected body of knowledge in a context that made sense to our students. We were certain that our choice to change from traditional to reformed curriculum was appropriate. We believed we had made good choices. We stood by our choices and by each other.

Challenges of Reform

Only eleven years have passed since the first NCTM document was published. Development and implementation of reformed curriculum and new pedagogy has a limited history compared to the time we have spent teaching the mathematics of Euclid and Descartes. The roots of teaching practices are challenged by the changes inherent in reform. Researchers tell us that mathematics curriculum reform is difficult and will take time:

> Because mathematics reforms challenge culturally embedded views of mathematics, of who can – or who needs to - learn math, and of what is entailed in teaching and learning it, we will find that realizing the reform visions will require profound and extensive societal and individual learning – and unlearning – not just by teachers, but also by players across the system. (Ball, 1996, p. 501)

> There is never enough time. Making significant change is extremely time-consuming, yet teachers have little flexibility with regard to time. The focus on coverage makes time an issue within each class...And because the process of change takes years before new practices are solidly established, the time problem never seems to go away. (Anderson, 1995, p. 35)

Teachers echo the difficulty of making change in classrooms:

> From a teacher: It's hard to change! It's much easier to stay with what you know; you feel comfortable with that. So I think [you should] take it easy on yourself and do one thing at a time and then feel like you've accomplished that and then move something else in all the time. Get that area so that you feel good about it, next year add another area, then another area, then another area. (Ferrucci, 1996, p. 45)

School personnel support the efforts of teachers with realistic expectations, patience, and understanding:

> From a principal: Don't expect to implement the entire program in one year. It is just not possible. It takes several years for [teachers] to get everything internalized and integrated and so part of the message we communicate and try to reinforce is that you take what you understand and what you can manage effectively and work on that, even if it's only one thing. (Ferrucci, 1996, p. 45)

These voices, which speak from the study of teaching and learning and from experience, confirm what we experienced. We tried to change too much too quickly. A complete change from traditional to reformed curriculum and instructional practices for all traditional Algebra 1 classes was more than the teachers could successfully accomplish at one time. The culture shock in the classroom overwhelmed both the teachers and the students.

What Would Have Helped Us?

Things we could have known might have helped us to make better decisions as we went through the year. We needed to know more about standards-based, inquiry-oriented teaching and learning, but we were so overwhelmed by the challenges that we could not and did not set aside the time for our own learning.

More Information

There were many things we should or could have learned before we began the year using the CPMP materials. There were a number of teaching and learning areas where more research-based information would have been helpful (e.g., cooperative learning, inquiry oriented teaching and learning). But the most important resources we failed to draw upon effectively were our own professional experience and judgement. There were innumerable instances where each of us sensed that things were not going the way we expected or wanted. Our experiences told us that something could or should be different. Nevertheless, we did not intervene to change a lesson or alter an investigation to fit our students. Our commitment to the constraints of the CPMP materials in spite of our knowledge of teaching was steadfast.

What kind of knowledge would have helped us to successfully implement the Core Plus Mathematics Project materials? We began the year knowing very little about the program as a whole. In retrospect, I believe we were irresponsible to begin teaching a curriculum about which we knew so little. The materials were a work in progress and not available to us as a whole. We needed more information about the materials, the content, and the instructional model. Certainly, more detailed information about the scope and sequence of the curriculum would have prepared us for making decisions regarding what students needed to know and when they needed to know it. Curriculum developers should provide that information, especially for implementation of new curriculum in its early stages.

Cooperative learning. Students working in groups was a large part of the curriculum and the problems we had implementing it. We made mistakes using cooperative learning in our classes. We attempted to implement the CPMP model of cooperative learning exactly as directed, intentionally setting aside our experience and expertise in regard to working with students in classrooms.

Classroom organization. The notion that *one-size-fits-all* in any classroom is an illusion. One classroom procedure for all activities does not work effectively. Fullan (1999) refers to theories of change and argues that there cannot be one theory that fits all situations:

> ...the reality of complexity tells us that each situation will have degrees of uniqueness in its history and makeup which will cause unpredictable differences to emerge. (p. 21)

The same cooperative learning model for all investigations day after day gave us a homogeneous class culture. Fullan goes on to reflect on the benefits of finding positive elements in conflict and diversity:

> Homogeneous cultures may have little disagreement, but they are also less interesting. (p. 22)

The mandate for all class activity to be in cooperative groups was not a realistic prescription for instruction on a day after day basis. The same class procedure every day was unwise if not boring. A group of four with the same role assignments and responsibilities for each activity, was a counterproductive instructional strategy for many tasks. Maintaining that stance in the face of difficulties served to prolong our problems.

We were not well informed on the many aspects of cooperative learning. There was information available on effective cooperative learning techniques at the time, but we did not seek it out. Nor did anyone suggest that we might consider cooperative learning models other than the one CPMP advocated. Even the suggestion to deviate from the groups-of-four model given by Art Coxford, a lead author of CPMP, in the fall of 1995, did not deter us from sticking with the CPMP cooperative learning model. Had we gone to the literature, the work of other scholars might have helped us avoid some of the negative experiences. In their guidebook Tinzmann, Jones, Fennifore, Bakker, Fine, and Pierce (1990) organize and illustrate the characteristics and principles that underpin effective use of collaborative work in classrooms. Their vision of shared knowledge in a collaborative classroom contrasts sharply with our experience. Shared knowledge took on new meaning with our students. They collaborated merely to minimize the amount of effort they expended, they copied each other's homework, and they shared answers on tests. More guidance on using cooperative learning might have helped us facilitate genuine collaboration in our groups.

Slavin (1983) and Kohn (1990a, 1990b, 1991a, 1991b) investigated rewards, incentives, and appropriate tasks for cooperative learning. However, the only rewards we were able to use effectively were letter grades on report cards. The tasks that were not challenging or interesting enough for groups of four students should have been assigned to individuals in our classes.

The size, composition, and productivity of the groups were all issues from the onset. The behaviors described by Salomon and Globerson (1989) and Cohen (1994) helped to make sense of what we encountered as I analyzed our work. Assigning roles influenced the level of participation and responsibility for completion of the task, as well as impeded problem solving regarding the requirements of the task (Lumpe, 1995). Brown and Palincsar (1986) offered guidance regarding the importance of flexibility, and cognitive function within the role dynamic. Their work helped me to identify the counterproductive patterns we described in our sessions and would have helped us to intervene to remedy situations as they occurred.

Our need to assume responsibility for every aspect of the learning environment including the participation of the students was very strong. Leaving that traditional direct-instruction model, learning to redirect questions, avoiding the tendency to lecture and explain, was difficult to accomplish without more knowledge of how to be the facilitator and intellectual coach in the classroom. Giving up the role of Atlas in the classroom was extremely difficult, especially when we observed that things were not going as well as they had when we were in charge (Finkel and Monk, 1983).

Had we known more about how and when to use cooperative learning in our classrooms we might have been able to avoid some of the problems we encountered. Again, our determination to adhere to the design of the program was a force that kept us on task. In addition, the two teachers who were trained in the summer reminded us of how well the cooperative groups had functioned in their experience. Their input served to reinforce our resolve to employ the CPMP instructional model. Consequently, time that was lost in unproductive group activity was also lost to instruction and investigation.

Teachers should not ignore their own professional experience and judgement when making decisions regarding classroom dilemmas. We worked to maintain the instructional model and position on cooperative groups of four even when we could see that it was not working. It was a mistake to set aside our knowledge of how to teach the mathematical content (Shulman, 1987) and instead, continue using an instructional model even when we clearly saw that students were not cooperating and not learning with the classroom format. Teachers need to rely on what they have learned about students and learning, and about classroom management. Although, they should not avoid change by cleaving to old methods just because "We have always done it that way," they should not also deny their judgement and experience, and blindly follow the teaching directions when it just does not feel right.

Inquiry oriented teaching and learning. The NCTM standards documents (1989, 1991) strongly suggest that students engage in mathematical inquiry. In addition, the documents refer to meaningful tasks and classroom discourse. A clearer understanding of what those terms meant in terms of our classrooms and students would have assisted us.

It is important to remember this was a group of teachers with many years of teaching experience. These were individuals who were all confident in their subject matter knowledge and their ability to teach it effectively. In this new environment, we were to be facilitators in the classroom not the persons with all the answers. We were expected to encourage creativity, avoid providing information, accept multiple answers, and support conjecturing. We were to help students develop an appreciation of and sensitivity to variation.

Those were worthwhile goals, but we did not know what a teacher might do to develop sensitivity and nurture appreciation. We needed to know when and how to intervene and move students on when they were stuck. Our experience and intellect prepared us to provide students with information, explanation, examples, and answers. However, we struggled with how to facilitate learning without taking that experience away from them.

The CPMP materials were written in such a way that students would explore and investigate, but our students were unaccustomed to reading and following directions. They expected us to explain and direct the activities in the classroom. In contrast, our understanding of the teacher role was that we should not give directions and instructions. It almost seemed that the materials assumed the role of the teacher, and we teachers deferred to that. We expected the materials and the cooperative learning structure to keep the students engaged in collaboration and cooperation. Hindsight suggests that we should have worked more to teach students how to collaborate and engage in inquiry-oriented learning. But we needed to know more about inquiry learning ourselves to accomplish that goal.

Assessing understanding. Determining what students had learned from the CPMP tasks was problematic. We would have been helped if we had possessed more knowledge about assessing work on more complex problems than we had in traditional algebra. We attempted to grade student work using standards that applied to traditional mathematics tasks such as A, B, and C or partial credit scales, which subdivided a task into the number of segments that were executed correctly. Instead, we needed to know how to grade student work using holistic rubrics. Even though we worked to establish a scale or standard by which to grade our students' papers, we simply did not have an efficient way to grade their work and communicate to our students regarding their progress.

Subject matter and technology. The new subject matter that was included in Course 1 consisted of statistics and data analysis. We were able to learn the concepts we had not taught previously. However, we could have benefited from a summary of the topics that were new to secondary curriculum and where they were positioned in the course of study.

Teaching with graphing calculator technology was new to most of the teachers. Consequently, learning the keystrokes and intricacies of the calculator with sufficient degree of confidence to use it as an effective teaching tool was time consuming and challenging. It took practice outside the classroom. The students were unsure of the calculator and required a great deal of assistance in the classroom. Additional training using the technology might have saved us preparation time.

Support and Professional Development

Attending to the professional and personal needs and dilemmas of the teachers is a substantial element to be considered in reform (Anderson, 1995). The significant changes the teachers must make in their beliefs, practices, and knowledge are an important consideration (Ball, 1996). A variety of persons might be able provide support and facilitate new learning for teachers as they attempt to make changes.

Building support. Teachers need time to collaborate with each other, time to share what has gone well in class and time to commiserate about the lessons that fizzled into chaos or into dead time and space. In addition, teachers need time to plan together for instruction, and time to revise the curriculum when they deem it necessary. Our school administrators provided us with professional development time each month, where we had the opportunity to work together on the issues that seemed the most compelling. We had the benefit of a common lunch period where we were able to compare notes and share ideas each day. Our classrooms were located in the same vicinity of the building as were our offices. All of these conditions served us well. Additional support could have been provided by adjusting the master schedule to enable those teachers who were assigned common courses to share common planning periods.

Leadership can provide benefits toward the enactment of reform. It is important that the leader be a person who will take responsibility for the details regarding materials, who can communicate with building leadership, and who will speak for the group when necessary. This person should have both a clear vision of and be committed to reform. The leader should have knowledge of subject matter, and have the drive to seek out necessary resources as well as the time to serve as a resource to the teachers who work with new materials (Anderson, 1996).

We had two teachers who acted as our teacher leaders. They were the unofficial spokespersons for the curriculum developers and provided us with their interpretation of implementation when we were confused or concerned. Although we had the benefit of their advice and guidance, we continued to encounter challenges. Designated lead teachers may need additional training to effectively spearhead reform efforts in a school.

A regular schedule to observe and collaborate concerning the effectiveness of our words and actions might help teachers new to reform to gain additional perspective on their teaching practices. If we had received constructive criticism based on observations in our classrooms, we might have gained some insight – from collective opinions regarding effective teaching – into the options available.

Professional development. Implementing reform requires new ideas. Schools should plan for time and resource persons to provide necessary in-service. Teachers might determine what type of information and training they need as the school year unfolds. In our situation, we needed information regarding cooperative learning and inquiry-oriented mathematics instruction.

The standards suggest teachers will provide students with guidance and direction but do not tell us how to decide when guidance is needed. How do teachers recognize when students are hopelessly mired in a problem and it is time to stop the process and redirect their thinking? They do not tell us what to do to provide students with assistance while leaving the essential elements of the task for the students. Teachers need specifics on intervention when students are working to explore and construct mathematical knowledge. We might have benefited from knowing more about when and how to intervene in the inquiry process without jeopardizing the learning experience for students. Such training might have helped us to decide that it was indeed appropriate to stop a lesson in progress and make adjustments in the task or the learning environment.

Curriculum support. We were a secondary field-test group, and as such did not receive the classroom observations and support that the primary field-test school received. Developing new materials is a challenging task for all parties involved. It is unfortunate we did not have the benefit of input from the developers regarding the interaction of students and materials. We were challenged to interpret the intent of the developers and to understand what our students were doing in the light of what was expected of them. CPMP diverged radically from traditional curriculum and it is likely we would have struggled with any newly developed program that departed so completely from the norm.

New and different materials challenge all persons involved, especially in the early stages of development. It is reasonable to expect curriculum developers to provide complete information that addresses the ways in which new materials differ from the established standard curriculum.

When the materials were ultimately published, some of the teacher directions were modified and suggestions for grading papers and assessing student work were included. The strict adherence to the cooperative learning model did not change nor was the cooperative learning for all activities modified.

Significance of the Study

Certainly all parties involved in mathematics education recognize that teaching and learning that is consistent with the NCTM standards documents will be radically different from their typical personal experience in classrooms. Different players in the educational community have different things to learn about the changes which accompany implementation of reform in mathematics instruction. Developers of reform curricula need to appreciate the challenges that teachers face as they use new materials. In order to appropriately revise and adjust newly developed curricula to address the major problems that occur, developers need an insider vision of real students and real classrooms day after day. In turn, teachers need to realize that curriculum materials are often designed to simplify teachers' work by clearly defining as many aspects of it as possible. Teacher input is valuable in curriculum development. However, the wide variance among teachers, learners, and classrooms suggests that writing universal curriculum might be a virtually impossible task. Teachers should be mindful that their judgements and experiences are an integral part of curriculum implementation and trusting those resources is important.

As additional schools embark on the implementation of new and radically different curriculum, teachers and other school personnel should be apprised of potential problems. Thus informed, they might effectively plan for and avoid the obstacles and uncertainty the teachers in this study encountered. School administration should be prepared to provide appropriate support and professional development for teachers making important changes in their teaching practices. Professional development providers can use the findings of this study to devise appropriate in-service to address the issues that arise for teachers engaged in reformed mathematics instruction. Teacher educators could work effectively to equip pre-service teachers with the content knowledge and pedagogy necessary to teach inquiry-oriented curriculum.

Epilog: Current Status of the Curriculum Improvement Plan

When we began, in the fall of 1995 there were thirteen sections of CPMP Course 1. In the fall of 2000, there are two sections of Course 1. After the first year, we added Course 2, then Course 3, and the students who began the program as ninth grade students continued into Course 4 in the fall of 1998. Table 6.1 illustrates the fate of the reform movement at Northwest High.

Table 6.1 Number of Sections of CPMP Courses per Year

Year CPMP	1995	1996	1997	1998	1999	2000
Course 1	13	14	13	13	2	2
Course 2	0	12	12	11	11	2
Course 3	0	0	8	8	6	4
Course 4	0	0	0	2	3	1

Our students and their parents consistently opposed replacing traditional algebra with a reformed and integrated curriculum. Parents expressed concern about students' performance on standardized tests (ACT and SAT) and with the fact that the mathematics their children brought home was unfamiliar, calculator dependent, and they were unable to help their sons and daughters with their homework. The opposition continued and was fueled by newspaper articles criticizing *Fuzzy Math* and *Bunny Hugger Math*. The critiques were unfounded but found responsive listeners in our community.

Our efforts at reform in the high school were undermined by members of our own community. In a complete lack of support for reform, middle school principals in the district offered traditional Algebra to any or all eighth grade students wishing to take the course. This made them eligible to enroll in a traditional Geometry course in the ninth grade. Parents saw the honors sequence, which began with eighth grade Algebra, and culminated with Advanced Placement Calculus, as the most desirable sequence of courses, and wanted their children to have that opportunity. They associated early Algebra with successful completion of Calculus and saw our efforts to reform the curriculum as watering down, or dumbing down the course offerings for their students. In addition, even though collegial respect and support within a school system is vital to the success of reform, members of our own faculty who were not fully informed on the merits and purpose of reform maligned the CPMP curriculum.

Yielding to parental pressure, the school has returned to the traditional course offerings: Preparation for Algebra, Algebra Tutorial[1], Algebra 1, Geometry, and Algebra 2. The CPMP courses remain as an option for students, however the enrollment is small. It is important to note that the students who are currently placed in CPMP Course 1 either failed Algebra 1, failed CPMP Course 1, or were not sufficiently successful in the Pre-Algebra course to be placed in Algebra 1. The CPMP courses have become: 1) a holding place for students until they are deemed prepared for the traditional sequence of mathematics courses, or 2) an alternative curriculum for students who bring little success or motivation to the study of mathematics.

Studies have shown the importance of involving parents and community members in the decision to make a significant change in curriculum (Anderson, 1995, Ball, 1996). We made a serious error in omitting parental input in the decision to adopt CPMP curriculum.

Advanced Placement Statistics has been added to the course offerings in 2000. Many students who studied CPMP Course 3 during the 1999-2000 school year are now enrolled in the statistics course, and there are three sections of that class. Unfortunately, those students are not completing the CPMP course sequence by enrolling in Course 4. Furthermore, because we were never able to increase the pace of the classes, students did not complete the content offered in the first three courses. For these students, important mathematics in the sequence has been left untouched.

The teachers who spent many weeks and hours learning new mathematics and new methods find themselves back where they started. However, I have reason to believe that their teaching will never be as it was before CPMP. Teachers made comments during that first year that lead me to believe the effects of student-centered inquiry-oriented found their way into the traditional classes and continue to do so today.

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[1] This is an extra support class for students in the Preparation for Algebra class. It is an even lower level course for students with very low mathematics ability. Previous teacher recommendation and standardized test scores in middle school determine student placement in this course.

Recommendations for Further Study

This study points to the need for teachers to know more about implementing reform before they begin with students in classrooms and as they continue to face the challenges which accompany learning new pedagogy and subject matter. Further study might address the priority of needs for in-service teachers. *What do teachers need to know and when to they need to know it?* Teacher experience and expertise may vary widely. Therefore, it is necessary to determine what needs, if any are common among seasoned teachers concerning inquiry-oriented teaching and learning. Professional development designed to meet the needs of specific teacher populations would be the most desirable option, however the ability to plan for universal content for teachers might make initial professional development easier to initiate.

There is a need for teachers to learn about how to direct students without telling. Teachers with a sincere desire to have students achieve the positive benefits of constructing knowledge for themselves need to know when and how to intervene in the learning process. We need to know more about how to educate teachers in the practices that facilitate inquiry learning. Future study might focus on different alternatives and explore the effectiveness of videotaped learning experiences as a medium for in-service teachers that would allow them to observe and discuss inquiry-oriented instruction.

The curriculum materials alone are not enough to help a teacher align practices with those suggested by reform. Further study is needed to determine what would be helpful to include with curriculum materials that might serve the teachers well as they make significant change in their classrooms. A variety of professional development structures that are be partnered with curriculum implementation might be studied to determine the most effective model for ongoing teacher support.

This study helps to confirm the importance of collaboration and communication for teachers making significant changes in their teaching practices. Further studies that focus on the benefits of collaboration would help to affirm for school administration personnel the need to allocate the time and funding necessary to ensure that teachers receive the collaboration support that this study indicated was beneficial.

We need further study of students who have completed reformed curriculum programs. It is necessary to follow students into post secondary environments, to determine whether they are advantaged by mathematics instruction that embodies the reform movement. Confirmation that students achieved mathematical literacy in a non-traditional learning environment might make the argument for reform more convincing, especially for those who espouse a return to the basics. Such follow up studies of students might also reveal that there is a need for a symbolic algebra course in secondary mathematics education.

Final Comments

This study has the potential to discourage rather than inspire efforts in reform. It was intended to investigate what happened when teachers made and honest effort to enact reform. In their struggles, these teachers and were troubled more often than they were encouraged. They believed they were doing the right thing and were empowered and energized by that belief. They should be commended for their commitment to their students and to improving their practice. Their difficulties suggest what we need to know and be able to do to underpin and scaffold the reform efforts.

This study suggests that teachers might be the most essential element in reform. Changing long-standing teaching and learning practices may require knowledge and support that had not been anticipated. Few would argue that the challenges of reform are at times daunting and disheartening. The education community should be encouraged and energized by the dedication and perseverance these teachers demonstrated. Teachers such as these are the human resources we need to inspire others to continue strive for better education for our children.

APPENDICES

APPENDIX A

DATES OF FIELD NOTES TAKEN AT PROFESSIONAL DEVELOPMENT

Appendix A

Dates of Field Notes Taken at Professional Development

1. September 19, 1995
2. October 17, 1995
3. November 28, 1995
4. January 7, 1996
5. February 6, 1996
6. March 12, 1996
7. April 16, 1996
8. May 7, 1996
9. June 4, 1996

APPENDIX B

JOURNAL ENTRY DATES

APPENDIX B

JOURNAL ENTRY DATES[1]

1. September 4, 1995
2. September 19, 1995
3. October 2, 1995
4. October 8, 1995
5. November 4, 1995
6. November 28, 1995
7. December 5, 1995
8. December 5, 1995
9. December 6, 1995
10. December 13, 1995
11. December 14, 1995
12. December 20, 1995
13. January 9, 1996
14. January24, 1996
15. January 25, 1996
16. January 29, 1996
17. January 29, 1996
18. January 30, 1996
19. January 30, 1996
20. February 1, 1996
21. February 6, 1996
22. February 6, 1996
23. February10, 1996
24. February 28, 1996
25. March 12, , 1996
26. March 27, 1996
27. March 28, 1996
28. April 16, 1996
29. April 20, 1996
30. May 1, 1996
31. May 1, 1996
32. May 1, 1996
33. May 6, 1996
34. May 7, 1996
35. May10, 1996
36. May 10, 1996
37. May 28, 1996
38. June 4 , 1996

[1] Multiple entries occurred on some days. Different subjects or incidents prompted a second entry later in the day.

39. June 13 , 1996
40. June 14 , 1996
41. July 9 , 1996
42. July 25, 1996
43. July 27, 1996
44. July29, 1996
45. August 6, 1996
46. August 7, 1996

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