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Janine T. Remillard

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CHANGING TEXTS, TEACHERS, AND TEACHING: THE ROLE OF CURRICULUM MATERIALS IN MATHEMATICS EDUCATION REFORM

VOLUME I

Ву

Janine T. Remillard

A DISSERTATION

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ABSTRACT

CHANGING TEXTS, TEACHERS, AND TEACHING: THE ROLE OF CURRICULUM MATERIALS IN MATHEMATICS EDUCATION REFORM

By

Janine T. Remillard

The aim of the study was to examine teachers' interactions with a new textbook in order to gain insight into the potential for curriculum materials to contribute to reform in mathematics teaching. It was motivated by the tendency of educational policy makers to use curriculum materials to implement curricular and pedagogical change in mathematics teaching and by discrepancies in research findings regarding their impact on teaching. While studies reveal a close match between mathematical topics most frequently taught and the core topics, skills, and content in texts (Freeman & Porter, 1989; Stodolsky, 1989), researchers have also noted variations between classroom instruction and what is suggested in textbooks, particularly when the texts are based on nonconventional views of mathematics. (Putnam, 1992; Stephens, 1982; Sosniak & Stodolsky, 1993). Many researchers have found that teachers are influenced by their beliefs and knowledge about teaching, learning, and the subject matter more than by what is presented in texts (Ball, 1988; Donovan, 1983). The intent of this study was to consider whether and how reform-oriented curriculum materials might contribute to change in mathematics instruction.

Using case-study methodology, the author analyzed the interactive relationships between a new mathematics textbook and two fourth-grade teachers' thinking about, and teaching of, mathematics during one school year. In addition to observing and

interviewing the teachers regularly, she analyzed the contents of the textbook for its depiction of mathematics teaching and learning. Through a cross-case analysis, the author developed a model of teachers' curriculum development activities, that is their construction of mathematics curriculum in the classroom. The model, which includes but is not limited to teachers' textbook use, consists of three arenas in which teachers engage in curriculum development: design, construction, and curriculum mapping. Each arena defines a particular realm of the curriculum development process about which teachers explicitly or implicitly make decisions. Through articulating each piece of the model, the author highlights the complex and multi-dimensional nature of teachers' curriculum processes, identifies significant characteristics of each arena that have implications for textbook use and instructional change, and indicates areas that call for further research.

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ACKNOWLEDGMENTS

As I prepare this dissertation to be bound, I am surprised to confront a mixture of emotions. On the one hand, I feel nothing short of pleasure and accomplishment that after many months of being "so close" to finished, the day has finally arrived. On the other hand, I must admit to feeling a touch of regret. This piece of work that has so consumed me for the last few years represents a significant chapter of my scholarly and personal growth. And while my work continues in other forms, this particular journey has come to a close. Looking back on my travels from my current vantage point, I realize that the prize is not in the finished pages, but in the journey itself; for it has changed me in ways I did not anticipate. Like most journeys, it was enriched, endured, and even made possible through the gifts of a number of fellow travelers along the way. It is to these people that I now turn knowing that my words cannot aptly capture their gifts or my gratitude.

I begin with the two teachers who made the study possible. These two women allowed me to visit their classrooms regularly and gave of their time to answer my probing questions. I am grateful for their willingness to share so much of themselves with me and to do so with remarkable interest.

I am also grateful to the many teachers who have guided me in my travels. Most prominent among them are the members of my committee who have unselfishly given of their wisdom and time. Deborah Ball, the chair of my committee and dissertation director, Suzanne Wilson, Ralph Putnam, and Glenda Lappan have contributed to my growth in their own distinct ways.

Since early in my graduate-school career, Deborah Ball has been an irreplaceable teacher, mentor, and friend. She had a way of seeing more in me than I knew was there, expecting more of me than I believed I could accomplish, while standing beside me and

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CHAPTER ONE

THE TEACHER, TEXTBOOK, CURRICULUM RELATIONSHIP

Introduction

A Teacher and a Text

Like many young teachers emerging from colleges of education, I began my career believing that textbooks were an artifact of tradition. Entrenched and uncreative, they were everything I did not want my teaching to be. The 22-year-old enthusiasm that I brought to my first teaching job enabled me to create educative and engaging experiences for my students without such texts in all subjects except mathematics. Math stumped me. Even though I was well-prepared mathematically, I had never experienced mathematics teaching that was intellectually engaging. As a teacher, I knew that there were important ideas to be learned, but I did not know how to sort the genuinely significant from those that were simply familiar.

Eventually, I found my way to an innovative mathematics program called Comprehensive School Mathematics Program (CSMP). Even though it was a published curriculum, it was unlike any textbook I had ever seen. Using it helped me engage my students in thinking about concepts and ideas that seemed important. I followed the scripted lesson plans as closely as I could and was pleased with the way they helped me establish conversations about math problems with my students. I liked the way the questions it suggested required them to think about mathematical ideas, not only find answers. Frequently, it suggested that I ask students to explain how they had come to a particular answer, even if the problem had been straightforward. These suggestions seemed irrelevant, so I discarded them.

CSMP also required me to think about mathematical ideas. The visual representations writers used to illustrate various mathematical relationships helped me see these ideas differently. Through using them, I began to think about numbers, functions, and operations more conceptually, that is, as big ideas that held a lot of procedures together. I wanted my students to see the same things.

With the help of a supportive principal, I managed to convince my colleagues to adopt CSMP as the school's mathematics curriculum. Even though they were willing, I was puzzled by the luke-warm reception they gave it. They were hesitant to whole-heartedly embrace this carefully designed program that meshed perfectly with the school's philosophy. They were reluctant to engage the mathematical ideas, and it seemed that they were too quick to impose substantial revisions on its offerings.

Texts and Teaching: A Broader Perspective

I left these concerns behind when I began doctoral studies at Michigan State

University. It was not long before they reappeared, albeit in different clothes. My work
on two research projects made me believe that my experiences with CSMP were not
idiosyncratic but examples of significant issues related to teaching and educational
reform. The first project entailed analyzing three alternative elementary mathematics
teacher's guides (one of which was CSMP) looking at their potential for fostering critical
thinking; I found they had quite a bit. In very different ways, each of the three programs
was designed to engage students in exploring and thinking about important
mathematical ideas (see Remillard, 1991a, 1991b). However, what I was learning from
the second project raised doubts about their likely impact. The project involved
observing and interviewing teachers in a study of the relationship between a state-level
policy and classroom practice. Our findings suggested that the relationship was less
than straightforward. Teachers made sense of the policy and their new textbooks
differently as a result of their views on teaching and learning math (see Cohen et al.,

1990). As a result, they sometimes omitted or altered what seemed to be the best parts of their texts.

My graduate studies also put mathematics and my former colleagues' discomfort with it in a different light. Even though my view of it was expanding, I became more cognizant that most people view math as a dry subject, driven by rules rather than reason. This view was perpetuated by school practices that focus on rote memorization and drill. For many, these rules are daunting. Teachers who have learned this version of math often find it intimidating and generally are not interested in giving it a second look.

These new perspectives helped me to understand my earlier experience in a broader context, but they also prompted as many questions as answers. Textbooks can be an influential factor in teachers' learning and teaching, but not in every situation, not with every textbook, nor with every teacher. In what ways and under what circumstances can textbooks help teachers learn to teach differently? This question is particularly relevant given the current reform efforts in mathematics education. Teachers are asked to teach mathematics in new ways—in ways they have never experienced as students or teachers (Cohen, 1989). As in previous periods of educational reform, policy makers, reformers, and teachers view changed textbooks as primary vehicles to guide their efforts (Tyson-Bernstein & Woodward, 1991).

Underlying this faith in textbooks is an assumption about the relationship between texts and teaching that I explored in this study. As a teacher whose teaching and learning were influenced by an alternative textbook and having a sense of the richness such texts could offer, I believed that changed textbooks might have a role in reform in mathematics education. However, seeing that teachers' uses of texts were shaped by myriad factors, I realized that determining what that role might be would require a better understanding of the relationship between texts, teachers, and their teaching. I examined this relationship by studying how two teachers interacted with a changed textbook in the process of teaching mathematics. The teachers, Jackie Yarnell

and Catherine McKeen, taught fourth grade in a school district in Michigan that had just adopted a new mathematics textbook, <u>Mathematics Plus</u>, published by Harcourt Brace Jovanovich (HBJ) in 1992.

Teachers, Texts, and Curriculum: Framing the Study

Considering the role that changed textbooks might play in educational reform requires more than studying the teacher-text relationship. How teachers use textbooks is only one factor that influences practice (Sosniak & Stodolsky, 1993). Thus, in this study, I focused on the three-way relationship among the teacher, the textbook, and the curriculum, in which the curriculum refers to the events teachers and students experience in the classroom (Clandinin & Connelly, 1992). Figure 1.1 illustrates this relationship and places it in two influential contexts. The first context is the teacher's immediate teaching and school setting, and the second is the context of reform in mathematics education. Both contribute to the interactions among the teacher, the text, and the curriculum being created.

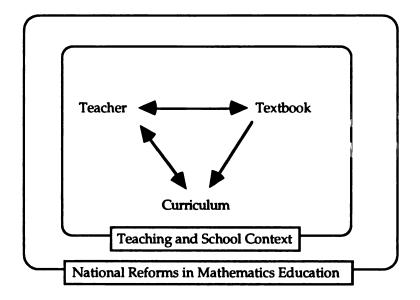


Figure 1.1. Teacher, textbooks, curriculum relationship

Embedded in this three-way relationship are several sets of interactions that have been subjects of previous research. These findings have informed my study. One body of research, for example, focuses on the teacher-text relationship, exploring how teachers interact with and use textbooks. Another examines how teachers construct curriculum in their classrooms, and a third (represented by both arrows that point to the teacher) is of teacher learning and change. Research in this area is particularly relevant to the reform context. This research examines factors that contribute to change in teachers and their teaching, providing the larger context in which this study resided. In this study of the role of a reform-oriented textbook in teachers' processes of curriculum construction in the context of reform, I drew on all three areas of research. Each one is reviewed below. First, however, I discuss a crucial element of the context in which both teachers were working and of this study: the national reforms in mathematics education.

The Reform Context

The reform context was crucial to this study because it was more than the background in which these teachers were teaching. It influenced the relationships at every level, and was evident in the messages teachers received from the district and within their school about what was important in math. The textbook the teachers were using had been redesigned in response to these calls for change, and also framed my conceptualization of this study. My choice to examine teachers' interactions with a reform-oriented textbook in the process of teaching mathematics was motivated by my interest in learning more about the role textbooks might play in helping teachers respond to the reforms. Thus, what these reforms represent philosophically, and what they suggest mathematically and pedagogically were of central interest in this study.

Throughout my thesis I use the terms "reforms" or "reform agenda" referring to a range of endeavors to stimulate change in mathematics content and instruction. These efforts are widespread but do not come from one source, nor do they reflect a single

Purthermore, most national or local documents outlining new curricular goals and pedagogical ideals present ambitious visions for improving mathematics education, not recipes (Ball, 1994). The <u>Curriculum and Evaluation Standards</u> (National Council of Teachers of Mathematics (NCTM), 1989), the most visible of these, outlines and describes a set of topics that should comprise the mathematics curriculum and a list of the changes in emphasis that these new goals imply. Because of its focus on teaching, the <u>Professional Standards for Teaching Mathematics</u> (NCTM, 1991) provides a more detailed image of what changed teaching might look like. Still, these documents are visionary rather than prescriptive. Thus they are underdetermined, and by their very nature are open to multiple interpretations. Teachers, teacher educators, textbook publishers, school administrators and educational researchers interpret the messages of such documents in the process of drawing implications for teaching from these visions.

Even though the messages of the reforms cannot be reduced to a simple set of goals or philosophies, it is possible to articulate general themes that pervade much of the reform rhetoric. I do so here in order to provide some sense of the reform context of the study and to clarify what I mean when referring to the "reforms." I begin with some background.

In 1980, the National Council of Teachers of Mathematics published <u>An Agenda for Action</u>, calling for a change in mathematics education to focus greater attention on problem solving and learning to reason. During the decade to follow, myriad state and national reform efforts emerged. Aimed at creating a vision for mathematics instruction that enhances students' understandings of underlying mathematical concepts and develops their problem solving, reasoning, and communication abilities, these efforts targeted the content and pedagogy of mathematics instruction. The state of California, for example, launched a major effort in the mid 1980s to reshape how and what mathematics were taught (California State Board of Education, 1985). The efforts in

Michigan have been decidedly less comprehensive or centrally controlled. Still, in the late 1980s, the state produced new goals and objectives, rewriting the mathematics state assessment test to be more in line with these goals.

Almost 10 years later, the NCTM published the <u>Curriculum and Evaluation</u>

<u>Standards</u> (in 1989), thus providing the spark that boosted these efforts into public attention. These documents, particularly the <u>Curriculum Standards</u>, played pivotal roles in the reforms. The <u>Standards</u> have had a significant influence on mathematics education. They are the most visible and frequently cited representatives of the calls for change; for many, they represent the reform agenda.

The aim of the <u>Curriculum Standards</u> (NCTM, 1989) was to establish standards for the revision of the mathematics curriculum, thus focusing on developing students who are "mathematically literate" (p. 1) and who have "mathematical power" (p. 5). This focus includes being able to establish, reason about, and solve problems, as well as to explore, conjecture, and reason logically. In order to accomplish these goals, the authors call for shifts in the traditional emphases of the mathematics curriculum. These goals include increased emphasis on conceptual understanding and meaning of topics related to number, operations, and computation as well as decreased emphasis on early attention to symbolic representations, isolated treatment of facts and paper-and-pencil computation, and long division. They also include increased emphasis on topics that traditionally have played a background role in the elementary curriculum such as geometry and measurement, probability and statistics, patterns and relations, and problem solving (including shifts in instructional practices). Recommended goals for kindergarten through fourth grade are listed in Figure 1.2.

Over a relatively short period of time, the <u>Standards</u> became known in schools throughout the country. As more states and districts adopted some form of this vision, the impact of the <u>Standards</u> increased. By the early 1990s, these reform ideas began to have an impact on the commercial textbook market. Prior to this time, nonconventional

Increased Attention

Decreased Attention

Use of manipulative materials Cooperative work

Discussion of mathematics

Questioning

Justification of thinking Writing about mathematics Problem-solving approach to

instruction Content integration

Use of calculators and computers

Rote practice

Rote memorization of rules One answer and one method

Use of worksheets Written practice Teaching by telling

(NCTM, 1989, pp. 23, 21)

Figure 1.2 Instructional practices recommended For increased and decreased emphasis

approaches to mathematics instruction were seldom found in mainstream, commercial textbooks; curriculum resources that offered innovative materials such as CSMP remained in the smaller, less profitable, alternative market. As the influence of the reform agenda increased, those selecting textbooks began to look for traces of these new goals. In response to these market demands, the five major textbook publishers produced revised mathematics texts, which represented a small step away from traditional approaches to teaching mathematics. All claimed to draw upon the NCTM Curriculum and Evaluation Standards. Even though the extent to which they are responsive to the reforms is open for debate, at the very least they all reflect attempts to take mathematics beyond the memorization of isolated rules. In addition to conceptual development, they devote a substantial amount of space to problem solving, mathematical thinking, group work, the use of manipulatives, and alternative forms of assessment. In response, districts have been quick to select new textbooks from these to help teachers install new ideas into their teaching. In Chapter 3, I describe the textbook that Catherine and Jackie used and critique its response to the reform agenda.

The Relationship Between Policy and Practice and Issues of Teacher Change

My study exists within and is an extension of a larger, longitudinal study on the relations between state- and district-level instructional policy and classroom practice in California, Michigan, and South Carolina. The project, Educational Policy and Practice Study (EPPS), was conceived in response to the appearance of a series of national and local efforts to effect curricular and instructional change in K-12 classrooms. Our research focused on teachers' and district- and state-level policy makers' experiences with, and thinking about, state mathematics and literacy policies and their impact on practice. A central assumption of the work was that teachers' encounters with, and responses to, various manifestations of instructional policy figure significantly in the policy practice relationship. Thus, we examined a wide range of factors relevant to how teachers interpret and respond to policy, including the ways they encounter it and the personal resources they bring to it (see Geist, in preparation; Grant, 1994; Jennings, 1992; Cohen et al., 1990). In Michigan and California, revised mathematics textbooks and other curriculum materials figured significantly in local efforts to promote change. Even though we collected general data on the various ways teachers used them, we did not examine teachers' relationships with their textbooks in detail. My study, then, places a magnifying glass in front of one aspect of the EPPS work with an eye toward providing some explanation for our findings with respect to teachers' use of changed texts.

The EPPS work is situated within a larger body of work as well. For some time, researchers have studied and written about the resistance of schools and teachers to change. Noting patterns, trends, or commonalties among teachers, as well as teaching practices and school organizations and structures, they have described established cultures that predominate in schools and into which new practices must fit (Cohen, 1989; Cuban, 1984; Jackson, 1968; Lortie, 1975; Sarason, 1982; Waller, 1932). These cultures, or regularities (Sarason, 1982), form a type of "internal momentum" that buffers schools from external attempts to accomplish change. By looking more directly

at teachers and the nature of their work, these scholars have posited that the demands of the work of teachers such as its immediacy, uncertainty, dependence on students, and its isolation have perpetuated certain characteristics for the purposes of survival. These demands have resulted in reluctance toward trying new practices.

teachers' work that stifle the possibility of change. We also found the lack of change to be a matter of opportunity and learning. As I mentioned above, policy documents are underdetermined. Teachers receive messages of change through varying means, and the messages themselves may vary. They also can interpret them through their ideas about teaching and learning. We observed many teachers who have embraced calls for change and have continued to create practices that look only mildly different from what is standard (Ball, 1990; Cohen, 1990) or mathematically shallow (Geist, in preparation). We observed teachers enthusiastically trying new activities only to find themselves confused by the mathematics (Heaton, 1992) or confronted with new management problems (Poppink, 1994). We saw many teachers overwhelmed by the prospect of adding new topics and activities to their already full curricula (Grant, 1994; Peterson, 1990). Findings suggest that, as in achieving any new purpose, accomplishing instructional change will require learning on the part of educators (Ball, 1994; Cohen & Barnes, 1993; Sarason, 1982).

The need for new learning is particularly poignant in the case of the reform in mathematics education because many of the ideas of the reforms are foreign to teachers, as well as the bulk of the American population. The reforms call for shifts away from skills that have been the foundation of the elementary curriculum and greater focus on conceptual understanding, reasoning, problem solving, and communicating. Having

¹Actually, teachers are not the only participants in the educational process who require learning if the current reform agenda is to be successful and long-lasting. The learning of policy makers, administrators, parents, and students can play a crucial role in making or breaking teachers' efforts to change.

elementary teachers posses the mathematical tools or images to accomplish such shifts in their teaching (Ball, 1994; Cohen, 1989; Heaton, 1994). Yet, we observed limited opportunities for teachers to learn mathematics in the way envisioned by the NCTM Standards. As is typical in education, most of the "learning" opportunities available to teachers are in the form of workshops that supply them with an armful of activities to take to their classrooms and implement. Even though these instances have not helped teachers confront the conflicts described above, it is unclear what would assist them. In other words, there is still a lot that we do not know about the types of learning apt to lead to fundamental change (Ball, 1994).

My study grew out of these findings and concerns. In current efforts to change mathematics instruction, as in previous ones, revised textbooks are expected to play a central role. If they are to offer something to educational change, these texts must contribute to teachers' learning and development. Bruner (1977) said: "If it [new curriculum] cannot change, move, perturb, inform teachers, it will have no effect on those whom they teach. It must be first and foremost a curriculum for teachers. If it has any effect on pupils, it will have it by virtue of having had an effect on teachers" (p. xv). An important question about the role of textbooks in mathematics education reform, then, is in what ways might they contribute to teachers' learning? The answer to this question depends on learning more about teachers' learning and on learning more about how teachers use and interact with textbooks. Thus, the work on teachers and textbooks is a second body of research that informed my study.

The Teacher-Text Relationship

The question of <u>how</u> teachers interact with and use textbooks is relatively new.

Until recently, textbooks were viewed as accurate representations of classroom curriculum. In fact, historical studies of school curricula have relied heavily on textbooks of the period to reconstruct the content of classroom practice (Walker, 1976). Implicit in

this perspective is a view of the teacher as a conduit for curriculum, not a user or shaper of it. This view is strikingly evident in the curriculum reform efforts of the late 1950s and 1960s that developed in response to Cold War competition with the Soviet Union. Mathematicians and mathematics educators wanted to determine the child's instructional experiences through construction of textbooks that the teacher would implement. The assumed focus of interaction was between the student and the materials. Analyses of teachers' encounters with these materials have raised questions about teachers' roles in mediating the impact these textbooks have on the curriculum.

Only since these curriculum reforms and their gross oversight regarding the role of the teacher in enacting curriculum has the teacher's mediating power been recognized and studied. The underlying assumptions about teachers and the capacity of textbooks to revolutionize classroom instruction and their consequent failure to do so have prompted commentators such as Sarason (1982) to question the possibility of "teacher-proof" curriculum materials. Sarason observed teachers in training workshops as students and as teachers using the "New Math" materials in their classrooms. He found struggles, that is, students and teachers struggling to make sense of math foreign to them. He posited a clash between ideals of the new materials and programmatic regularities about what mathematics is and how students learn it. His articulation of this clash brought the role of the teacher in textbook use and curriculum reform to the fore.

Stake and Easley (1978), examining the state of science education in the 1970s, produced detailed case studies of mathematics and science classes using new curriculum materials with similar insights. The case studies depict teachers making similar adaptations to the written teacher's guides that fit traditional notions about the tasks of teaching and the nature of the subject matter. In their observations, Stake and Easley never observed mathematics or science being taught through inquiry which was the

²New Math is the term most frequently used in reference to the curriculum materials developed by the School Mathematics Study Group (SMSG).

curriculum developers' intent. The teachers they observed seemed intent on "covering the text," by marching the students rapidly through the "inquiry" process and presenting the subject matter as facts that experts found to be true.

These studies opened the eyes of many to the role that teachers play in shaping the curriculum experienced by students. For the most part, classrooms are no longer seen as places in which teachers simply pass content to students who receive it. Other researchers have since examined teaching and textbook use, providing insight into the teacher-text relationship. This research, however, has not been extensive. Moreover, considerable variation exists in the perspectives and foci researchers have taken, resulting in incommensurable findings. I will discuss three foci taken by researchers in studies of teachers' use of texts: factors that influence textbook use, the nature of textbook use, and the characteristics of texts teachers use.

What Influences Teachers' Use of Textbooks?

One focus of research on textbooks is on factors that influence how teachers use them. Researchers examine the perceptions held by teachers that figure in the choices they make, including conceptions of knowledge, mathematics, learning, teaching, contextual pressures, and the text itself.

Perceptions of external pressures. The Content Determinants Study, conducted at the Institute for Research on Teaching (Floden, Porter, Schmidt, Freeman, & Schwille, 1980; Kuhs & Freeman, 1979) surveyed more than 60 teachers and observed and interviewed seven upper elementary teachers over the period of a year in order to trace factors that influenced substantive elements of the content of their mathematics curriculum, that is, the topics and skills taught. They found that teachers' decisions ultimately determined content and were shaped by their perceptions of pressures and expectations brought on by testing, parents, or district policy, as well as by their personal interests, commitments, and expertise. The Content Determinants Study did

not address how mathematics was represented or the nature of the learning experiences provided for students.

Ideas about the purpose of schools and the nature of learning. Stephens (1982) and Donovan (1983) analyzed teachers using innovative curriculum materials grounded in nonmainstream conceptions of mathematics. They focused on how teachers presented the nature of mathematical knowledge. Stephens found that teachers interpreted and transformed the intended curriculum, imposing a rigid and narrow portrait of mathematics. Most teachers' instructional patterns focused on group management rather than mathematics. Donovan described teachers subverting the authority of exploration-based materials by relegating exploratory activities to an aide and then giving them no emphasis in assessment. Both researchers drew on sociology of knowledge and political theory to explain their findings by pointing to embedded cultural assumptions about the role and purposes of school and the nature of learning. In his analysis, Stephens posited that the authors of the materials

failed to challenge the traditions of existing schooling, or even to understand what they were. The conceptions of work and knowledge which most teachers brought to the implementation of [the curriculum materials] were embedded in a management perspective of instruction where the focus of instruction was on the efficient transmission of a fixed body of subject matter to the children who comprised the classroom group. (p. 220)

The case studies written by Stake and Easley (1978) depict teachers making similar adaptations to the written teacher's guides that fit their notions about the tasks of teaching and the nature of the subject matter. Stake and Easley ascribed the departures that teachers made from texts to concern for classroom control. Like Stephens (1982) and Donovan (1983), Stake and Easley pointed to teachers' needs to maintain classroom control as a powerful influence in teacher action. They raised further questions about the relationship between teacher authority and control in the classroom and the nature of knowledge such levels of control represent. These questions have implications for the current reforms that emphasize the need for students to have more authority over their knowledge and learning.

Knowledge of and views about mathematics. Ball (1988) and Thompson (1984) examined teachers' knowledge and beliefs about mathematics and they considered how these beliefs contribute to classroom practice. Even though neither researcher focused specifically on textbooks, their studies illustrate how subject-matter knowledge impacts teachers' planning decisions. Their work stands apart from previous studies because mathematics, rather than knowledge in general, played a central role in their analyses. Believing that teachers' conceptions of knowledge are subject-matter specific, both considered teachers' beliefs about the substance and nature of mathematics, linking them to their ideas about teaching mathematics. Ball looked at the knowledge and beliefs prospective teachers brought to their preservice education experiences within four categories: (a) mathematics, (b) learners, (c) learning, and (d) teaching. She found that these prospective teachers lacked conceptual knowledge of mathematical ideas, viewing mathematics as a collection of isolated rules and procedures. When planning a lesson to teach concepts such as two-digit subtraction, they generally selected representations for their interest-grabbing appeal rather than their fit with the conceptual underpinnings of the topic. She also found that these teachers thought little about what students might think, understand, misunderstand, or find interesting. The implication is that one can learn as much about the enacted curriculum from attending to what teachers tend not to believe as well as what they do believe.

Thompson (1984) examined teachers' conceptions of mathematics with respect to their instructional practices. From observations she wrote case studies of junior high school geometry teachers, focusing on how they represented mathematics. Then she compared these observations with each teacher's beliefs, views and preferences about mathematics, as determined by a teacher-belief instrument. Her findings suggest consistency between the teachers' "professed conceptions" and the conceptions of mathematics portrayed in the classroom through instructional practices. Teachers, for example, who viewed mathematics as a static body of knowledge presented the content

as a finished product of rules and procedures to be memorized. Nevertheless, their approaches varied according to their views on the interrelationship between topics and how students learn. The teacher who held a dynamic view of mathematics engaged her students in a "creative generative process" (p. 119).

In their observations of teachers using commonly used textbooks in mathematics and social studies, Graybeal and Stodolsky (1987) found that the alterations teachers made to mathematics textbooks tended to lean toward traditional conceptions of mathematics, focusing on rote memorization of isolated facts rather than on understanding concepts and application. Even though the textbooks used in these classrooms tended to reflect many aspects of traditional mathematics, they all contained opportunities for application and conceptual development that teachers often omitted or restructured when using them.

Graybeal and Stodolsky's (1987) findings confirm Ball's (1988) and Thompson's (1984) suspicion that the subject matter in question bears considerably on how teachers use textbooks. They found that the major difference among subjects was "the extent to which the textbook content represents the <u>maximal</u> content coverage" (Graybeal and Stodolsky, 1987, p. 181). In general, teachers tended to supplement and complement content in the social studies texts with other material and activities, whereas the mathematics texts rarely were supplemented, and, if they were, it was most often with additional practice. In a more recent study of teachers' use of textbook materials in four subjects, Sosniak and Stodolsky (1993) found that the same teachers who tended to enrich the textbooks' suggestions in reading and language arts tended to stick to the student exercises in mathematics.

Researchers have found that teachers' subject-matter knowledge and beliefs impact their textbook use in other subjects as well. For example, the teacher's view of the subject and how it is learned influenced textbook use in reading and science. Smith and Anderson (1984) and Roth and Anderson (1987) studied teachers using textbooks

grounded in conceptual change theories of learning science. Their case studies of teachers using curriculum materials revealed that the views teachers hold about learning and the nature of science influenced how they guided their students through material in science textbooks. They found that teachers' beliefs about learning impeded their abilities to help students replace misconceptions with scientific conceptions presented in the texts. Durkin (1983) linked teachers' views of reading with their undertreatment of comprehension and overtreatment of skill development, which is contrary to suggestions made in teacher's guides of basal readers. Similar to Stephens (1982) and Stake and Easley (1978), Durkin found that classroom management and control were powerful determinants of instructional activities selected by the teacher.

The above studies looked at how teachers' perceptions of knowledge, the subject, learning, students, or external demands shape how teachers use texts. They focused on the role teachers' perceptions play in the translation process of written materials to classroom practice. The following studies also examined the impact of teachers' perceptions on textbook use, but focused less on the curriculum as it is enacted and more on the nature of the relationships the teachers form with the texts.

Teachers' perceptions of texts. Several studies have sought to understand how teachers use texts by considering how they think about their textbooks. Unlike studies that portray teachers as mediating or filtering agents for how written curriculum materials become enacted, these imply that teachers hold beliefs about textbook use and authority that shape how they use or ignore its offerings. As in previous studies, this relationship is viewed as a function of teachers' beliefs and perceptions. By focusing specifically on this relationship, these researchers have provided insight into the role of teachers' thinking about texts in influencing textbook use.

Several researchers' have observed that teachers tend to relate to texts as authorities (Duffy, Roehler, & Putnam, 1987; Remillard, 1991c; Stake & Easley, 1978; Woodward & Elliot, 1990). Duffy et. al., hypothesizing that teacher decision making

was impeded by prescriptive textbook following, instructed teachers to make decisions about reading while using a mandated reading text. During the one-year program in which they guided teachers in making intentional decisions about their textbook use, student achievement increased. In spite of this evidence, teachers returned to prescriptive use of the basals the following year. Duffy et al. concluded that the teachers did not believe they were "empowered to be in cognitive control of their instruction" (p. 361). Teachers tended to look to the teachers' guides as authorities, believing that the authors "know more about it than I do" (p. 362).

In a study of a teacher using CSMP, I (Remillard, 1991c) observed a similar entrusting of authority to the text's authors that led to prescriptive following of the teacher's guide. The teacher, trusting that the text was designed to develop student understanding, attempted to follow the script in the teacher's guide precisely. In doing so, she searched for correct answers and particular responses it suggested. Even though the program was designed to stimulate interaction between the teacher and students, relying heavily on student ideas and solutions, this teacher's strict focus on following the script in the text restricted her from hearing and responding to the varied content of student responses.

An interesting pattern in the findings of studies of teachers who view texts as authorities is that their prescriptive approaches to following the teacher's guide tended to lead them to treat ideas, suggestions, and guidance as steps to "get through." Furthermore, the conviction that they needed to "cover the content" and their views of what this meant limited the options they had available in practice, which is particularly evident in the studies by Stake and Easley (1978) and Remillard (1991c). Both studies described teachers moving students quickly through activities and problems designed to facilitate inquiry and discovery. In other words, when attempting to follow the text, these teachers constructed their own practices that could be viewed as antithetical to the authors' intentions.

At the opposite extreme of teachers who tended to rely heavily on textbooks, seeing them as subject-matter authorities are those who reject texts indiscriminately. In a longitudinal study of two teacher preparation programs, Ball and Feiman-Nemser (1988) found that prospective teachers developed negative impressions of textbooks and teacher's guides. Both programs aimed to encourage novice teachers to maintain control over their instruction, leading them to reject any authority of the text. The implicit message received from instructors was that good teachers did not follow the textbooks but created their own lessons and materials. Doing so presented problems for student teachers when teaching in classrooms in which textbooks were central to instruction. The prospective teachers, lacking the knowledge and experience needed to develop their own curriculum, relied prescriptively on activities introduced in their methods courses as teachers in previous studies relied on texts. Ball and Feiman-Nemser described poorly constructed lessons based on shallow understandings of the subject matter. They also described how one student teacher's understanding of place value was enriched through careful following of a teacher's guide. For this student, the teacher's guide had been a last resort. She turned to it after the lesson she designed had failed. The authors have called for greater emphasis in teacher education on helping students to use texts discriminately, rather than to reject them indiscriminately. In a study of preservice teachers in secondary mathematics, Bush (1986) made similar recommendations: "A better understanding of texts and their roles, capabilities, and limitations might enable preservice teachers to make better decisions" (p. 28).

When examined side-by-side, these studies provide important insights into teachers' perceptions of themselves in relation to the textbooks they use. These perceptions are likely to figure significantly in understanding the ways that teachers use textbooks.

<u>Missing pieces</u>. These studies focused on how teachers mediate their textbook use. They had suggested that teachers shape the written text and interpret the authors'

intentions through their beliefs about knowledge, the subject matter, learning, and the texts themselves. One implication is that much of the shaping results from <u>mis</u>interpretation or revision.

Two important factors are often left out when studies take this perspective. Even though each is mentioned once, the focus on teachers as "shapers" limits examination of how teachers might be shaped by their texts or of factors other than teachers that influence how curriculum is enacted. First of these is the role of the student in shaping the enacted curriculum. In my study of a teacher using CSMP (Remillard. 1991c), I found that students significantly shaped the discourse and influenced how the teacher responded. The enacted curriculum was constructed by student-and-teacher interactions around particular problems or tasks. The teacher in the study was using a scripted lesson format that placed student ideas and solutions central to each lesson. Student ideas that did not follow suggestions in the lesson led the teacher to call upon her understanding of the task in order to bring the class back to the script.

Also undertreated in these studies are the ways in which teachers might learn from, or be transformed by, the textbooks or teacher's guides. Ball and Feiman-Nemser (1988) described a student teacher broadening her conceptual understanding of place value by relying heavily on the class textbook. Researchers examining the relationship between a state-level mathematics policy and practice in elementary classroom in California also found instances in which textbook changes had altering effects on teachers' practices and beliefs about mathematics teaching and learning. Wiemers-Jennings (1990) related an account of a teacher discovering the value of having students draw fractions, and Remillard (1992) told of a teacher who found that his students were applying estimation strategies to assess the reasonableness of their answers.

These teachers had reluctantly followed textbook suggestions when having students

draw fractions or use estimation. Such accounts of teachers learning new practices from texts occur infrequently in the literature.

The studies described above focus on factors that influence teachers' mediation of textbook use. However, they do not clarify what it means to "use" a textbook. In the following section, I examine the range of perspectives on textbook use that is implicit in the literature.

Characterizing "Use".

From the studies already described, it is evident that what it means to "use" or "follow" a textbook is thought about differently. Floden et al. (1980) and Bush (1986), focusing on topics and skills, attended to the content of the curriculum in characterizing textbook use. Bush, for example, described preservice teachers following the text closely, but the transcripts he provided referred to topic selection only. These student teachers claim to "pick out the topics they [the text] want to talk about, then I explain it freehand on the board" (p. 25). Some researchers have examined student activities and classroom formats in their discussion of textbook use (Durkin, 1983; Graybeal & Stodolsky, 1987). Others have considered how the subject is presented and represented, as well as the pedagogical and epistemological assumptions that underlie its presentation (Ball, 1988; Stephens, 1982; Thompson, 1984). These differences in what researchers looked at reflect different conceptions of classroom practice and the subject matter. They also limit comparisons across findings.

Another related dimension that researchers discuss is the degree of fidelity between written and enacted curriculum. I grouped the following studies according to the researchers' stances on possible relationships between written texts and enacted curriculum. The studies were selected as examples of each perspective rather than as an exhaustive list. The first group of studies were based on the assumption that textbooks are fixed, embodying discernible and complete images of practice. A second group takes classroom practice, rather than the text, as the starting point for analysis

and views textbooks as influencing the construction of practice. Researchers in this group do not assume that fidelity between texts and practice is possible. A third group focuses on the teacher and asks how the teacher is making sense of the text. As the following discussion illustrates, researchers' initial perspectives influence their findings.

Use as following or subverting. Many studies of textbook use take the text as the starting point and consider the degree to which teachers followed or subverted it. An underlying assumption of many of these studies is that complete uniformity between the written and enacted curriculum might be possible under ideal conditions. Thus, these researchers have concerned themselves with how to bring about greater clarity on the part of the written curriculum and closer guidance for the teacher in using it. These concerns are relevant because of the ubiquitousness of textbook use and the tendency to see them as potential vehicles for change. These studies could help one understand how teachers might learn to follow and learn from written curriculum.

Freeman and Porter (1989) found that teachers' use of textbooks varied according to subject matter, and it was influenced by the teachers' views of the text as a content authority, their convictions about what should be taught, and their knowledge of the subject matter. They argued that the conviction that textbooks determine the curriculum is grounded in "a narrow view of teacher decision making" (p. 404) because it assumes that a teacher's guide can address all facets of the decisions teachers make. If textbooks are to have greater influence on classroom content, Freeman and Porter suggested that teachers be given strong incentives or sanctions to follow their texts, as well as specific guidance regarding how they are to be used. Freeman and Porter claimed that textbooks are relatively silent on content decisions such as time allotted to mathematics or each topic taught, how students should be grouped for instruction, what and in what ways topics should be presented, and standards of achievement. Therefore, in order for textbooks to dictate content, they must address these concerns

unambiguously. This final point seems reasonable, but it ignores the power of their own findings regarding variation in textbook use. How addressing the above decision will contribute to the uniformity of teachers' views, convictions, and knowledge is left unclear. Furthermore, their claims about the areas in which texts are silent seem unsubstantiated by recent textbook analyses (Graybeal & Stodolsky, 1987; Remillard, 1991a, 1991b).

Stephens' (1982) study also depicted the teacher's use of a written curriculum as translation or transformation. His study of teachers using a developmentally focused mathematics program designed to link pedagogical, psychological, and mathematical perspectives of appropriate mathematical knowledge, describes a mismatch between author intentions and teacher enaction. Similar to Sarason's (1982) conclusions, he ascribed this incongruence between the epistemological assumptions underlying program goals and how teachers tended to carry them out to the authors' failure to be aware of, or to challenge, the traditions inherent in schools. The program was intended to "transform the teaching and learning of mathematics in the elementary school" (p. 220). In order to do so, Stephens claimed that the authors needed to address this fundamental conflict.

Komoski (1977) looked to school officials, rather than text authors, to guide teachers in their use of texts. He claimed that unless schools are committed to assisting teachers to use newly selected textbooks that what is "ultimately practiced in the classroom will end up quite different from the curriculum described by the curriculum office" (p. 46). In other words, following the text and making the curriculum experienced in the classroom as close to the written curriculum as possible can be achieved through careful attention and guidance.

<u>Use as incorporating</u>. By looking first at the classroom, rather than the text, some researchers have described use as ways in which teachers draw upon and incorporate texts into their instruction. They view texts as one of the many resources

that teachers use in constructing practices. Researchers who take this perspective aim to understand what influences the choices teachers make and how they are played out in the classroom.

Many teachers consider themselves "textbook dependent" and describe themselves as relying heavily on their textbooks in planning and teaching. One might believe that this would imply a close match between the text and instruction.

Woodward and Elliot (1990), however, reminded us that the term "dependence" is misleading. We should not interpret it to indicate that the teacher follows the plans in the book word-for-word. In earlier studies that tended to focus more heavily on mathematical topics and skills than on pedagogy and student activities, relying on the text to determine topics, while designing one's own instruction, was seen as following the book. As researchers' views of teaching have become more complex, recognizing the connections between what is being taught and how it is taught, they have given greater attention to other aspects of teaching than actual topics. Nevertheless, many of these studies have focused on the text as unambiguous and have asked if it is being followed. There are still relatively few studies that look carefully at how teachers use textbooks as resources in their practice.

McCutcheon's (1981) ethnographic study of teacher planning examined, among other factors, how textbooks influenced their planning decisions. By following topics found in texts, teachers allowed a number of pedagogical and logistical concerns to shape how they would teach them. These concerns varied from classroom control, to available materials, to students' prior experiences. Knowledge, attitudes, and perceptions of the context also weighed heavily in these teachers' reasoning.

McCutcheon claimed that teachers tended to transform program recommendations into lessons that they believed they could engineer in the classroom. Other examples of such adherence to textbook topics, but transformation of pedagogical recommendations, can

be found in Graybeal and Stodolsky's (1987) study of mathematics and social studies and Bush's (1986) study of preservice teachers.

<u>Use as interpretation</u>. A final stance that researchers occasionally take is to focus on the teacher as interpreter of the written curriculum. This perspective assumes that fidelity between written words in a teacher's guide and classroom action is impossible. Similar to the other perspectives discussed, this view assumes that teachers' beliefs and perceptions shape the way they interpret their textbooks. This perspective, however, does not assume that the written text has one meaning. Through using them, teachers interpret the intentions of the authors.

The EPPS study took this perspective with respect to textbooks, as well as policy documents. The documents were written in general, visionary language and are incomplete regarding specific intent for classroom practice. Many of the teachers involved in this study were using newly adopted textbooks that presented their interpretation of the policy. The teachers also learned of the state's efforts through a variety of channels, each providing an image of the state-level policy and expectations for instruction from a slightly different angle. Teachers brought to their textbooks a variety of perceptions about the policy, mathematics, and teaching and learning in their particular classroom. These perceptions shaped how the topics, recommendations, skills, and examples in the teacher's guide translated from written words into classroom practice.

Another area calling for more clarity in the discussion of textbook use involves the nature and characteristics of textbooks. Up to this point, I have focused on understanding the perceptions that teachers bring to their textbook use but have not focused on the role of the textbook in this process. Turning to this question can broaden one's perspective of the relationship between written and enacted curriculum.

Characteristics of Texts Teachers Use

Textbooks are talked about generically; however, analyses of traditional and innovative textbooks reveal variation among them (Graybeal and Stodolsky, 1987; Remillard, 1991b). Consequently, to say that a teacher follows, transforms, draws upon, or interprets a text, without some image of which part of the text, provides only partial information about the nature of the teacher's textbook use. Thus, the question of how researchers characterize texts, that is, what they consist of, needs to be explored. Doing so I will develop a clearer understanding of what teachers confront in their interactions with texts and will create a context for talking about the differences among textbook offerings at all levels, not just between traditional and innovative.

Several researchers, whose work I have discussed, have looked specifically at the different components of textbook offerings and have characterized how teachers treat each. In this section, I consider frameworks used by Freeman and Porter (1989) and Stodolsky (1989).

Stodolsky (1989) used three broad categories to describe major chunks of the four textbooks she and her colleague observed teachers use: (a) topics, (b) student pages, and (c) teacher suggestions. Even though the six teachers they studied varied considerably in their overall use, they found several points of agreement in relation to these categories. The greatest amount of agreement was in their adherence to the topics in the textbook, although the sequencing of these topics was not consistent. There was little consistency between the suggested activities in the teacher's guide and the actual classroom practice; most teachers made significant departures from the suggestions in their guides. In general, teachers readily dispensed with manipulative activities and suggestions for enrichment. In regards to the student pages, four of the six teachers used them regularly but supplemented them with problems and activities from other sources. In summary, it seems that teachers were most likely to use the topics and exercises that appeared on the students' pages and felt freer to omit or revise

suggestions in their guides. These categories are helpful in revealing patterns in teachers' use of specific parts of textbooks. Nevertheless, they focus on structural features of the texts, i.e., where things are located, rather than substantive elements, thus offering limited insight into how different types of student exercises or topics are treated.

Freeman and Porter (1989) used five categories, thus providing additional details about the nature of the items in each. Their findings are similar to Stodolsky's (1989). The most commonly used portion of the textbooks was the student exercises (92%). Eighty-six percent of the review sections, 73% of the teacher directives, and 56% of the enrichment sections were used. The sections in the textbooks used the least were those that provided additional practice (23%). What we do not gather from these statistics is whether similarities exist in the nature of the 8% of student exercises and 14% of review sections not used.

In both cases, attempts to provide greater detail about the nature of teachers' textbook use by focusing on particular characteristics of texts help to make the picture more complex. Various characteristics of the text actually shape whether the teachers use them. A component that these studies are missing, however, is the teacher's perspective. Much can be learned from teachers about why they made the selections they did. In addition, these studies do not contribute to one's understanding of how the teacher used these components.

<u>Textbooks as Reform Levers</u>

In the face of the evidence we have about variations in teachers' textbook use, it is ironic that they continue to be the primary means to guide and leverage instructional reform. Districts throughout the nation are turning to the newly revised textbooks in the commercial market. With the help of many federal and private dollars, a number of mathematics educators are in the process of developing alternative curriculum materials. Given the presence of textbooks in American classrooms (Komoski, 1977), this is not a surprising approach. Nevertheless, some of the findings that I just discussed suggest

that merely giving teachers a particular text does not ensure the type of classroom practice that will result. This seems to be the case particularly when teachers are using texts designed to present a nonconventional view of mathematics. Seven of the studies described earlier (Donovan, 1983; Remillard, 1991c, 1992; Sarason, 1982; Stake & Easley, 1978; Stephens, 1982; Wiemers-Jennings, 1990) were of teachers using texts revised in response to a reform or, by design, nonconventional. In all but two of these cases, the researchers reported instances in which teachers had difficulty with, or significantly altered, suggestions in the text. In the other two cases (Remillard, 1992; Wiemers-Jennings, 1990), the teachers tried new suggestions and came away with new pedagogical insights. These two cases of change involved textbooks published by commercial publishers, which were not substantially different from the mainstream. It is possible that the familiarity of the text plays a role in teachers' willingness to use it, although this is a question requiring further exploration.

Some researchers might argue that making the teacher-text relationship the central factor in analysis oversimplifies the picture of textbooks in teaching. Sosniak and Stodolsky (1993) studied elementary teachers' use of textbooks in four subjects. The patterns of textbook use observed were inconsistent across teachers and school subjects. Teachers did not see them as "blueprints" or "driving forces." Rather, they viewed them as "props in the service of managing larger agendas" (p. 271). This finding suggests that we need to understand teachers' larger agendas and the role the textbook plays in them. This perspective makes the teachers' relationship with the curriculum central and views the textbook as one of many tools. These findings suggest a need for understanding teachers' larger curricular agendas and the role the textbook plays in them.

The Teacher and Curriculum Relationship

The studies described above have focused on the relationship between teachers and textbooks, placing the curriculum in the background. Other researchers have

studied classroom practice by examining how teachers construct or enact curriculum in their classrooms. This research includes how they draw on various resources, including textbooks, and assumes that the process necessarily involves interpreting the meanings and intents of these resources (Doyle, 1993). Implicit in studies of teachers' curriculum processes is a view that the curriculum is more than what is captured in official policy documents or textbooks. In order to distinguish among the various representations of curriculum, theorists have delineated categories to describe them. Formal (Doyle, 1992) or planned curriculum (Gehrke, Knapp, & Sirotnik, 1992), for example, refers to the goals and activities outlined by school policies or designed in textbooks. The intended curriculum refers to teachers' aims, whereas the enacted or experienced curriculum refers to what actually takes place in the classroom (Gehrke et al., 1992). These meanings are relevant to my research because examining the role that a textbook played in classroom practice involved looking at the relationship between the planned curriculum and that enacted by the teacher.

The enacted curriculum has been of recent interest to researchers because it acknowledges the role of teachers in creating curriculum (Connelly & Clandinin, 1986; Cornbleth, 1988; Posner 1988; Snyder, Bolin, & Zumwalt, 1992). It also changes the focus of research from the "remote control" of teaching to teachers' curriculum processes (Doyle, 1993). From this perspective, studying the role of textbooks in teachers' mathematics teaching involves studying teacher's processes of constructing the enacted curriculum and the role that resources, like the text, play in it.

This view of the process of curriculum construction through the in-action thoughts and activities of teachers is based on two related assumptions about the meaning of curriculum and its relationship to teaching. First, it assumes an integration of two aspects of teaching conventionally treated as distinct: curriculum and instruction (Clandinin & Connelly, 1992). Rather than defining curriculum as the educational objectives or the <a href="https://www.what.org/what.or

the how and the what, the means and the ends, are inextricably linked. Second, this view of curriculum and curriculum development assumes that the teacher is an active creator of curriculum, rather than a transmitter or implementor of it. Some view teachers as deliverers of curriculum (Venenzkey, 1992), that is, conduits between intended learning goals and students. My view is that teachers, through their work, contribute substantially to the construction of curriculum (Clandinin & Connelly, 1992).

Research on policy and practice and teachers' relationships with textbooks motivated the design and initial question of my study. Research on teachers' curriculum processes became crucial during my analysis as it became increasingly evident that studying how teachers make sense of and use a reform-oriented mathematics textbook involved studying teachers' curriculum construction. This domain of research broadened my perspective on what I was studying by bringing the enacted curriculum to the fore. In the remainder of this chapter, I describe my study and its relevance to mathematics and teacher education.

A Study of Teachers, Textbooks, and Curriculum in the Context of Reform

In this study I examined two teachers using a new textbook for the first time.

The overarching research question was:

What factors influence how elementary teachers makes sense of a reform-oriented mathematics textbook during its first year of use?

My aim was to explore issues in teachers' textbook use by examining the relationships two teachers develop with their texts, factors that contribute to the relationships, and how they are enacted in classroom practice. This study builds on the research discussed above on teachers' use of textbooks. These studies confirm the variation in textbook use, suggesting that factors such as the teachers' orientations and beliefs, ideas embraced in their textbooks, and contexts in which they teach significantly influence their interactions with the text. Yet, they provide little detail about the nature of these interactions and how they figure in the curriculum construction process. These details, however, are

crucial to understanding whether and how textbooks can contribute to change in mathematics teaching. Thus, I used case study methodology to investigate the interactive relationships between a new mathematics textbook and teachers' thinking about, and teaching of, mathematics. Because the textbook proposed nontraditional approaches to teaching and learning mathematics, I was particularly interested in the potential for this relationship to promote learning and change in the teachers. In the following sections I discuss key assumptions underlying the study's design.

Sense-Making and the Factors That Influence It

I refer to the process through which teachers became familiar with, related to, and came to use their textbooks as making sense. Embedded in my use of this term are the assumptions that sense-making is a necessary part of using a textbook and that there are multiple ways to make sense of a single textbook. Sense-making takes the form of cognitive acts of constructing meaning and actual actions taken in practice with respect to the text or students. For example, how teachers interpret the purpose of the contents of their textbooks and how the contents of the text influence their ideas about math are two cognitive features of sense-making. Closely related are other features that are more directly observable in their practice or actions such as what parts of the text they read and how they read them, as well as how they translate them into tasks to pose to students.

Understanding sense making is crucial to understanding the relationships between textbooks and practice because it is the sense that a teacher makes of the text that mediates its role in thinking and practice. This study was designed to inquire about the nature and process of sense-making; to reveal how it is impacted by various characteristics of the text, teachers, and context; and to understand how the sense teachers makes is reflected in their teaching practices. In order to develop a more elaborate understanding of the process of sense-making in the context of using a new

mathematics textbook, I examined how various characteristics of the text, context, and individual teachers influenced this process.

Textbook

Freeman and Porter's (1989) and Stodolsky's (1989) research suggested that teachers drew differently from various parts of their mathematics texts. My aim was to extend this work by providing a detailed picture of the text in use and how the teachers interacted with it. This piece of the study was particularly important for two related reasons. First, it did not treat the text as generic or internally consistent. Teachers might respond differently to different aspects of the text. Furthermore, because it had been revised to reflect reform-related ideas, teachers were likely to encounter unfamiliar aspects of the text. Understanding how teachers make sense of unfamiliar characteristics in a text is crucial to speculating on the role that changed texts might play in mathematics education reform. Second, the above understanding also can contribute to the work of those developing reform-oriented curriculum materials. Characteristics likely to be relevant include format, content selection, sequencing, and presentation, as well as the ways in which these are made accessible to the teacher.

Context

The context in which teachers used these new materials was complex, including the ethos, expectations, opportunities, and relationships in the district and particular schools. It also included characteristics of the teachers' particular circumstances such as opportunities they had to interact with others regarding mathematics teaching, the type of support and/or pressures they experienced from colleagues, superiors, or parents, and their ongoing experiences with the text, as well as students. The context also included the national reform movement.

Teacher

Characteristics that individual teachers brought to their use of the textbook significantly influenced the sense-making process. Drawing on previous research on

teaching, I examined the beliefs and ideas that teachers brought to their teaching about mathematics, teaching, learning, students, purposes of school, and themselves as teachers and users of textbooks.

Teachers as Curriculum Developers

As explained earlier, my analyses of the teachers' interactions with the text focused on the role it played in their curriculum enactment activities. In Chapter Six, I refer to this as the teacher's role in curriculum development. This term generally is used to refer to those who write textbooks or materials designed to guide teachers in teaching, but I also use it to refer to teachers in the process of developing the enacted curriculum. My aim was to emphasize that the curriculum development process does not stop when textbooks are printed; rather, it continues with the teacher in the classroom. My choice of this term also was influenced by Ben-Peretz (1990), who labeled the alterations, interpretations, and adaptations that teachers impose on textbook offerings as the teacher's role in curriculum development.

The Importance of Cases

In this study I relied on case-study methodology to analyze and present data. This choice was more than methodological; it was related to the object of study (Stake, 1978). Case studies allow researchers and readers to examine a "bounded system" (Smith, 1978) in its rich detail and complexity. My aim was to capture and study the complexity and detail of teachers' encounters with a new textbook. Thus, the case studies I developed present interpretive stories of teachers' experiences.

Researchers have used case studies effectively to illustrate how teachers make sense of reform initiatives because they offer rich portraits of classroom practice that illustrate important issues (Cohen & Ball, 1990; Prawat, Remillard, Putnam, & Heaton, 1992; Stake & Easley, 1978). Even though cases do not offer grand generalizations across situations or teachers, they suggest themes, areas of significance, or problematic circumstances to researchers and readers. Often a single case can establish limits to

generalization or suggest alternative interpretations. Furthermore, comparative analyses of cases can suggest new issues or pose problems not evident in a single case.

The cases and cross-case analysis in the chapters that follow represent much of the process of my analysis as well as the product. The act of developing cases was a crucial analytical tool. In Chapter 2 I delineate this methodological process in greater detail. In Chapter 3 I present a description and analysis of the textbook used by both teachers in the study. Chapters 4 and 5 present case studies of the teachers' encounters with the text. In Chapter 6, I offer a comparative analysis of the two cases. Finally, chapter 7 presents conclusions and implications of the findings.

Educational Significance

The findings of this study have the potential to inform the work of three groups:

(a) textbook authors, (b) policy makers and implementors, and (c) teacher educators.

My hope is that it speaks to textbook authors who aim to communicate with teachers through their texts. My findings contribute to a deeper understanding of how and why teachers respond to specific characteristics of a reform-oriented text and what this implies for their teaching. They also provide details on which aspects of the text actually contributed to teachers' curriculum development.

Understanding the relationships between teachers, the text, and the curriculum is only a piece of the puzzle. Even though carefully designed textbooks may contribute to changes in teacher thinking and practices, a teacher's use of any textbook also is influenced by other factors. My findings point to particular factors significant in how teachers use texts. Thus, they speak to school-, district-, and state-level policy makers interested in fostering changes in the way mathematics is taught.

Finally, this study speaks to teacher educators and staff developers. My interest in how teachers learn from using texts grows out of my belief that textbooks can be tools for learning about teaching and mathematics—not just teaching guides. Nevertheless, teachers may seldom think of their texts as this type of resource. In some cases, good

teaching is defined, in part, by the degree to which a teacher moves away from her textbook (Ball & Feiman-Nemser, 1988). Ball and Feiman-Nemser suggest that teacher educators should play a significant role in helping prospective teachers learn to use textbooks as foundations for further learning: "Beginning teachers must be oriented toward learning from teacher's guides and other curriculum materials, so that they can move toward being able to build their own units of study that are responsible to subject matter goals and responsive to their students" (p. 338). As a teacher educator, articulating ways that prospective and practicing teachers can learn from reformoriented textbooks has been an important part of my work.

CHAPTER TWO

DESCRIPTION OF METHODOLOGY AND RESEARCH PROCEDURES

Methodological Overview

In this study, I examined two contrasting cases of teachers during their first year of using a new textbook. Focusing on two teachers enabled me to undertake in-depth investigations of each teacher's process of making sense of the textbook, while also allowing for contrasts to emerge. Empirical work for this study was based on observations and interviews of the two teachers throughout the year, content of the HBJ textbook, and other classroom artifacts. My interest in understanding and articulating the relationships that emerged among the teacher, the textbook, and the curriculum led me to employ a phenomenological approach to inquiry in which interpretation was central (Patton, 1990). This perspective examines the essence of people's experiences and how they make sense of them. My aim was to describe, explain, and compare the teachers' experiences teaching mathematics and using the textbook. Thus, I designed the interviews to probe their teaching decisions and experiences with the textbook, as well as the factors that influenced them. The observations provided images of their teaching and interactions with the text that I later explored through interviews. My examination of the textbook provided another lens through which to observe and interview the teachers. In this way, these three sources of data collection served to inform one another and allowed me to cross-check and validate my findings (Patton, 1990). Because I was interested in what the teachers brought to their interactions with the textbook, the first interview also focused on their personal histories related to teaching and learning mathematics and their beliefs, conceptions, views, and knowledge about these areas.

In order to look at the two teachers comparatively, I used case studies to analyze, interpret, and display my findings for each teacher and then to make comparisons across them. Case studies aim to describe the unit of analysis in depth, with detail, and in context (Stake, 1978). In this study, the unit of analysis was the teacher's curriculum construction and the text's role in it. Patton (1990) argued that case studies are particularly valuable when trying to capture "individual differences or unique variations from one program setting to another, or from one program experience to another" (p. 54). With this in mind, I followed the writing of the two cases with a cross-case analysis in which I examined themes that cut across both and then used the individual cases to explain differences within these themes.

In this chapter I describe my research procedures. I explain my sample selection and methods of data collection and analysis. I also describe the process of analyzing across the two cases from which my central findings emerged.

Methodological Procedures

Sample Selection

Site Selection

This study was part of a longitudinal investigation of the relationship between policy and practice in mathematics and reading instruction in three states. Project researchers selected several districts in each state from which to draw schools. The Mapleton School District was one of Michigan's districts participating in this study and one of the 10 largest in the state; it included 37 elementary schools. Like many districts, Mapleton was struggling financially. Prior to the beginning of this study, the district was faced with cutting \$7 million from its budget in order to comply with the state mandate that all school districts operate within a balanced budget.

The district was situated in a midsize, urban city of approximately one quarter million people. The city's residents were primarily working class but also included a low-income population. One third of the families in the district lived in poverty.

Approximately one third of the students were African American, one tenth were Hispanic American, approximately one half were Anglo American, and a small percentage were Asian American. In 1970, the district introduced a bussing program in response to a court-ordered desegregation mandate.

I selected the Mapleton District because it recently had adopted a new mathematics textbook with the intent of aligning mathematics instruction in the district more closely to current national and statewide reforms. During the 1991-92 school year, four newly published texts were piloted by several elementary teachers at each grade level throughout the district. After much deliberation, Mathematics Plus was selected. The district also made the commitment to purchase the manipulatives called for in the text. These included classroom sets of materials such as base-ten blocks, pattern blocks, and counters. The district math coordinator was committed not only to adopt a textbook that could move math instruction toward change but also to make the needed supplies readily accessible. It also is worth noting that during the deliberations over how to reduce the district budget that the teachers' union lobbied vigorously to drop the purchase of new texts. Led by the math coordinator, the district math committee pushed the selection and purchase forward. This resistance and the fact that the district was not deterred from proceeding with the adoption reveal general tensions in the distract surrounding the issue of change in mathematics instruction. The union's efforts to stop the purchase of the text may not have been an instance of explicit resistance. In the wake of harsh budget cuts, it appeared just as likely that they did not see the new math text as a priority.

Teacher Selection

I selected one fourth-grade teacher from each of two schools in the Mapleton School District. Even though it was not part of the design, both were Anglo American women and veteran teachers of approximately 30 years; both had spent most of those

years in the Mapleton School District. Other than these factors, the two teachers were markedly different.

Jackie Yarnell taught at Kipling Elementary School. The school was located in a predominantly Anglo American, working-class neighborhood, yet served an economically and socially diverse range of students. These students came from three distinct communities. Two thirds of the children were bussed to Kipling from the inner city or a nearby trailer park, and the other third came from the surrounding neighborhoods.

Kipling was unique in that it had recently become a Professional Development School (PDS), associated with a nearby school of education. This association had initiated a range of contacts with university educators, making professional growth opportunities a central focus of the school. Thus, there were explicit attempts to foster an environment in the school that supported teachers' ongoing professional development. Jackie was an active participant in several PDS activities, one of which related to math.

Catherine McKeen taught at McKinley Elementary School, one of the schools participating in the Educational Policy and Practice Study. The school was located in a middle-class, predominantly Anglo American neighborhood, bussing one third of its students from a low-income area not far from the school. Unlike Kipling, McKinley did not have an explicit focus on professional development. The school provided few formal opportunities for teachers to interact around teaching issues. Catherine participated in few professional development activities.

The differences between the teachers and their school settings allowed me to examine how these characteristics played out in the teacher's use of her new textbook. By holding the district, grade level, amount of teaching experience, and textbook constant, I was able to focus on the differing ways the teachers' personal characteristics

such as beliefs and knowledge of the subject matter, teaching and learning, and students, and the differing school contexts contributed to their use of the textbook.

Data Collection

Classroom observations and interviews formed the corpus of data for this study. During three rounds of data collection distributed throughout the school year, I observed, took field notes, collected documents, and interviewed the teachers about their mathematics teaching and how they used the textbook. In addition, I collected data about district and school policies as well as activities related to the textbook and its adoption. I also conducted a document analysis of the HBJ textbook. Below I describe my schedule for data collection and the instruments used to collect data.

Schedule

I collected data in three rounds that spanned the 1992-93 school year. These rounds varied for each teacher according to circumstances in her work. The first round in the fall included four weekly observations; each was followed by an interview. Prior to the first observation, I carried out a structured baseline interview aimed at probing each teacher's personal mathematical history, beliefs, and knowledge. The post-observation interviews were semistructured; that is, they were flexible and responsive to the lessons I observed. I asked questions such as, "How do you think the lesson went?" and "What did you want the students to learn with that activity?" I also asked them to talk about the role the textbook played in their lessons and planning. The lessons I observed served as instances around which the teacher and I had conversations about her use of the new textbook.

The second round of data collection in the winter was much shorter. I observed Catherine three times and Jackie once. Again, I followed each observation with a semistructured interview.

¹ Jackie had a student teacher during the winter who taught mathematics almost daily.

The final round of data collection occurred in mid spring. I observed each teacher daily during the first two weeks of a unit on fractions. The purpose of this round of data collection was to examine how each teacher developed a mathematical topic over a period of time. I was interested in her understanding of, and ideas about, the mathematical topic, whether these changed, and the text's role in both. I selected fractions as the topic to observe because it has a broad conceptual base but is taught procedurally in schools (Behr, Harel, Post, & Lesh, 1992). Given the current emphasis on conceptually based instruction, I believed it was likely that the approach to teaching fractions in the text would be unfamiliar. I also expected that it would provide an opportunity to gather data informally on the teachers' subject matter understandings. I interviewed each teacher once each week during this period. My goal was to learn whether her thinking about fractions had changed from the previous year and how her teaching of it had taken shape.

I also interviewed each teacher at length after the school year was over, using a more structured interview. My primary focus was on each teacher's perspective on using the textbook after a year. Figure 2.1 summarizes the times and purposes of the rounds of data collection.

| Data collection round | Dates | Purpose of collection round | Extent |
|-----------------------|--|--|---|
| Round I | Jackie-September and October | To collect background and baseline data and | Initial baseline interview; four classroom |
| | Catherine-October, November, December 1992 | | observations and follow-up interviews. |
| Round II | February and March, 1993 | To collect data on teaching mid-year | Classroom observations and follow-up interviews |
| Round III | April and June, 1993 | To collect data on the instruction of one complete topic; follow-up at end of year | Daily observations and weekly interviews; end-of- year interview |

Figure 2.1 Summary of rounds of data collection

Description of Instruments

The instruments consisted of interviews and observation guides that developed recursively as the study proceeded. I began with interview protocols adapted from the EPPS study. These protocols had been developed and revised during the four years of the project. Each round of data collection and subsequent analysis led me to adjust and further refine the instruments. These changes consisted primarily of adding questions in order to obtain information on issues or patterns that emerged in the teacher's talk or teaching. Samples of the following interviews can be found in Appendix A. All interviews were audiotaped and later transcribed.

Baseline interview. This structured interview consisted of two parts. Part I was designed to explore the teacher's personal history with respect to mathematics, including her memories of her experiences as a student, as well as what she recalled about teaching math. Part II was designed to gather background information about the teacher's initial thinking about and experience with textbooks and teaching mathematics. Many of the questions on this interviews were adapted from and instrument used by Ball (1988) in a study of prospective teachers' knowledge and beliefs.

<u>End-of-year interview</u>. This structured interview was designed to collect data on the teacher's reflections on the textbook and her first year of using it after the school year concluded. During this interview, I asked the teachers to assess the HBJ textbook and their use of it. I also asked them to talk about ways they may have changed over the year.

<u>Post observation interviews</u>. These semistructured interviews consisted of the skeletal protocol used to guide the lesson follow-up conversations. During these interviews. I focused on the lesson observed and the teacher's views about how it went and how she planned to proceed. An important component of this interview was the questions about the teacher's use of the textbook. Depending on the extent to which the

lesson was related to the text, I would have her talk about how she viewed the text and how she made the selections she did.

Observation instrument. I collected classroom observation data by audiotaping each lesson observed and taking extensive notes throughout. During my observations, I focused on the teacher's activities, what the students were doing, and the role the textbook seemed to play. After each observation, I used notes and the tape to "write up" the lesson. The write-ups included a narrative summary of the lesson and responses to the set of analytic questions taken from the observation instrument. These write-ups represented the observation data for the study. The observation instrument was adapted from the EPPS project instrument (see Appendix B).

Data Analysis

The complete data set was comprised of 25 observation write-ups and 18 interview transcriptions. Thus, the first steps in analysis were primarily managerial, but allowed me to become closer to, and more familiar with, the data. The next steps involved deeper and more deliberate analyses prior to the third step of writing cases. The final step involved analysis across the two cases. This step was the first in which I formally brought the two cases together and looked at them side-by-side. My analysis prior to this focused on the individual teacher across one year.

Analysis of Observation Data

Analysis of the observation data involved two steps prior to writing the cases. First I wrote up the observations, and then I wrote a characterization of each teacher's teaching throughout the year.

Observation write-ups. Even though the observation write-ups constituted the observation data analyzed, writing them was also an analytic process. Using notes and the audio tape, I responded to the questions on the instrument. Answering these questions required analyzing various aspects of the lesson such as the teacher's role, the role of the text, and the extent to which students are encouraged to interact with one

another, problem solve, and engage in mathematics discourse. I supported each response with examples from the lesson. These analytic questions served to stretch my eyes and mind as an observer. Responding to questions forced me to review my notes and to reconsider generalizations made about the lesson. Supporting them with examples from the lesson also pushed me to ground the claims and questions taken from the lesson in the data.

Characterizing teaching throughout the year. The next step involved looking for and describing patterns and changes in their teaching and textbook use throughout the year. It involved a recursive process of writing in which I made claims and supported them with data from the observations. I then developed matrices that allowed me to check the validity of these claims throughout the year, looking for disconfirming evidence and discovering ways that the claims might need to be adjusted or refined. For example, in characterizing Catherine's teaching, I noted a pattern in her daily lessons throughout the fall. She started with instruction, followed with a significant amount of practice, and then a quick review. I verified this process by using a matrix in which I charted the amount of time she spent in each. In writing up the spring lessons, I began to notice that this pattern was not the same. Going back to a matrix, I compared changes in the amount of time she spent in each type of activity. Refined examples of these particular matrices can be found in Chapter 5.

The matrix allowed me to see details that I would have missed otherwise. In order to characterize the different ways that Jackie improvised in her teaching, I organized them into a matrix according to category. In this process, I noticed several subcategories that I had not considered.

At the end of this stage I had a picture of the teachers' teaching throughout the year, the role the text played in it, and the ways in which it had or had not changed. I reviewed each, adding quotes from the interview analyses (described below).

Analysis of Interview Data

The first step in analyzing the interview data allowed me to become familiar with the data, which was similar to the analysis of the observation data. The second step involved drawing out relevant quotes and organizing them according to theme. The final stage involved using this organization to write analytic memos about each teacher.

Verifying and coding. The first two steps in analyzing the interviews were primarily organizational, but they provided useful opportunities to become familiar with the data. First, after each interview was transcribed, I verified it as soon as possible. This procedure allowed me to identify themes and issues that were emerging and suggested questions or ideas I wanted to pursue in upcoming interviews. Second, I generated a list of questions to code and organize the data for each round of data collection. Some of these questions were the following:

- 1. How did the teacher talk about the lesson I observed?
- 2. How did teacher talk about her use of the text during the lesson I observed?
- 3. How did she talk about her use of the text in general?
- 4. How did talk about the text?
- 5. How did she talk about students?
- 6. How did she talk about contextual influences?
- 7. How did she talk about her own mathematical knowledge?

By cutting and pasting, I moved excerpts from the interviews to the questions they helped to answer. These interview analyses became the data I used in the next step.

Analytic, thematic memos. This process was similar to writing characterizations of the teachers' teaching described above, but I used fewer matrices. I wrote a series of analytic memos in which I made claims about the teacher, her experiences, and thoughts about the text, as well as supporting them with interview data. In some cases, I also drew on the observation data to support developing claims. The first memo was entitled, "What she brought to the text." This memo provided me the opportunity to

examine the baseline interview, as well as other interviews from the early fall, and to develop claims about the teachers' ideas concerning mathematics, teaching, learning, the reforms, and the textbook. I also wrote related memos about the teachers' past experiences. I wrote a similar memo for each teacher at the end of the year, using data to support claims about changes in her thinking.

Developing Cases

I began to develop a sense of each teacher's story regarding teaching, the text, and change through the processes described above. At this point I began to write the cases, however this involved further analysis. As I wrote, new points became evident whereas old points lost their potency. Because this process also involved putting together the observation and interview data, I began to develop a holistic portrait of each teacher. At this point I began to formulate explanations from the data. Up to this point my writing had been descriptive. The section in each case in which I discuss the teacher's orientation toward textbook use is the most prominent example of more explanatory writing. In these sections, I draw on the data to characterize the teacher's orientation toward textbook use and then use that characterization to explain their interactions with the text and how those interactions impacted their thinking and teaching.

Textbook Analysis

The analysis of the HBJ textbook had three purposes. First, it was to provide the reader a picture of what the teachers were working with and talking about. The second purpose was to examine it with respect to the current reforms in mathematics education. Again, my intent was to offer an assessment for readers of the cases regarding response to the reforms. Last, because one of my aims was to examine how teachers made sense of particular elements in the text, it was necessary to have a thorough picture of its contents.

Analysis of the text began prior to the beginning of this study and continued as I observed the teachers and wrote up the observations. Formal analysis began by writing a detailed description of the text's contents, its means of communicating with teachers, and what it communicated about. Examination of the text suggested several themes in the areas of content and pedagogy. Content themes included increased emphasis on problem solving, topics traditionally marginalized in the elementary curriculum, and underlying concepts. Pedagogy themes included the use of representational tools, active learning approaches, and learning through exploration. For each of these six topics, I interrogated the text to assess its level of commitment. I considered how thoroughly they were incorporated into the text and the depth with which they were treated. I also considered the degree to which these aspects were accessible to the teacher and usable within the context of the entire program. Last, I tried to describe how the text represented mathematics, teaching, and learning.

Cross-Case Analysis: Emergence of a Framework

The cross-case analysis involved iterations of comparative analysis of the cases, exploring themes, and then returning to the cases to check their validity. In accordance with the question of teacher learning underlying the study, I began by comparing the nature and contexts of their learning. This analysis revealed patterns in the types of learning that occurred through particular activities both teachers engaged in. In order to situate these patterns within the teachers' general textbook use, I drew on the cases to develop a model of their activities involved in curriculum development. This theoretical frame includes, but is not limited to, teachers' textbook use. It allowed me to examine the work of two extremely different teachers side by side and to speculate on teachers' curriculum development more generally.

CHAPTER THREE

DESCRIPTION AND ANALYSIS OF THE MATHEMATICS PLUS TEXTBOOK

The "reform-oriented" textbook that the Mapleton School District Mathematics Committee selected was Mathematics Plus, which was published in 1992 by Harcourt-Brace Jovanovich (HBJ). According to Catherine and Jackie, the HBJ text was appealing because of its emphasis on problem solving. I called it a reform-oriented textbook because it was published and selected under such pretenses, and was one of the four texts the district considered—all of which were published by companies claiming that their text reflected the changes called for by the NCTM <u>Standards</u>.

The intent of this chapter is to provide a description of the offerings of the HBJ text and to discuss the extent to which it was responsive to the reforms. My purpose is two-fold. First, I aim to provide the reader with a picture of what Jackie and Catherine had available in the text. Second, I hope to provide a critique of the text's offerings, vis-à-vis the emphases of the reforms, that I will draw on later when I consider ways that the nature and format of the textbook contributed to the teachers' curriculum development. Before describing the text, I provide a brief historical account of textbooks in American schools and the publishing industry.

Mathematics Textbooks in Elementary Schools: An Historical Context

Like chalkboards and desks, textbooks are part of almost every American classroom (Tyson-Bernstein & Woodward, 1991). For decades, commonly used mathematics textbooks (those published by large, commercial publishers) have changed little. The large, shiny student texts containing cuddly animals and colorful

photographs of real children doing math may be a little larger, shinier, and more colorful than 25 years ago (Elliot, 1990), but there is little new about the general content, format, or implied instructional design (Bowler, 1978; Broudy, 1975, Tyson-Bernstein & Woodward, 1991). Divided into 12 or 13 chapters, the content focused on computational processes such as addition, subtraction or two-digit multiplication, as well as other mathematical topics, like fractions and geometry. The chapters were organized into two-page modules, each on a different topic or skill, around which each day's lesson was shaped. There might be an example of the particular skill at the top of the first page, followed by a series of similar computations. Over the last 20 years, one likely would find some story problems at the bottom of the second page. The large, spiral-bound teacher's guide contained pictures of the student pages surrounded by wide margins that provided instructional suggestions and answers to all the problems.

Textbook Stability

Not only have mathematics textbooks seen little fundamental change over 30 or more years, 1 but there has been remarkable similarity among different publishers' texts. This uniformity is an artifact of the nature of the textbook market itself, which is highly competitive. Publishers respond to the demands of a large market that, in general, leans toward conservatism and resists fundamental change (Apple, 1986; Bowler, 1978; FitzGerald, 1979), particularly in mathematics. When a change makes its way into a textbook, it usually makes its way into all. Furthermore, consolidation of the textbook market beginning in the early 1980s from 12 or more independent publishers to five large companies has increased the move toward "product sameness" (Rothman, 1989; Sewall & Cannon, 1991). Fewer, more powerful companies competing for large shares of the market have made being different an unfathomable risk. Small, independent publishers and those producing inventive texts have faced exclusion.

¹The federally funded curriculum development projects that began in the late 1950s had a brief and slight impact on the commercial textbook market in the late 1960s. Some major publishers marketed new curriculum materials. This period was short-lived. Within a decade, commercial texts reflected little difference from those published in the 1950s (Elliot, 1990)

Mathematics textbooks have seen gradual changes over the last 20 years. These changes have been "more evolutionary than revolutionary;" that is, they reflect slow, steady movements in education (Elliot, 1990). Most changes have been in surface features such as illustrations and titles (Tyson-Bernstein & Woodward, 1991). Illustrations, for example, have become more colorful and representative of student diversity. Some of the more substantive changes have come from initiatives by the mathematics education community that gained sufficient visibility and influence among policy makers and textbook adoption committees to alter the market demands. I discuss some of these below.

Cases of Change

The first of these changes came after the publication of An Agenda for Action (NCTM, 1980), calling on math teachers to incorporate problem solving in the curriculum. In this document, its authors argued that problem solving involved more than word problems; it was a way of thinking that included developing and applying solution strategies to nonroutine problems. Within a few years and in response to market pressure, the mainstream texts began to include instruction in problem solving. In most cases, this took the form of lessons that instruct students on specific problem-solving strategies inserted periodically into the chapters. The surrounding lessons were unaltered except to have one or two more story problems added at the end. Still, these story problems were single-step, single-operation, arithmetic exercises (Remillard, 1991a). The format, organization, instructional design, and emphasis on computational procedures remained the same.

These textbooks were not entirely devoid of attention to underlying concepts and application of basic skills, but these items rarely found their way into the students' text. As Graybeal and Stodolsky (1987) found in their examination of mathematics texts published in the late 1970s and early 1980s, activities designed to develop conceptual understanding of the procedures were included but generally were suggested in the

margins of the teacher's guide only. Rarely were they on the students' pages, and rarely, it seemed, were these suggestions heeded (Stodolsky, 1989).

Another instance of change in mathematics textbooks that occurred later in the 1980s in California provides an example of how the textbook market operates. In their efforts to effect change in the state, education officials established rigid criteria for placement on the state list of authorized textbooks. Assuming that what made it onto the student page had a better chance of making it into classroom instruction, reformers advised publishers that no less than 20% of the student text must reflect changes in content and instructional activities proposed in the 1985 State Mathematics Framework² When the state rejected all 14 of the K-8 textbooks that had been submitted for adoption (Honig, 1991), editors scurried to make the appropriate alterations. The challenge for these companies was to maintain the California market without losing other states that were not making the same demands. Their solution illustrates the market influence on the design of textbooks. Those companies that made it onto California's list produced special editions of their texts for this market, selling their unchanged editions in other states.

Ironically, these California editions did not look significantly different from the others. Editors met the criteria by changing a few lessons per chapter to meet the 20% minimum. The new lessons included conceptually oriented introductions to topics, frequently incorporating the use of manipulatives and group work. Publishers also added cooperative enrichment activities at the end of chapters (Putnam, Jennings, & Remillard, 1990). Because publishers produced separate editions for the California market, this move did not have the impact on texts nationwide that observers had anticipated.

²The Mathematics Framework is the state's document outlining curricular and pedagogical goals. With an eye toward substantial change, this document was overhauled in the mid 1980s and, for the first time, established the criteria for textbook approval (Honig, 1991).

Changes in the non-California market, however, were soon to follow in response to the publication of the NCTM Standards in 1989 and its subsequent acceptance. Implicit in the Standards' call for change are criticisms of the way the mathematics content has been broken into discrete pieces, its emphasis on computational skills, and the corresponding lack of attention to conceptual understanding. The Standards and other reform documents expressed equal concern about instructional practices, focusing on repeated drill, practice of computational procedures, and independent work rather than collaborative and meaningful applications in which skills could be employed. Most prominent among current practices targeted for criticism was the inauthentic, "cookbook" approach to problem solving. Even though publishers had begun to include more problem solving in their texts, critics claimed that these instances were contrived, routine, inauthentic, and readily solved with simple strategies. They neither required students to think nor encouraged them to assess the sensibleness of their results.

As versions of the goals offered in the <u>Standards</u> were added to adoption criteria in districts throughout the country, publishers were forced to respond. In the early 1990s, each major publisher produced a new edition of its mathematics text, advertised as congruent with the NCTM <u>Standards</u>. <u>Mathematics Plus</u> was one of these textbooks. How valid were these claims? I examine this question in the remainder of this chapter.

To What Extent Does the HBJ Text Reflect Current Reforms?

In the sections that follow, I consider this question by looking at what the text offers teachers and what it implies about teaching in today's reform context. First, I describe the teacher's guide and student text. Then, I analyze the implications of these offerings with respect to key aspects of the reforms and how they represent mathematics, teaching, and learning. My overall assessment of the HBJ text is that it is responsive to the reforms but in a fragmented and superficial way. As the description below reveals, publishers have added substantial amounts of new material to the text's

traditional offerings. However, it looks and feels familiar in its representation of what and how teachers and students should learn.

What the Textbook Offers: General Description

The HBJ Mathematics Plus series includes a large selection of resources in addition to the familiar teacher's guide and student textbook. A vast selection of supplementary materials accompanies and is referred to in the basic text. They contain additional student work pages and testing activities (from standardized test formats to alternative assessment suggestions and guidelines). Manipulative kits, calculator sets, computer software, and books containing suggestions for using manipulatives and other forms of "interactive" teaching also are available. Still, the core program is found in the teacher's guide and student's textbook.

For this reason, I focus this analysis on the teacher's guide, which includes a reproduction of the student textbook. In citing specific examples or discussing the content offering, I draw from the fourth-grade textbook. The general organization and format of the textbook are the same at each grade level; consequently, much of the overall analysis applies to the HBJ series as a whole.

The Teacher's Guide

As is typical of textbook series, the HBJ teacher's guide contains the key to the entire program. All other materials associated with the series, including the student textbook, are pictured or referred to in the appropriate places in this guide. In addition to outlining the daily lessons, this hefty volume contains general information about the series and additional problems and activities not found in the student's text. The publishers have gone to great lengths to show that their text is in keeping with the ideas of the reform agenda. Quotes from the <u>Standards</u> are woven throughout the text along side-related activities. The fourth-grade teacher's guide contains the following sections:

1. <u>Introduction</u>. The first 27 pages in the teacher's guide are a mixture of advertisements for the HBJ text and an orientation to the range of offerings in the

series. It includes information about who the authors are and what they believe about teaching and learning as well as several pages of charts that provide different overviews of the content of the chapters. One chart lists objectives for each chapter, indicating which commonly used standardized tests assess each. Another chart offers a pacing schedule. A third provides a scope and sequence chart, showing when different skills and concepts appear across the entire K-8 series. Another chart overviews all teaching components available for each grade level. The last three charts summarize how manipulatives are integrated into the program. The emphasis in this section is on explaining how this text is aligned with national reform efforts, including a list of 14 philosophical statements that begin with, "We believe that. . . ." This section also speaks to those reviewers concerned with student achievement on standardized tests.

- 2. <u>Pupil's edition</u>. This section is the largest portion of the teacher's guide. It guides the teacher in using the student's text, as well as presenting students with instructional activities and tasks. For the most part, the guide is divided into two-page spreads, each of which defines a lesson. Each spread consists of pictures of the two corresponding pages from the student text surrounded in the margins with suggestions for the teacher.
- 3. <u>Minute math</u>. This section is a collection of open-ended activities designed to be used as fillers when teachers find themselves with extra time. They vary from being oriented toward quick practice of computational skills to more open ended explorations such as finding times of the day that are palindromes.
- 4. <u>Problem of the day</u>. This section contains a collection of problems, one for each numbered lesson in the book. These problems generally require more than a single operation or step to be solved and do not have straightforward solution paths. Many problems require logical thinking, and some have more than one solution.
- 5. <u>Alternative teaching strategies</u>. This section is a collection of instructional activities that can be used to teach various concepts in the series. There are two to four activities per chapter. Most activities involve whole class or partner work and almost all involve manipulative or visual materials. A few review skills in a format other than traditional practice such as games and other interactive activities.

6. NCTM issues and answers. Throughout the teacher's guide, the authors make reference to NCTM, frequently quoting from the NCTM Standards. This section contains several ideas frequently associated with the reforms such as problem solving, communication, mathematical reasoning, connections, manipulatives, and cooperative learning. Each idea is labeled as if it were written by one of the text authors pictured at the beginning of the book. Each page provides a brief description of one topic and a rationale for its importance to students' learning of mathematics. It also lists ways that the HBJ series is designed to attend to the ideas, starting with the phrase, "In Mathematics Plus. . . . " In a few cases, it gives suggestions for teachers to nurture them in students.

The student text. The student textbook consists of 13 chapters. Even though the content of each reflects little change from those of the past (e.g., place value, addition and subtraction, multiplication, division, fractions, and measurement), some of the titles suggest greater emphasis on developing understanding of the topic. The first chapter, for example, is given the title, "Place Value: Developing Number Sense." Each chapter also has a nonmathematical theme, such as protecting the environment, which is then used to provide a context for the problems in the lessons. These themes seem to represent an attempt to integrate nonmathematical topics into mathematics, thus showing its relevance to actual situations.

The chapters are identical in format and organization. Each chapter contains 10 to 15 numbered lessons presented on a two-page spread in the teacher's guide.

(Appendix C contains copies of example pages from the teacher's guide in Chapter 10. In referring to these throughout my description, I use the page number in the textbook.) Two of the lessons in each chapter are devoted to instruction on problem-solving skills and strategies (see pages 326 and 334, Appendix C).

In addition to the numbered lessons described above, each chapter contains eight extra activities. The first activity is the "Chapter Opener," which introduces the nonmathematical theme and the mathematical topic. For example, the theme for

³According to Keith (1991) the actual writers of textbooks are generally in-house editors, not those pictured on the books title page.

Chapter 10 (Understanding Fractions and Mixed Numbers) is health and fitness; it contains a large color photograph of young people participating in the Special Olympics and a story problem about one of the athletes. The margins that surround these two pages in the teacher's guide contain a collection of activities to introduce the topic of fractions and the chapter theme to the class. All activities suggest whole-class formats, with many drawing on students' personal experiences. (see p. 316, Appendix C).

The next nonnumbered lesson in each chapter is a "Review and Maintenance Test," which is found midway through. On the opposite page is a problem-solving activity, which focuses on developing a particular problem-solving strategy. At the end of each chapter are eight additional pages: a two-page chapter review, a two-page chapter test, a teamwork project, a page of extension activities, and a two-page cumulative review test (see pp. 340-345, Appendix C). These items are listed in the chapter lesson guide but are not actual lessons. Even though a substantial portion of the text's "reform-oriented" offerings are found in these nonnumbered lessons, they are not accounted for in the yearly pacing plan. The plan recommends that teachers spend one more day per chapter than there are numbered lessons. Chapter 10, for example, contains 11 numbered lessons and the standard 8 additional activities. The yearly pacing plan suggests that 12 days should be spent on this chapter. Thus, these extra activities are allotted little time in the year's schedule.

Additional to the student text. In addition to copies of the student text, the teacher's guide contains three pages per chapter of related activities not found in the student edition. Called "links," these activities are presented on two-page spreads between lessons. They suggest nonroutine problems, work with manipulatives, or tasks that relate math to other school subjects (see pp. 318A&B, 326A&B, and 338A&B, Appendix C). Like the nonnumbered lessons in the student text, extra time is not allotted for these activities in the chapter or yearly schedules; they are referenced on the regular lessons as optional resources.

Problem Solving in the Curriculum

The textbook developers claim that problem solving is a central focus of the HBJ program. They argue that it "must become the focus of mathematics instruction to prepare students for life in the twenty-first century" (HBJ, 1992, p. D2). The publishers have attempted to increase the amount of problem solving in the text without shifting the emphasis from skill development. Even though they have attended to many aspects of problem solving such as the use of strategies, problems with nonstraightforward solution paths, or those requiring multiple steps, in most cases their efforts appear contrived and inauthentic. The problem-solving focus takes the form of instructional activities designed to teach students how to solve problems, as well as a range of different problems to solve. Despite claims of importance, these activities could be described better as being added to, rather than integrated into, other lessons in the text.

Instruction in problem solving. According to the writers' claims, the text employs a "heuristic" approach to teaching problem solving. The heuristic includes a set of steps to follow and a list of problem-solving strategies to use. The four steps appear in each problem-solving lesson with questions similar to those shown in Figure 3.1:

| •Understand the problem | What are you asked to find? What information is given? | | | |
|-------------------------|--|--|--|--|
| •Plan a solution | -What problem-solving strategies can you use? -About what do you think your answer will be? | | | |
| •Solve the problem | -How will you solve the problem? -What are the solutions? | | | |
| •Look back | -How do you know your answer is reasonable? -What other strategies can you use to solve the problem? | | | |

Figure 3.1 Steps of the problem solving plan

The questions are used in the student's text to guide them through the problem solving process. One of the nonnumbered pages in each chapter, "Spotlight on Problem

Solving," also focuses on this heuristic by providing practice with one of the four steps. the lesson on page 331 in Chapter 10, Appendix C, is titled "Check the Solution for Reasonableness" and focuses on the "Look Back" step.

Each problem-solving lesson is devoted to one of the 10 strategies or 13 skills associated with the steps. The skills and strategies in the fourth-grade problem-solving lessons are shown in Figure 3.2:

Problem-solving strategies
Make and use tables, charts, and graphs
Make a list
Guess and check
Find a pattern
Draw and use pictures
Make and use models
Write a number sentence/equation
Work backward
Act out the problem
Use logical reasoning

Problem-solving skills
Choose the operation
Use estimation
Solve multistep problems
Interpret remainders
Analyze relationships
Identify too much or too little information
Analyze/compare data
Check reasonableness of solution
Draw conclusions
Make an organized list
Make predictions
Find hidden question
Interpret answer

Figure 3.2 Problem-solving strategies and skills

The focus of these lessons is on practice using strategies and skills, not determining which to use. Even though the questions under the step "Plan a Solution" involve selecting a strategy, the expected method is obvious, since it is often the title of the lesson. Furthermore, the problem is posed in such a way that the method being taught is the most natural choice. For example, the first problem-solving lesson in the text is titled "Use a Table." A table lists children's names and tally marks to indicate the number of patches each collected. Students read the table rather than making one themselves. The feasibility of other strategies also is considered. More often, the question under the last step, "Look Back," asks whether a different strategy is possible. The answer in the teacher's guide is another of the 10 problem-solving strategies.

Problem-solving applications. In addition to providing instruction on the strategies and steps in the problem-solving process, the text contains a range of different "applications." Most of these applications are routine⁴ story problems and are found on the pages of the student text under the heading "Mixed Application." Unlike the problem-solving instruction (described above), these problems require students to select the strategy or approach. Some of these problems draw on specific mathematical skills or concepts taught in the lesson. Most require a range of mathematical skills. For example, the problem-solving lesson on page 326 in Chapter 10 (Appendix C) follows instruction on using the "act it out" strategy with eight story problems that require different operations and lend themselves to various strategies. Most other lessons include a few story problems; not all of these require mathematical skills taught on the page. This reflects a consistent attempt to avoid presenting problems that require the same operation and approach. Four story problems are illustrated in Figure 3.3.

Even though these story problems are somewhat routine, the solution process varies from problem to problem, thus requiring students to identify appropriate strategies and to apply them. This is typical of many story problems in the text. In

- Each medal for the field-day events weighs 2 oz. There are 72 medals in a box. The empty box weighs 12 oz. How much do the medals and the box weigh?
- Estimation If every student in your class climbed onto a big scale, about how much would they weigh?
- •Mr. Tims has 258 packages of raisins. Each package weighs 5 oz. What is the total weight of the raisins? Write your answer using lb. and oz.
- •Which container of juice is the better buy? [Picture shows a 6 oz. can for \$0.56 and a 14 oz. can for \$1.26.]

(HBJ, page 231)

Figure 3.3 Example story problems

contrast to routine story problems traditionally found in textbooks, which make the appropriate operation obvious (Remillard, 1991b), these story problems avoid giving

⁴"Routine" is generally used to characterize story problems that are straightforward in nature and can be reduced easily to an arithmetic expression and solved with a single operation.

such clues. In most cases, a student would need to comprehend the situation in order to determine how to treat the information in the problem. In the first example above, the student would need to determine how to account for the weight of the box as well as the weight of the medals. Even though found less frequently, problems like the last one require more than an understanding of the situation. Unlike the first two examples, it cannot be rewritten easily in a number sentence and solved. Instead, students must determine how to compare prices of the two different weights.

Despite the text's emphasis on problem-solving strategies, they are seldom mentioned with these application problems, which is an example of the text's fragmented commitment to the reforms. The text might instruct students to select a solution strategy, but the teacher's guide contains only the solution. The teacher's guide offers no suggestions for focusing attention on the strategy or the rationale for selection; it merely provides the correct answer.

Other problem-solving tasks are found on the "Problem-Solving Link" pages and the "Problem of the Day" section in the teacher's guide. These problems range from straightforward story problems to multiple-step, nonroutine problems; most are the latter. The following problem is presented in the first "Problem-Solving Link:"

You earn 1¢ for cleaning your room on Monday and 2¢ on Tuesday. Each day you earn twice as much as the day before. How much will you earn on the next Sunday? (HBJ, p. 8A)

The text recommends that students work together using a "think-along" sheet to solve this problem. This sheet poses questions that guide students through the four steps of the problem-solving plan. Problems in the Problem-of-the-Day section also require interpretation and reasoning in order to develop a solution strategy. Most cannot be reduced to an equation to be solved. The first problem of the day, for example, asks:

How many ones will you write if you write the numbers from 0 to 99? How many twos will you write?

For an example page from the Problem-of-the-Day section, see Appendix D. The teacher's guide offers no assistance in using the Problem-of-the-Day section.

Daily Lessons

Daily lessons comprise the most substantial portion of the program. The entire curriculum is built around these lessons, which is another way in which the HBJ text is not substantially different from its predecessors. Each lesson includes a set of pages in the student textbook, as well as a selection of instructional, complementary, and supplementary activities. Completing all activities would take several days.

Types of lessons. The text contains three types of lessons: (a) instructional, (b) exploration, (c) problem solving. Only the exploration and problem solving lessons are clearly labeled with these headings. Even though similar characteristics appear in all lessons, each type of lessons varies in purpose and structure. I describe these below.

Sixty percent of all lessons in the text are <u>instructional</u> and designed to provide direct instruction followed by practice (see, for example, lesson 10.2, p. 320, Appendix C). The first two student pages introduce students to the topic using examples, explanations, and questions. A section entitled "Check for Understanding" follows with several related questions, drawing on material introduced. The second page of the student text is devoted to practice and is labeled as such. Approximately two thirds contain a series of short-answer questions similar to those under the heading "Check for Understanding." The final third presents two to four story problems under the heading "Mixed Application" (see above discussion of Problem Solving Applications).

The <u>exploration</u> and <u>problem-solving</u> lessons follow a similar format. They begin with an introduction, followed by practice and application problems. The main difference in the types of lessons is what is introduced and how. The exploration lessons, all entitled "Exploring ______", begin with a partner or group activity that uses visual models. The focus is on developing students' understanding of specific concepts or relationships through exploration with concrete or visual models. Lesson 10.1, p. 318 (Appendix C), instructs students to represent one fourth by folding a paper into fourths and then tearing it into fourths. A series of "talk-about-it" questions encourages students

to discuss the similarities and differences between parts of a whole and parts of a group.

The second student page follows this exploration with questions related to the concept.

The structure and purpose of problem-solving lessons are described above in the discussion on instruction in problem solving.

Table 3.1

Number of Lessons Devoted to Exploration in each Chapter

| Chapter | Number of explanatory lessons | | | |
|---|-------------------------------|--|--|--|
| 1. Place Value: Developing Number Sense | 1 out of 11 | | | |
| 2. Adding and Subtracting Whole Numbers | 1 out of 13 | | | |
| 3. Multiplication and Division: Using Facts | 1 out of 15 | | | |
| 4. Time, Graphing, and Data | 3 out of 14 | | | |
| 5. Multiplying by 1-Digit Numbers | 2 out of 10 | | | |
| 6. Multiplying by 2-Digit Numbers | 1 out of 10 | | | |
| 7. Measurement | 3 out of 11 | | | |
| 8. Dividing by 1-Digit Numbers | 3 out of 12 | | | |
| 9. Geometry 8 out of | | | | |
| 10. Understanding Fractions and Mixed Numbers 4 out of 10 | | | | |
| 11. Using Fractions and Exploring Probability 5 out of 11 | | | | |
| 12. Understanding Decimals 2 out of 11 | | | | |
| 13. Dividing by 2-Digit Numbers 2 out of 9 | | | | |

The problem-solving lessons, described in the previous section, appear regularly throughout the textbook (two per chapter.) They constitute approximately 15% of all lessons in the text. Exploration lessons occur less consistently. Overall, they make up one fourth of the lessons in the text, but the proportion of these lessons per chapter varies. Most chapters contain significantly more instructional lessons than exploration lessons. As Table 3.1 indicates, several of the computation chapters include only one or two exploration lessons. However, a few noncomputational chapters such as Geometry, Understanding Fractions, and Using Fractions and Exploring Probability devote one third to one half of their lessons to exploration. Table 3.2 lists chapter titles and themes, shows the distribution of instructional and exploration lessons per chapter, and lists problem-solving skills taught in each.

Table 3.2

Overview of Contents of Each Chapter

| Number of lessons in each category ^a | | | | | | | |
|---|-------|--------------|--------------|-----------------|-------------|---|-------------------------------------|
| Chapter | Total | Plan days | Explo ration | Instru ction | Prob. solve | Problem-solving strategies taught | Chapter theme |
| Place Value: Understanding | 11 | 12 | 1 | 8 | 2 | •Use a table •Find a pattern | Space Camp |
| 2. Adding and Subtracting Whole Numbers | 13 | 14 | 1 | 10 | 2 | •Draw a picture •Make a table | County Fair |
| 3. Multiplication and Division: Using Facts | 15 | 16 | 1 | 12 | 2 | •Too much/too little information •Write a number sentence | Children's Sports and Hobbies |
| 4. Time, Graphing, and Data | 14 | 15 | 3 | 9 | 2 | Use table or schedule Analyze data to make decisions | Shopping at the Mall |
| 5. Multiplying by 1-Digit Numbers | 10 | 11 | 2 | 6 | 2 | Work backward Choose a method of computation | After-School Activities |
| 6. Multiplying by 2-Digit Numbers | 10 | 11 | 1 | 7 | 2 | Make a graph Guess and check | Protect Our Environment |
| 7. Measurement | 11 | 12 | 3 | 6 | 2 | •Draw a picture •Multi-step problems | Things in Our Everyday World |
| 8. Dividing by 1- Digit Numbers | 12 | 13 | 3 | 7 | 2 | Choose a strategy Choose a method of computation | Communi- cation and Media |
| 9. Geometry | 14 | 15 | 8 | 4 | 2 | •Multi-step problems •Make a model | Imagination |
| 10. Understanding Fractions and Mixed Numbers | 10 | 11 | 4 | 4 | 2 | •Act it out •Choose a strategy | Health and Fitness |
| 11. Using Fractions and Exploring Probability | 11 | 12 | 5 | 4 | 2 | •Make a model •Make an organized list | Games |
| 12. Understanding Decimals | 11 | 12 | 2 | 7 | 2 | •Work backward •Use estimation | Sports Stars |
| 13. Dividing by 2- Digit Numbers | 9 | 10 | 2 | 5 | 2 | •Find the hidden question •Interpret the remainder | Careers |

^a Total refers to the number of regular numbered lessons in the chapter. Plan days refers to the number of days allotted to the chapter in the yearly pacing chart. Exploration refers to the number of exploration lessons per chapter. Instruction refers to the number of instruction lessons per chapter. Problem solving refers to the number of problem-solving lessons per chapter.

Suggestions for teachers. Regardless of these distinctions, the lessons are more similar than different, particularly when examining their presentation in the teacher's guide. Each two-page spread is identical and follows a single pattern of instruction and guidance for the teacher. A picture of the two student pages lies at the center and is surrounded by wide margins containing instructional suggestions. These suggestions are presented under the same major headings in each lesson: Motivate, Teach, Wrap Up.

The Motivate section suggests a pretextbook-lesson activity that does not include work in the student text. Most often, this activity calls for active participation from the students and usually is designed to occur in a whole class setting. For example, the Motivate suggestion in Lesson 10.1 on exploring fractions recommends that students fold paper into equal parts, that is, first one part, then two, three, and four. Each time students shade one part and record the fraction of the paper that the shaded part represents in a chart. Other Motivate suggestions are similar; that is, they act as a prelude to the subject of the lesson and involve active participation.

The Teach section is concerned with suggestions on how to guide students through the textbook page. It poses additional questions that the teacher might ask when introducing the information on the student page. The Teach section also lists common errors students make and suggests strategies for correcting them.

The suggestion under the third heading, Wrap Up, is always brief and oriented toward bringing the lesson to a close. Most often it describes how the teacher might summarize the lesson by asking students a specific question. The Wrap Up in lesson 10.1 suggests that students explain the difference between fractions representing part of a whole and part of a group.

Also included with each daily lesson are two minor headings: Quick Check and Double Check. Each section poses a set of three or four questions on the topic at hand that can be answered quickly. The teacher's guide does not offer suggestions for using these sets of questions.

The margins of the teacher's guide also contain other activities related to the lesson. These activities include (a) three supplementary pages, providing reteaching, practice, or enrichment; (b) tasks entitled "Meeting Individual Needs" for students to do individually; and (c) a box in the top, left-hand corner of the page listing other optional resources.

Assistance for Teachers

As is evident from the preponderance of activities from which teachers may choose, the HBJ program is not short on task suggestions—activities to give students to do or questions to ask them in order to guide their work. In addition to the suggestions on each two-page spread, the teacher's guide also provides organizational assistance at the beginning of each chapter in the form of a six-page overview. These pages summarize the topics and features of the chapter, list the objectives and materials the teacher will need, and provide suggestions and information on topics such as manipulatives, a bulletin board game, meeting individual needs, and ways to assess students other than the chapter test.

The textbook is, however, short on actual pedagogical suggestions and information. It says little about ways teachers might help students develop the ability to complete various tasks and says little about the mathematical ideas and goals underlying them. Neither does it offer suggestions for the appropriate use of supplementary materials accompanying each lesson. The lack of instructional guidance is prominent in sections of the textbook that are atypical. The Problem-of-the-Day section, for example, contains only a collection of problems and their answers. No additional suggestions can be found for helping students approach these nonroutine problems.

Other places in the teacher's guide that include information for the teacher are the introductory portion and the section entitled NCTM Issues and Answers. As described earlier, these sections contain little information regarding ideas about

mathematics, teaching, or learning that have informed the development of the textbook.

Rather, examples are used from the program to demonstrate the extent to which the ideas emphasized in the NCTM <u>Standards</u> have been incorporated into the textbook.

<u>New Ideas in Familiar Clothing</u>

The HBJ text incorporated several new ideas associated with the reforms such as more problem solving, exploration with manipulatives, emphasis on student talk and explanation, and noncomputational topics. However, they also left many of the more conventional aspects of the text intact. They continue to organize the content into many small pieces, focusing on procedures rather than conceptual relationships. Teachers may use the standard end-of-chapter tests found in the text or the alternative assessment activities offered in one of the supplements. An overall look at the contents of the text raises questions about the publishers' commitment to the reform agenda. They seem to be offering something for everyone in a package and format that looks and feels familiar.

A Look Beneath the Labels

Even though the sincerity of the publishers' commitment to the current reform warrants skepticism, the text contains several new components associated with these calls for change. In this section, I examine aspects of the content and pedagogy in the HBJ text that stand out as being responsive to the current reform agenda. I consider the level of commitment to these ideas by examining how thoroughly they are incorporated into the text and the depth with which they are treated. I also consider the degree to which these aspects are accessible to the teacher and usable within the context of the entire program.

Mathematical Content

The calls for change in mathematics target the substance and nature of the content, that is, what mathematics includes and what it is like. Rather than placing the mastery of computational skills central in the curriculum, the reform calls for broadening the content of school mathematics to encompass, at all levels, undertreated

and often omitted topics such as geometry and spatial sense, probability, statistics, data analysis and representation, and algebra (NCTM, 1989). In addition, reformers argue that a change in the way one views the nature of mathematics content also is in order. Rather than encountering it as a set of isolated skills, students should see and experience math as a way of thinking, reasoning, and problem solving that occurs in daily situations (Mathematical Science Education Board, 1989; NCTM, 1989). They "should be making conjectures, abstracting mathematical properties, explaining their reasoning, validating their assertions and discussing and questioning their own thinking and the thinking of others" (Lampert, 1990, p. 33). The NCTM <u>Standards</u> makes problem solving and reasoning central in the curriculum and calls for a shift in emphasis from rote, skill mastery to the meaning and understanding of the concepts underlying these skills. Attention to these ideas is evident in the HBJ program in the emphasis on problem solving, attempts to make marginalized topics more visible, and efforts to focus on underlying concepts. Below I describe and analyze the HBJ text's treatment of each.

Problem solving. The most prominent feature of the HBJ textbook associated with current reform efforts is the attempt to make problem solving central to the total curriculum. This effort is evident in the number of problem-solving activities available and in the frequency with which problem-solving tasks are incorporated into regular lessons. Furthermore, the treatment of problem solving in the text, that is, the emphasis on developing solution strategies and the inclusion of nonroutine problems and mixed problem sets, reflects an attempt to stimulate thinking and reasoning beyond the application of computational skills in story contexts. Nevertheless, this commitment is not consistently reflected throughout the entire program. The most authentic and nonroutine problems are not found in daily lessons but in special sections in the teacher's guide. Many of the problems in the student lessons are routine story problems.

The increased frequency of problem-solving opportunities suggests a strong commitment on the part of publishers to incorporate problem solving throughout the

text, but the increase in variety does not necessarily make problem solving central to the curriculum. The curriculum is organized around chapter topics that form the central core of the program. Problem solving has been inserted in and around this core.

Despite its high visibility, problem solving in the HBJ text gives the impression that even though it has been added, it can just as readily be omitted. Even though the quantity of problem-solving opportunities increases the chances that at least some will be used, there is little about its treatment that suggests it is central to the curriculum. At best, problem solving is an important piece that has been added to, rather than integrated with, the central and primary emphasis on computational mastery.

Another characteristic that contributes to the superficial treatment of problem solving is the large number of inauthentic problems in the student text. Even though the publishers have made attempts to include problems that do not have straightforward solution paths that involve multiple steps and require reasoning, these are primarily found in the teacher's guide only. Many of the story problems on the student pages are typical and routine that can be rewritten as a arithmetic sentence and solved computationally. Because the problems that are more consistently and authentically problematic are not in the student's text, the teacher must introduce them. Given the large selection of tasks from which teachers must choose, it is likely that they must skip some of these optional problem-solving activities.

<u>Unmarginalizing topics</u>. In response to calls for increased emphasis on topics that traditionally have been marginalized in the mathematics curriculum, the publishers of HBJ have taken noticeable steps to include topics such as graphing, work with data, and probability. In the past, these topics were found only on enrichment pages tucked at the end of chapters (Remillard, 1991a). These pages have a more prominent place in the HBJ text, but this place is still less prominent than conventional topics such as basic computation.

Chapter Four in the fourth-grade text entitled Time, Graphing, and Data provides an example of the best treatment given a new topic. Its contents address collecting and recording data in different forms and gathering information from charts, graphs, and tables. Its early placement in the textbook may increase the likelihood that teachers will use it. Furthermore, charts and tables are used fairly consistently throughout the text as a way to present information or to solve problems. The most noticeable weakness in the treatment of data collection and representation is that few tasks can be found in which students actually collect their own data and record it in a table or chart. Most often, they are asked to gather information from existing charts in the text. This process raises questions about the extent to which students might learn to use such methods to represent information or to solve problems.

Chapter Eleven, <u>Using Fractions and Exploring Probability</u>, provides a more feeble attempt to broaden the curriculum. Even though the title implies that the chapter involves using fractions to explore probability, it is the first nine lessons that focus on skills involved in operating with fractions and the last two introduce concepts related to probability, that is, expressing probabilities as fractions and listing all possible outcomes. In addition, the two problem-solving lessons focus on determining or examining possible combinations, which may be seen as a precursor to probability. This level of treatment represents an increase when compared to textbooks of the recent past, but the increase is small and superficial. Despite the changed rhetoric and a handful of extra lessons, probability remains a marginalized topic.

<u>Underlying concepts</u>. Reformers also are calling for change in teaching more traditional topics. Less emphasis should be given to developing rote knowledge and more to developing students' understanding of the concepts that underlie the procedures. Thus, changes in a textbook responsive to this aspect of reform are more likely to be integrated throughout its contents and evident in emphasis on mathematical concepts and ideas. Many of the tasks and questions in the HBJ textbook suggest that

the publishers have attempted to increase emphasis on conceptual development and meaning, and decrease emphasis on rote rules and procedures. In spite of this change, developing computational skills and procedures remains central to the curriculum, and exploring the meanings underlying these skills has been added.

The publishers' attempts to place greater emphasis on conceptual understanding are most evident in their consistent inclusion of questions and tasks that require explanations. Almost all of the lessons include questions that ask students to explain some aspect of an underlying concept. Many of the lessons have sections entitled, "Talk About It," which include questions that explain why a particular step makes sense or is necessary. One of the questions on the student page in lesson 10.2 asks: "How can you explain that $\frac{1}{3}$ is 1 divided by 3?" In addition, suggestions in the margins of the teacher's guide consistently state that students should be asked to explain their answers or knowledge.

Questions such as the above are particularly common in exploration lessons, described earlier. These lessons generally begin with an activity designed to illustrate a particular concept or relationship. Questions that follow often are oriented toward extending students' understanding of these ideas in other contexts. Lesson 10.1, for example, focuses on the meaning of fractions as part of a whole or part of a group. The exploration portion involves naming fractions based on this part-whole relationship (i.e., one of four pieces is $\frac{1}{4}$). The follow-up questions on the next page continue to pursue this relationship by asking questions that compare the same fraction of different-sized items. The first question shows two student-drawn posters, one twice as large as the other, both of which are half green. The question points out that each student colored half of the paper green and then asks if they had colored the same amount of paper. This question is followed with the questions: "Why or why not?" Similarly, two questions at the bottom of the page ask students to explain their answers.

An emphasis on understanding also is apparent in the wording and selection of story problems which require students to understand the solution process. As described in the section on problem solving in the text, the sets of story problems are mixed; that is, they require different solution strategies and different mathematical operations. Furthermore, the wording is such that students would need to have some understanding of the situation in order to solve it.

Commitment in the text to developing understanding is evident in the extent to which explanation questions and mixed sets of story problems are found throughout the lessons. However, like the treatment of problem solving or the inclusion of marginalized topics, the emphasis on underlying concepts does not constitute a significant change in the main emphasis on the text. The text contains many more lessons devoted to instruction on procedures than lessons devoted to exploration. Moreover, there are many more questions for which students must produce a correct answer than those requiring explanation. The editors have found ways to build conceptually oriented tasks and questions into the existing content rather than subjecting the content to revision.

Despite these criticisms, the consistent integration of conceptually oriented questions and tasks into the regular content of the text, placing them on the student's pages rather than in the margins of the teacher's guide, is a significant change from conventional texts (Graybeal & Stodolsky, 1987; Remillard, 1991a). This change has the potential to prompt teachers to use them or take extra care to avoid them.

<u>Pedagogy</u>

The calls for change in mathematics instruction do not stop at content. They also target how students learn and how they are taught. The changes in content imply complementary pedagogical revisions. For example, when the focus of mathematics was on learning rote procedures, instruction on the steps of those procedures followed by repeated practice was a logical approach to student mastery. The shift in emphasis to

problem-solving and reasoning abilities, based on conceptual understanding, calls for a different type of learning experience. Students require opportunities to develop understanding and to engage in reasoning and problem solving. Thus, the reforms call for pedagogical changes that include less teacher telling and more student exploration intended to promote understanding. They also suggest the use of tools such as visual models, computers, and calculators to focus students' attention on underlying meanings and away from blindly following rules (NCTM, 1991). In addition, reformers have suggested that "doing mathematics" does not necessarily mean doing a page of problems. Rather, doing mathematics means applying mathematical knowledge and solving problems in realistic contexts (Lampert, 1990; NCTM, 1989, 1991). These particular pedagogical emphases are treated in the new HBJ textbook in the following ways.

Instructional tools. The use of instructional tools such as concrete and visual models, calculators, and computers plays a major role in the reform agenda, even though positions on the pedagogical purposes of these tools vary. The general consensus is that concrete or pictorial tools can enhance a student's understanding of mathematical ideas by representing, modeling, or concretizing abstract concepts and relationships. Thus, they can provide students access to ideas that underlie mathematical rules and notations. Some reform documents, such as the Professional Teaching Standards (NCTM, 1991), have suggested that such tools can provide contexts in which students can explore ideas and relationships and should not be limited to modeling algorithms (Ball, 1992). Reformers also have viewed computers and calculators as tools that facilitate thinking because they allow students to focus on problem solving without being encumbered by computation (Kaput, 1992). Through technological tools, students can see and focus on patterns and relationships rather than on mechanics.

Regardless of their philosophical motivation, the publishers of the HBJ textbook have placed major emphasis on incorporating these tools into instruction. In particular, they have integrated visual or concrete models into the curriculum. The student pages contain pictures to illustrate mathematical concepts. Even though the frequency varies from chapter to chapter, the teacher's guide consistently recommends manipulatives or calculators during parts of many lessons. Also, most of the exploration lessons involve work with manipulatives or another visual model. The publishers also recommend additional manipulative-based activities elsewhere in the teacher's guide. One of the three Link pages is devoted to manipulative activities, as is the section called Alternative Teaching Strategies. Compared to texts of the recent past, this edition of the HBJ text includes greater emphasis on instructional tools.

Still, a look at how these tools are used raises questions about the extent to which they are intended to enhance understanding. Most frequently, manipulatives are used to introduce, through a visual model, an underlying concept that is later replaced by an algorithmic procedure. The emphasis seems to be on developing conceptual groundwork on which the procedure can be built rather than on exploring the meaning of the concept. For example, Lesson 10.4 begins by using counters to assist students in representing a fraction of a number. Instructions in the text guide students through specifically ordered steps that fit the pattern used on the next page in order to introduce the computational procedure. In this case, the only purpose of the manipulatives is to lead students through the procedural algorithm. There are no apparent instances in the text in which students use manipulatives to explore ideas and to draw their own conclusions. Modeling conceptual underpinnings of mathematical procedures is a useful role for manipulatives, but it seems limiting to their potential.

Calculators are integrated into the regular curriculum in the text less frequently than manipulatives, but they still make a strong appearance. One third of the regular lessons include suggestions to use a calculator to assist in computation, analyze data,

solve a problem or demonstrate particular number relationships. In addition, several problem-solving activities that are not regular lessons recommend calculators.

Computer-related tasks are not integrated into the regular curriculum, but are suggested in a special section at the end of the student text entitled "Computer Connection." This section devotes 15 pages to instruction in the use of LOGO, word processing, spreadsheets, and data bases.

The extent to which the use of manipulatives is accessible to teachers varies considerably. The text provides guidance for teachers in using manipulatives to model procedures in the manner described above. Thus, it assumes a level of familiarity that might not exist. The implication seems to be that students will have had prior experience with manipulatives and that the teacher is comfortable using them. The text does not offer suggestions to assist the teacher in managing them in a classroom of 30 students. Facilitating first-time use of such instructional tools does not seem to be a goal of the editors. Nevertheless, because of the way they are built into the lessons, it is less likely that they will be omitted than if they were suggested only in the teacher's guide. In fact, given the way manipulatives are used to represent abstract procedures throughout the text, it is likely that these tools may enhance the teacher's understanding of mathematical concepts.

The same assumption is made about teachers' familiarity with calculators. Even though they are often called for, the text fails to provide much information to the teacher about using them. The phrase "use your calculator" is placed frequently and prominently on problem-solving pages. Yet, no suggestions are available in the margins of the text regarding how to guide students in using them.

Learning through doing. Other pedagogical shifts emphasized by the reform agenda involve changes in what students should do in order to learn mathematics.

Rather than independently completing 30 problems on a textbook page, reformers have argued that students should explore mathematical ideas and solve problems in group

contexts. The HBJ publishers have attempted to incorporate this image of "learning-by-doing" into the design by suggesting activities in which students work cooperatively on tasks that involve manipulatives, recording and analyzing data, problem solving, or general exploration. The lack of genuine commitment to this pedagogical alternative, however, is evident in the way such activities are fit into and around the more traditional lesson format that makes exercises on the textbook page central.

The learning-by-doing suggestions rarely are integrated into the regular lessons or found in the student's text; they usually are located in the Link pages or the Problem-of-the-Day section in the teacher's guide. These activities also are included with the regular lessons in the teacher's guide but, again, only marginally. They do not replace the traditional textbook page but, rather, precede it. For example, activities under the heading "Motivate" provide examples of interactive tasks that do not revolve around completing a textbook page. These tasks are intended for the teacher to use prior to introducing students to tasks on the page. Similarly, the initial part of the exploration lesson is designed to engage students in exploring a concept with manipulatives, which is followed with a page of practice problems.

In making such activities precursors to more traditional tasks, it is likely that the publishers have diminished their role in the curriculum. The publishers have involved instructional approaches significantly different from those common to most teachers, whereas the text provides little assistance designed to guide teachers in using these alternative pedagogical approaches.

Learning through exploration. An aspect of a learning-by-doing approach to mathematics instruction fairly prominent in the rhetoric of the HBJ textbook is exploration. As I discussed in the general description, one fourth of all the numbered lessons in the text begin with exploratory activities. These lessons appear to be attempts to engage students in discovering or realizing specific mathematical ideas through work with visual or concrete representations rather than "telling" students these ideas through

direct instruction. The fact that one fourth of all regular lessons focus on exploration demonstrates a notable commitment to such learning opportunities while maintaining primary emphasis on direct instruction. Further examination of the distribution of the exploration lessons (displayed in Table 3.1) and the actual depth of exploration actually encouraged reveals that exploration is a vehicle for learning only certain topics. The largest concentration of exploration lessons is found in noncomputational chapters. Computational topics such as addition, subtraction, and multiplication only contain one or two exploration lessons. The focus of these chapters is on learning and practicing procedures, not exploring ideas. Division is the only computational topic that includes significant exploration.

The nature of the exploration activities also raises questions about the extent to which students are allowed to explore. As mentioned in the above discussion on manipulatives, exploration in the HBJ text means using concrete materials and specific questions to guide students to predetermined conclusions. The teacher's guide provides correct answers, communicating the message that each exploration should lead to a single, correct conclusion. The text says nothing about listening to students' ideas or discoveries when they are not the answers printed in the teacher's guide. In fact, it does not address the possibility that students might produce alternative answers. Inclusion of these lessons represents a step on the part of the publishers towards acknowledging that students construct meaning through exploration, but the meaning they are meant to construct is specific.

The gaps between current reform goals and the depth of responses to them are characteristic of the HBJ textbook. As the above analysis suggests, this text represents evident attempts to add reform-initiated characteristics without taking on fundamental change in content, format, or instructional design. As a reform-oriented textbook, what message does it communicate to teachers? What does it suggest about mathematics, teaching, and learning? What does its design enable and support teachers to do? These

questions are examined in the following section by considering the underlying assumptions about mathematics, teaching, and learning embedded in the textbook.

Mathematical and Pedagogical Analysis

In order to consider the underlying assumptions about mathematics teaching and learning implicit in the text, I examined the content, organization, and teaching suggestions of the textbook. Drawing from evidence in the textbook, I made claims about how mathematics, teaching, and learning are represented, as well as the publishers' overall intent and the relationship forged with the teacher.

Representation of Mathematics and What It Means To Know It

The mathematics content in the HBJ textbook represents the substance and nature of mathematics broadly. It touches, in one way or another, on an extensive number of mathematical topics. Some topics, such as whole number computation have been part of the elementary curriculum for years. Others, such as data organization and representation and probability are more recent arrivals. Even though number skills and computation receive the greatest attention, topics such as graphing, data, and geometry hold prominent positions. The text also represents the nature of mathematics in a variety of ways. The publishers have placed primary emphasis on rules and procedures but have woven in tasks that focus on their conceptual underpinnings. The publishers also have emphasized that thinking, reasoning, and problem-solving skills are part of the mathematical territory, frequently inserting problem-solving lessons and activities into the text.

This broad and varied representation of mathematics reveals a response to the reform agenda's call for increased emphasis beyond number computation and a reluctance to relinquish long-standing aspects of the mathematics curriculum. The textbook publishers appear to accommodate the ideas of the reforms by adding them to the extant curriculum rather than making any significant changes. This approach is particularly evident in the way two central emphases of the reforms are treated in the

text: (a) mathematics is a connected body of knowledge and (b) it has relevance in the real world.

Connections among mathematical ideas. The content selection and organization of the textbook represent mathematics as a large collection of discrete concepts, skills, and procedures that are related to one another, but should be thought about and addressed separately. The whole of mathematics is like a stone wall made up of countless individual stones that together form a solid structure. From a distance, one might see only a wall, but a closer survey would reveal the conglomeration of stones.

In the HBJ textbook, the multitudinous stones that form mathematics are introduced individually, each in its own lesson. The mathematics content is organized into 13 chapters, each of which is divided further into separate lessons. Each lesson deals with a slightly different skill or topic. Many of the divisions between lessons and chapters are not determined by conceptual distinctions but by the nature of the procedural steps involved. For example, three different chapters address the topic of division. Chapter Three focuses on single-digit multiplication and division facts, Chapter Eight focuses on division by single-digit numbers and introduces the division algorithm, and Chapter Thirteen deals with division by two-digit numbers and further develops the algorithm. Similar distinctions between topics appear within the chapters. For example, after an "explore" lesson in Chapter Eight, which uses base-ten blocks to model the long-division algorithm, another lesson instructs students to estimate quotients, a third introduces the steps of the long-division algorithm with a two-digit dividend, a fourth introduces the algorithm with a three-digit dividend, and a fifth addresses the same algorithm when there is a zero in the quotient. The emphasis in each lesson is on the procedural steps and how they are different in each of the above situations. There are no apparent efforts to show connections among the many different steps. For example, the conceptual steps of dividing the tens and then the ones among the number of groups determined by the divisor, emphasized in the explore lesson, are

not brought into those that follow or are students asked to estimate quotients outside of the context of the lesson with that title. The implication is that students need to learn and follow new and different steps with each new case. Conceptual relationships between different procedures or the meaning of division that underlies all of them receive no attention.

Certain underlying concepts are, in fact, woven throughout many of the lessons on division and other computational topics. Place value is the most prominent. The lessons on two- or three-digit computation all call on the place value concepts developed in the first chapter. Similarly, the relationship between multiplication and division, developed in Chapter Three, is frequently brought into later work on division. Thus, in some cases, the publishers have emphasized that the individual stones in the wall work together and that many are cut from the same rock. It is often the case, though, that this connection is obscured by differences in procedural steps.

Connections between mathematics and its applications. In its presentation of mathematical skills and concepts, the HBJ textbook persistently stresses that mathematics is related to the real world and that knowing mathematics includes being able to apply it in daily life. The emphasis on realistic applications of mathematics is woven throughout the text and is most evident in the variety of life-like situations used as problem contexts. Each lesson is introduced through a situation in which the particular skill being taught can be applied. The unmistakable message is that mathematical skills can be used in a range of real-life situations. Still, the extent to which the applications presented in the text are realistic is questionable.

As I mentioned in the general description, selection of problem-solving and application opportunities in the HBJ text is diverse, ranging from routine story problems that emphasize mathematical procedures to complex and nonroutine situations that require reasoning, developing, and using strategies. For the most part, mathematics educators agree that the latter more closely emulates the type of thinking most often

called for in life situations. In order to solve them, students must examine the problen:, develop a solutions strategy, test it, and then assess its reasonableness. They must discern the problem from the situation and determine how to solve it. Routine story problems, on the other hand, are life-like situations that provide contexts for computational practice. Students need to determine which algorithm to use and then apply it. Thus, the image of mathematical application portrayed in the HBJ text is as broad as the range of problems described earlier. Nevertheless, it is clearly weighted toward the routine, that is, the procedural application of skills in life-like contexts. Most of the story problems integrated into the daily lessons fit this classification; their only connection to real life is that they use situational contexts that are sometimes realistic, even though the mathematical problem may not fit the situation. Problems that involve more authentic applications of mathematical thinking are found in the teacher's guide on the Link pages or in the Problem-of-the-Day section.

Representation of Student Learning

The "stone-wall" analogy introduced earlier also applies to the view of student learning implicit in the textbook. The image of mathematics as a collection of separate pieces naturally supports the view that learning mathematics involves acquiring each piece individually. As each stone is separately laid in place to form the entire wall, each discrete concept or skill must be placed in students' mathematical knowledge. The processes used in the text to place these stones have implications for the theories on learning that underlie them. Below I discuss two aspects of instruction that are most prominent in the textbook. Then I consider the assumptions about learning embedded in each. The first emphasizes instruction and practice, whereas second addresses conceptual development through visual and concrete models.

<u>Instruction and practice</u>. The dominant pattern of teaching in the HBJ text assumes that students learn through instruction followed by practice. Each lesson begins with instruction on, or exploration of, a particular skill or concept through which

rules, procedures, or understandings are developed. Then these are practiced for a large part of the lesson through questions or exercises similar to those in the introduction. At the end of the lesson, students apply these skills in story problems. This pattern is evident in the format of each type of lesson described above. The implication is that learning occurs through being taught, followed by practice in isolated contexts and then application in more realistic situations.

Visual and concrete models. The use of visual and concrete models as instructional tools throughout the text suggests a view that students' learning is enhanced through use of materials that model abstract concepts. Through seeing visual representations of concepts, students are more likely to understand the underpinnings of algorithmic procedures. Base-ten blocks, for example, are used to model the multiplication and division algorithms when they are first introduced. Visual models are seen as particularly helpful when students have difficulty working with abstract symbols. Many of the supplemental "Reteaching" pages pictured in the teacher's guide employ visual models to reteach the lesson topic, even if the models are not part of the regular lesson. For example, Lessons 8.6 through 8.9 all address different aspects of the division algorithm. Visual models are not used on these student pages. Each of the "reteaching" options, however, returns to visual models in order to reteach the particular skill. The implicit message regarding visual models seems to be that they are useful instructional tools for building understanding of algorithmic procedures but should be eliminated and replaced by work with the symbolic; they are not viewed as tools to facilitate the exploration of mathematical ideas.

Representation of Teaching

The predominating view of teaching and the teacher's role embedded in the HBJ text are implicit in the suggestions provided in the margins of the teacher's guide. The teacher's role seems to guide and facilitate students' interactions with tasks in the text.

Guiding, not telling. The types of suggestions the text offers imply that showing or telling students the correct steps or how to obtain an answer is not part of the teacher's role. Rather, the text guides her in introducing particular topics by offering questions she should ask in order to engage students in explaining the steps or relationships shown on the student page. For example, the introduction to Lesson 10.2, Fractions as Part of a Whole (p. 320, Appendix C), shows three children sharing a pizza. The fractional numeral $\frac{1}{3}$ is written on the student's page, with arrows to the numerator and denominator explaining what each means. The teacher is instructed to ask the students what the denominator tells them while they are looking at the information on the page. Often the text suggests a question that requires an explanation not explicitly shown in the student's text. In these cases, the teacher's guide indicates that the teacher should "elicit" a particular response from students. The text provides the response she should elicit but does not discuss how to do so. For example, the warm-up question at the beginning of Lesson 10.2 asks, "How can $\frac{1}{4}$ of a pizza be different from $\frac{1}{4}$ of another pizza?" The recommendation in the teacher's guide is: "Elicit from students that the pizzas can be different sizes" (HBJ, 1992, p. 320).

Even though it is not stated, the text's tendency to avoid suggesting that teachers tell or show students is likely a response to the current emphases on constructivism often associated with the reforms (Chazan & Ball, 1995). Increases in the popularity of constructivist theories of learning and references to the need for students to "construct" meanings of concepts in the NCTM <u>Standards</u>, have associated antitelling views of teaching with the reforms. Telling and showing are not totally avoided by the HBJ text; rather they seem to be the role of the textbook not the teacher. As the fraction example above illustrates, information on the student page shows the specific steps included in the procedure being taught; it never suggests that the teacher tells or shows students these steps. Rather, it suggests that the class or groups of students discuss the steps, work through them with manipulatives, or one student explains them to the class.

Monitoring practice. Once students successfully pass the first few exercises and begin the practice portion of the lesson, the teacher's role is to monitor and correct. Few suggestions, though, are given for how she might monitor students' work, with the exception of being alert to particular common errors. These errors are described in the margins of the guide, with suggestions for how she might correct them. Many of these suggestions avoid explicitly telling students the correct answer or steps. They tend to correct them by having students respond to questions or use manipulatives; others employ strategies to decrease student errors. When dividing a three-digit number by a single-digit, for example, the "Common Error Alert" states that students may "bring down the ones digit instead of the tens digit," (p. 253). This can be corrected by "having students determine the number of digits in the quotient before dividing" (p. 253) or by using graph paper to keep the digits aligned. Beyond these common errors, the text does not discuss what or how to monitor students' work.

Selecting activities. A more implicit role of the teacher is to make decisions about which textbook offerings to use and which to discard. Using all the suggestions and activities in the complete program in a single school year is unmistakably impossible. As mentioned in the description, not only is each lesson packed with activities but several pages in each chapter are not figured into the allotted time for the chapter. Furthermore, there is a host of options found in the teacher's guide to incorporate into various chapters; thus, teachers must make selections among these options, even though the text offers little direction. In fact, there is no apparent acknowledgment or discussion of this aspect of the teacher's role or of its necessity.

The lack of guidance in making selections is one example of the text's tendency to give teachers new activities with minimal help in learning about their intent or how to use them. Because of the text's reform-oriented nature, the teacher frequently is asked to facilitate tasks or interact with students in ways not typical. This raises a slightly

different question about the text's image of teachers. How do text publishers envision teachers' roles in the process of change? I pursue this question in the final section.

The Role of the Text in Teacher Change

As the above analyses suggest, the HBJ text includes changes in content and pedagogy that reflect emphases of current reforms. However, the mode of communicating new ideas to teachers is similar to those used by the text it replaced. Essentially, it provides a collection of sequentially structured tasks, activities, and questions that teachers can present to students. Even though it is often referred to as a "guide," the extent to which the teacher's text actually provides the teacher with guidance beyond suggesting activities is limited. Despite its markedly different approach to teaching mathematics, the textbook does not include changes in how it interacts with teachers in order to help them incorporate these new ideas into their teaching; it does not talk to teachers about these ideas by explaining their intent or providing rationales for their selection. The implication is that changed teaching, that is, teaching in line with the reforms, will occur simply by using tasks offered in the text. However, as my observations of two fourth-grade teachers using this textbook suggest, the process is not straightforward. I now turn to these stories of two teachers.

CHAPTER FOUR

LEARNING TO TEACH MATHEMATICS FOR UNDERSTANDING: THE CASE OF JACKIE YARNELL

Jackie Yarnell was unlike many teachers whom reformers intend to reach. When she first encountered the HBJ textbook, she had already made significant changes in her mathematics teaching. She taught in a school that had focused on teacher development for several years. As a result, she had seen nonconventional teaching practices, experimented in her teaching, and talked with others about her observations and reactions. Over a short period of time, she had come face-to-face with many of her beliefs about teaching, learning, and mathematics and had begun to reexamine them. She also had considered much of her experience as a student in a new light and became determined to provide her students with opportunities that she had not had. She felt the freedom to begin to draw more on her own resources to design lessons and less on her textbook. This freedom and the opportunities that supported and encouraged her growth made Jackie a somewhat unusual case of an elementary teacher.

Jackie represents a small but increasing number of teachers who have opened their classrooms to new ideas about teaching mathematics and who teach in settings in which such growth is encouraged. Like many teachers, Jackie had high expectations of the new HBJ textbook. She had developed a strong set of commitments about what students should learn and the types of opportunities and instruction that might support this learning, and she hoped the textbook would help her provide them. She believed that she still had much to learn and needed mathematical and pedagogical guidance to continue along these lines. She expected that a recently revised textbook would provide some of this guidance.

The HBJ textbook fell short of Jackie's expectations. As she tried to fit the text into her developing vision of good mathematics teaching, she confronted a number of conflicts between her ideas about teaching math and what was in the text. As she drew on her own resources to construct lessons, she moved away from much of what the textbook offered. As a result, Jackie ended the year still in need of an instructional resource that could support her growth.

The intent of this case is to use Jackie's teaching and interaction with the HBJ textbook as a lens to explore the role a textbook might play in a teacher's continued learning to teach mathematics for understanding. In it, I examine Jackie's developing approach to teaching and what this meant for the textbook. I also discuss the personal, textual, and contextual factors that influenced her encounters with the HBJ textbook and their outcomes in her teaching. First, though, I introduce you to Jackie and acquaint you with the experiences and perspectives she brought to the textbook.

Introduction to Jackie

Jackie Yarnell had been at Kipling Elementary School for 6 years prior to this study. She was in her 30th year of teaching and her 28th year in the Mapleton School District. The principal of Kipling, Wynn Taylor, had encouraged her to transfer there. Wynn had been the principal of Jackie's previous school, and Jackie had enjoyed her support. She was anxious to leave the nonsupportive conditions that had evolved under the new principal. Even though she had taught all the upper-elementary grades, most of her years teaching had been in third grade. During this study, Jackie taught fourth grade for the first time in more than 10 years.

<u>Jackie's Experiences with Mathematics</u>

<u>Jackie's Experience as a Teacher of Mathematics</u>

Jackie's favorite subject to teach was math. "I've always felt math was someplace you could succeed in teaching . . . and it was fun to see the kids learn" (Interview, 9/11/92). Indeed, during most of her years of teaching, Jackie felt the success of helping

students make rapid gains in their computational abilities—gains reflected on standardized tests. She focused on developing computational mastery and followed the chapters and lessons in the textbook. More recently though, she had begun to rethink her ideas about what it meant to succeed in mathematics. Recognizing the importance of independent thinking and reasoning, she started to question whether the ability to apply computational rules could help her students understand when to use them.

The stimulus for these questions was a series of teacher-enhancement activities that occurred at Kipling Elementary School. In fall 1989, the school had become a Professional Development School (PDS) associated with a local university's school of education. This association initiated a range of contacts between Kipling teachers and university educators aimed at changing educational practices.

Jackie was involved in one of the first of these activities. She permitted a university professor to teach social studies to her third-grade students several days a week. This activity turned out to be an earth-shattering experience. Because the professor's teaching practices assumed substantially different ways of thinking about how children learn and what it meant to learn social studies, Jackie found herself confronting and examining her own beliefs about all subjects. "Watching [her] did a lot of opening my eyes, and there were things I didn't like and questioned, but there were so many things that I felt, yes, that's really what I would like kids to be able to do" (Interview, 10/22/92). Naturally, these changes did not happen overnight or without significant struggles. By the beginning of the next year, however, Jackie had embarked on a second collaborative project integrating social studies, science, and reading and had begun to experiment with changes in her own teaching.

My first contact with Jackie was during this second year when I began a collaborative project that involved teaching mathematics with another teacher in the school. Jackie and I had occasional hallway conversations, during which she voluntarily reported on instances of her mathematics instruction. These conversations suggested

that the changes she was experiencing in regards to her work with the integrated curriculum project had been nagging at her unchanged ideas about teaching mathematics. Eventually, she began to experiment in this domain as well. Even though I had not seen her teach at that time, she reported to be focusing her efforts on getting students to explain their solutions to story problems. Just as she had described her other PDS work, she found herself consistently astonished by the complexity of her students' thoughts. While she confessed to having rigid views about mathematics, this experience seemed to whet her appetite to examine her mathematics instruction more carefully.

The following year (preceding this study), Jackie and two of her colleagues expressed interest in receiving support while making changes in their mathematics teaching. In response, the four of us initiated a mathematics study group. I served as the university collaborator facilitating the group and working with the individual teachers. The group met regularly to discuss issues related to teaching mathematics in ways that fostered students' understandings. Each teacher individually decided how to pursue making changes in her own practice at a comfortable rate. Jackie's pace was decidedly gradual and not without hesitation. She developed a particular interest in allowing students to construct their own strategies for solving problems and to articulate their approaches to others. Throughout the year, she occasionally experimented with posing "nonroutine" problems to her students and engaging them in whole-class discussions about their solutions. As she began to place greater emphasis in her instruction on student understanding and reasoning, she questioned her former definitions of success in math. She also was realizing that even when her students could produce correct answers, they did not necessarily understand why or how to apply the concept to a slightly different situation. These insights prompted Jackie to examine her own experiences as a student from a perspective that she had not considered.

¹Nonroutine problems are situationally based and are generally more complex than straightforward story problems traditionally found in textbooks. See Chapter Three for a fuller description and examples of nonroutine problems found in the HBJ text.

<u>Jackie's Experience as a Student of Mathematics</u>

As a student, Jackie never liked her math classes, but she loved solving problems. Her math classes frustrated her because, as she recalled, "They wanted you to solve [problems] their way, and I liked solving them my own way" (Interview, 9/11/92). This was the "big turnoff" for her. In order to illustrate, she told me about an experience with algebra—the only class she ever failed. According to Jackie, it was not that she was unable to solve the problems. "I had every answer right on the test," she recalled, "but I did every problem my way so I had every one of them marked wrong."

Jackie was convinced that the reason she had disliked math was because she had been given few opportunities to think for herself. She saw connections between how stifled she had felt being told which procedures to follow and the few opportunities she afforded her students to solve problems in their own ways. "It really dawned on me... that the reason I was so turned off to math was the not being able to think for myself and just having to follow rules and patterns." (Interview, 9/11/92). Jackie became more and more convinced that students should learn to think for themselves.

At the same time, Jackie realized that she lacked much of the mathematical knowledge that she believed good teaching required. "I'm not a strong mathematician," she frequently reminded me. As is typical of many elementary teachers (Ball, 1988, 1989; Ball & McDiarmid, 1990; Remillard, 1993), Jackie took the minimum number of math courses required. It was the area in which she had the least experience and in which she felt weakest. "There are so many things I did not take in math. I was the typical if I didn't have to take that math class, I didn't take it" (Interview, 10/15/92). Despite the lack of formal experience, Jackie believed that she was good at solving problems when she was given sufficient time and the freedom to use any method. "I am very confident if I'm given a piece of paper, a pencil, and the time; I can solve almost any math problem if I'm left alone to do it" (Interview, 10/15/92). She wanted her students to develop this ability.

Jackie's School Context

The PDS environment at Kipling provided a level of support for teachers' professional development uncommon to most elementary schools. Many teachers were involved in collaborative projects with colleagues and university partners that involved experimenting with innovative teaching practices. Jackie continued to participate in the math study group during her first year of using the HBJ textbook. The three teachers and I met once or twice a month, and I met with individual teachers at their request. In Jackie's case, our interactions took the form of the observations and interviews for the present study.

Jackie also was involved in another PDS project that significantly shaped the context in which she taught; it involved teaching the same students for more than a single year. This experimental project, conceived by Jackie and the other third-grade teacher, examined how teaching students over a 3-year period would impact the classroom community and the learning experiences they initiated. This project was in its second year at the beginning of the study. Thus, even though Jackie was teaching fourth grade for the first time in many years, she was not working with a new group of students.

These experiences as a teacher in a PDS significantly influenced the personal "resources" that Jackie brought to her first year of using the text. These resources take many forms, including mathematical and pedagogical knowledge, as well as understandings, ideas, beliefs, personal theories, and commitments (Thompson, 1992). Often tacit components of her thinking, these resources originated in and contributed to Jackie's experiences teaching and learning math. In the present study, I was most interested in resources that acted as tools in her exploration and use of the HBJ text and provided lenses through which she saw and interacted with it. I discuss these below.

²I use the term "resources" to refer to the range of tools (personal, collegial, published, structural) that teachers bring to, and draw on in their teaching. Here I refer to personal resources that Jackie brought to her teaching. Later in the case, I discuss other resources such as the textbook and the context.

What Jackie Brought To Her Use of the Textbook

The categories I use to describe the personal resources that Jackie brought to her teaching such as ideas about mathematics, students' learning, teaching, and the reform context reflect Schwab's (1978) notion of curricular commonplaces such as subject matter, learners, teaching, and context. These, he argued, should be considered by developers in "making a defensible curriculum" (p. 368). The categories I used also reflect Shulman's (1987) characteristics of teaching knowledge; that is, the content of the learning and teaching categories is specific to the subject matter at hand. Below I describe ideas about mathematics, learning, and teaching that Jackie brought to her use of the textbook.

<u>Jackie's Ideas About Mathematics</u>

Jackie considered her knowledge of mathematics to be weak, but she had strong beliefs about its nature and power. She believed that mathematics was a connected, logical set of ideas that involved patterns and interrelationships. Even though math included isolated skills such as multiplication, she believed that the real power of mathematics was in seeing these relationships and patterns, "seeing there are things that you can kind of build upon," and applying them to an array of situations or problems.

As Jackie stated: "When you can learn to understand one thing and learn how to pick things apart, then you can, when there's something you don't understand, you've got some strategies for figuring out what you don't understand" (Interview, 10/15/92). She believed that a person who knew math well was someone who understood mathematical concepts and was able to solve a range of different problems and articulate why the solutions made sense.

Consequently, the mathematical goals Jackie had for her students were in the domain of thinking and application. "I think the most important thing," she told me early in the year, "is that they can solve problems. And I don't mean problems like 365 plus 298,000. I'm talking about, uh, I've got to put a rug in this room, and I need to

know how big a piece I need to get" (Interview, 9/11/92). For Jackie, this problem solving involved more than plugging formulas into situations to arrive at answers. She hoped that students would become critical about their own problem-solving processes in order to assess their application to other, unanticipated situations:

If they don't learn how to question their own learning and thinking they're never going to know whether it's right or wrong or what could they do when they can't get something the right way. They need to have lots of ways of trying to figure out something because we don't even know what kind of problems they're gonna have to solve as they're getting older. (Interview, 10/15/92)

Jackie believed that an essential ingredient of this type of critical thinking was understanding the tools of problem solving (mathematical concepts and relationships) well enough to apply them to different situations. For example, she argued that she would know if her students really understood place value if she could give them a subtraction problem without showing them how to regroup and they could "make that leap" to figure out how to trade 1 hundred for tens, or a ten for ones to solve the problem. "If they can do that, then that really shows their understanding" (Interview, 10/15/92). Another indicator of understanding, Jackie believed, was the ability to explain why a particular answer or procedure made sense. "I think it is important in math that they learn to express themselves" (Interview, 9/11/92). This belief was evident in her tendency not to accept answers without accompanying explanations. lackie's Ideas About Students' Learning of Mathematics

The ideas about how students learn math that Jackie brought to her use of the text were related to her ideas about its substance and nature. Thinking and problem solving were more than mathematical goals. These processes were also the avenues through which students developed them, which is one reason she liked the Problems of the Day found in the HBJ textbook. "They [the problems] do really well at leading the kids to do more thinking and discussing" (Interview, 9/24/92). She believed that, through exploring ideas, talking about them, and explaining them to others, students would develop understandings of underlying relationships and concepts. "The more

you can explain to somebody else, when you can teach something to somebody else, you have to understand it better in order to teach it" (Interview, 10/22/92).

Jackie also believed that the best learning occurred when students figured problems out for themselves rather than being given the exact steps to follow. She believed that by struggling with problems, students would further their understanding of the mathematical concepts involved while developing a more general capacity to solve problems. Thus, she preferred to give students problems that involved mathematical skills that they had not been taught and "let them puzzle" over them and invent their own strategies. She encouraged students to use different approaches to solve problems and gave significant air time to sharing their approaches during class. Jackie's Ideas About Teaching Mathematics

Given her ideas about learning, Jackie believed that her role as a teacher involved challenging students to solve problems and to discuss solutions with their classmates. During these discussions, Jackie acted as a guide and facilitator. She called on students to explain and justify their solutions and then encouraged others to respond by agreeing, disagreeing, elaborating, and suggesting alternative approaches. She believed that a teacher should not accept a student's correct answer without probing the child's thinking in order to understand how he or she arrived at the answer. The purpose of this belief was twofold. Not only would students clarify the concept for themselves and others by articulating their solutions, but hearing her students' explanations would give Jackie insight into their developing understandings and misunderstandings. The information she gleaned from their explanations guided the next question asked, the task next assigned, and the way she shaped the next lesson.

Jackie allowed her lessons to unfold in this way because she believed that good teaching required improvising and following the lead of her students. This process included pursuing a question or issue when it was brought up in class by a student or

changing entire lesson plans in response to students' struggles or interests; Jackie did both regularly. Consequently, it was rare for her lessons to fit her initial plans.

Even though Jackie's ideas about teaching mathematics seemed well developed at the beginning of the year, most had come about through recent changes in her teaching. From time to time, she confessed doubt about whether she knew what she was doing. Nevertheless, Jackie believed that she was a good teacher, particularly in math. She talked openly about her successes and the amount of time she devoted to her students. This devotion and her "logical mind" guided her efforts to change her mathematics teaching.

<u>Jackie's Ideas About Reforms in Mathematics Education and the HBJ Textbook</u>

Jackie did not see the reforms as limited to mathematics; they cut across most curriculum areas, emphasizing critical thinking, understanding, and the application of school knowledge. In mathematics, these goals meant focusing on understanding concepts over learning procedural rules, discussion over rapid computation, and problem solving over performing procedures out of context. She used her own experience to illustrate that computational proficiency did not necessarily help students understand how and when to apply it: "I was successful in teaching them how to compute wonderfully, but every time I'd have to teach them each new step. They weren't able to figure out that" (Interview, 9/11/92). Jackie hoped that the changes in her teaching would help students to develop the understanding needed to apply their abilities to new situations.

To Jackie, the HBJ textbook did not necessarily represent the reform agenda. In fact, she was not inclined to think of any textbook as innovative. It was the lock-step, one-page-per-lesson approach to teaching that she hoped to move away from through the recent changes she had made. This is how she compared her former and current approaches to teaching:

Instead of assigning a page in math, like doing 20 or 30 problems, they do a lot more talking with each other, sharing how they solved the problems. . . . Today,

we may not even open a math book or we may stick with one problem and work on one problem for the day. There's a lot more discussing and kids sharing ideas and hopefully learning from each other. (Interview, 9/11/92)

Jackie was hopeful about this new textbook and its potential to help her continue to make changes in her teaching. Of those she had looked at and tried, Mathematics

Plus seemed to be aimed in the direction she saw herself moving. She had scrutinized it and found that, in spite of its shortcomings, it had some promising features. She believed that it seriously attended to problem-solving and thinking activities that facilitated discussion. Even though she had begun to incorporate these activities in her teaching, she was pleased that she would not have to spend extra time searching other resources for good problems or ideas: "It's nice to have it right in the book. . . . I mean, I was going out and hunting for problems that would make kids think, because most of the problems in the textbook I didn't think would do that" (Interview 9/24/92).

At the beginning of the year, she believed that the text had potential for a teacher like her, and she was looking forward to trying it. She predicted that she would use it closely to guide her teaching. Not only did she want to learn what the textbook had to offer, but she felt uneasy about working with the fourth-grade curriculum: "This year I'm using it more as at least a basis, because I'm not that sure of all I need to do for fourth grade, whereas third grade was very easy. I knew third grade" (interview, 9/24/92).

Jackie and the HBJ Textbook: Dashed Hopes

Jackie started the year using the textbook "as a basis." She began with the first lesson in Chapter 1 and continued to draw from it throughout the year. But her initial expectations gradually turned into disappointment as conflicts surfaced between her notions of good mathematics instruction and those she saw underlying the text. The first conflict grew from Jackie's desire to "teach for understanding." This conflict was evident in the tension she felt between allowing the text to guide her path and pace through the topics it suggested and being guided by her students' needs and interests. The second conflict was a result of her tendency to use the text as a source of

mathematical topics, concepts, and representations, as well as the developers' seeming intention for the text to be a source of tasks. The descriptions and analyses that follow examine the nature of these conflicts, how Jackie negotiated them, and how they impacted her use of the textbook. As the analyses suggest, these conflicts were interrelated and served to stimulate changes in Jackie that further distanced her from many aspects of the text.

Jackie's Vision of Good Mathematics Teaching

Jackie brought to her use of the textbook developing ideas about what learning mathematics involved and what good teaching looked like. Her experiences over the previous year had nurtured in her a commitment to help students understand and apply mathematical concepts and relationships and a conviction that this learning required a teacher to be responsive to the students' interests, ideas, and struggles. These intentions were evident in the first lesson I observed on September 16th; she had designed this lesson to develop students' understandings of place-value relationships. Even though the text did not play a visible role, the lesson was drawn from the two-page spread on pages four and five in the teacher's guide. Jackie developed the central task of the lesson from one of three examples on page four, which illustrated how the same number could be written in multiple ways:

1,400 = 1 thousand 4 hundreds
14 hundred
14 tens
1,400 ones
(HBJ, p. 4)

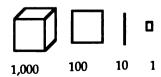
A lesson on place value. Jackie started math first thing in the morning after taking roll and attending to other administrative details. She called for the students' attention and waited for them to return to their seats. She had arranged the students' desks in clusters of four or five, each comprising a "team." These clusters were spread around the perimeter of the room. The floor space in the middle was open and covered with a large rug. Students frequently used this

space to work. At the front of the middle space was an overhead projector that Jackie and her students often used to illustrate points during class discussions.

This lesson began with all students at their seats and Jackie at the middle space in front of the chalkboard. She did not immediately start with the textbook. Rather, she spent approximately 10 minutes reviewing the relationships among the pieces of the base-10 materials provided by HBJ.³ Holding up a unit cube, she asked: "How much does this represent?" The students all agreed that it represented one and that it could be shown on the board by drawing a small square. Jackie reviewed the other pieces of the base-10 blocks-the ten strip, hundred flat, and thousand cube. She held up each and asked the students what quantity it represented, how they should draw it, and how many of the previous pieces would it take to equal it. For example, the 1 hundred piece that contained 10 rows of 10 little cubes was represented by drawing a large square and was equal to 10 tens and 100 ones. Jackie encouraged students to confirm these equivalencies by modeling them with the blocks and counting by one unit up to the next. When Carl did not know how many tens made 100, she armed him with a handful of ten rods and a hundred flat and had him lay the rods on top of the flat until they matched. Then she had him count by tens to ensure that it equaled 1 hundred before counting the individual rods.

Jackie then turned the students' attention to the textbook and instructed them to open to page four. Jumping past the introductory material on the student page and the suggestions in the teacher's guide on teaching the lesson, she began with her interpretation of example A on page four: "It says name some examples of fourteen hundred" she said, as if reading invisible words from the text. "They said one way of writing fourteen hundred or one thousand four

³Base-10 Blocks are three-dimensional models of the quantities represented by base-10 numerals. The smallest unit is a 1 centimeter cube; the next consists of a row of 10 cubic centimeters connected together. Ten rows are put together in a 10-by-10 grid to make the next unit. The largest is a 10-by-10 by-10 cube. Each piece in the set, regardless of the value it represents, is scored to indicate its relationship to the smallest unit (the cube) giving the appearance of a collection of individual cubes. Because they had used these blocks fairly frequently, Jackie and her students had agreed on conventions to use when representing each piece of the base-10 block set as follows:



They used these representations of the blocks to share their work with the class.

hundred was 1 thousand, 4 hundreds." She then read the other example in the book under example A: 14 hundreds, 140 tens, 1400 ones. "I don't know," Jackie continued, "the book says it, but I don't believe everything books tell me. I think it is your job right now to prove that. I want you to figure out if a thousand four hundred is the same as a thousand and 4 hundreds, is it the same as 14 hundreds, is it the same as 140 tens, and is it the same as 1400 ones."

Jackie gave each child a large piece of newsprint and instructed them to work in teams to "prove" whether the relationships in the text were true. Each group, she said, had to agree, even though the students could do their own drawings of the base-10 blocks. Immediately the noise level increased as the groups settled themselves on the floor or at their desks and began to discuss the equivalencies they wanted to draw. Jackie circulated and interacted individually with each group of students.

After 25 minutes, she brought the class together and asked if someone wanted to share a solution. The students were poised and ready for this question. Instantly numerous arms shot into the air, as students pleaded to be called on. Jackie called on Jared, a very tiny, soft spoken fourth-grade student who walked to the board and drew:

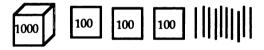


Figure 4.1 Jared's representation of 1,400

When Jared was finished, Jackie asked him a series of questions about his drawing. She then invited others to respond. A few students voluntarily commented on his solution. Jackie drew other students into the discussion by asking them whether they agreed or if they could explain in their own words what another student had said. She did not go on to another child's solution until the class had discussed Jared's and agreed that it made sense, even though it was not quite like the examples in the text. The class then discussed one more solution. Before ending the lesson, Jackie had the students respond in their notebooks to the question: "What did today's class help you understand?" (Observation, 9/16/92)

The design and structure of this lesson exemplify several characteristics common to Jackie's lessons. These characteristics illustrate how her ideas about mathematics, teaching, and learning played into the lessons she constructed and her use of the text.

Following Ideas, Inventing Tasks

The design of this lesson illustrates how Jackie used the text in constructing tasks to present to her students. The overall lesson focused on the central idea in the textbook lesson, which was the relationship between ones, tens, hundreds, and thousands. Jackie did not use any of the tasks offered on the page; typical of the lessons I observed Jackie teach, she created her own task that involved students modeling the central concept. Most lessons focused on a single mathematical idea or relationship and included tasks that engaged the students in examining or illustrating it. When she drew tasks from the text, she generally found them in the margins or other places in the teacher's guide rather than on the student's pages. In either case, the task served as a "jumping-off" point from which the lesson evolved. Her goal was not to merely get the students to solve the problem but to use it to get them to explore mathematical ideas. She consistently incorporated models, situations, or pictorial representations into the tasks to help students "visualize" the concepts.

<u>Lesson Structure</u>

The structure of this lesson also was typical of Jackie's mathematics lessons. She commonly began with a period of individual or small group work and followed it with a whole-class discussion. During the discussions students shared and explained their work and responded to questions and comments from Jackie or their classmates. Jackie rarely accepted correct or incorrect responses from students without accompanying explanations. She responded to students' explanations with more probing questions that challenged them to

⁴Lampert (1990) described a similar approach to cultivating mathematical discourse as a contrast to conventional approaches in which teachers ask students questions with the intent of making sure they can answer them. From her perspective, "The content of the lesson is the arguments that support or reject solution strategies rather than the finding of answers to teachers' questions. . . . The solution is more than the answer, just as the problem is more than the question" (p. 40).

elaborate or justify their ideas. For example, while Jared was still drawing (in the lesson above), Jackie insisted: "Now tell us what you are doing." As he completed his drawing, Jared explained that he took 1 thousand, then 3 hundreds and 10 tens. "And that equals a thousand four hundred?" Jackie continued questioning him. "Can you prove that to me?" Jared wrote:

When he wrote the last 100, which represented the 10 lines in his picture, Jackie asked: "How many tens do you have?"

"Ten."

"How many do you have written down?" Jared looked at his list of numbers for a few seconds and then said 10.

"So you are saying that 10 tens is the same a hundred?" Jackie wanted to know. Her voice seemed unconvinced, even challenging.

"Mmm hmm," Jared nodded.

"Would you show me how you know that?" Jackie asked. Jared returned to his drawing and counted each of the 10 lines by 10 and arrived 100. Jackie turned to the class and asked them if they agreed with what Jared had done.

Jackie also asked Taurie, the next student to present a solution, a series of follow-up questions. Taurie timidly responded to each and appeared relieved when it was over. When I later asked Jackie about this interaction, she explained: "I want to get her to push herself a little bit more to make sure she really understands what she is doing" (Interview, 9/16/92).

Students' Role

During these whole-class discussions, Jackie usually took the lead in questioning students about their solutions, but she encouraged students to develop similar scrutiny.

She often asked students whether they agreed or disagreed and expected them to explain why. She also solicited alternative approaches to solve problems by asking: "Did anyone do it another way?" She encouraged students to argue about the mathematical ideas, occasionally letting a disagreement result in a contentious exchange, which she did little to curtail. She used disagreement to involve students in talking about ideas and examining other perspectives. When I asked about the disagreements, she explained "I'm trying to get them to value that each of them has different things to contribute" (Interview, 10/15/92). She attempted to involve as many students as possible in these discussions because she believed that these interactions helped to develop their understandings. After a lesson that involved animated debate about exchanging tens for hundreds, Jackie said: "I think they started realizing how much they help each other with each giving each other ideas. And then, after we took everybody's ideas, they could see how then the whole group helped even get more ideas on what we were trying to do. That way all of them are getting more than they would all by themselves" (Interview, 10/15/92).

Throughout each lesson, Jackie paid close attention to what students said and then tried to gather as much information about what they understood. She used their journal writings similarly. As on September 16th, Jackie regularly assigned journal-response questions at the end or beginning of a lesson.

These characteristic features changed little throughout the year and were evident in all lessons I observed. Table 4.1 provides a summary of all lessons I observed.

Another pattern I observed in her teaching, when looking across a set of lessons on the same topic, was a decrease in her use of the text to determine the contents and pacing of topics; this is described in the following section.

Table 4.1

Summary of Observed Lessons Taught by Jackie Yarnell

| 9/16/92 | Lesson summary | |
|---|---|---|
| | Entire lesson focused on discussing, showing, proving relationship between ones, tens, hundreds, and thousands of various quantities. After review of | Asked at the close of the lesson: |
| Relationship among ones, tens, hundreds, and thousands. | the value of each base-10 block, students worked in teams to draw various base-10 representations of 1,400 (taken from an example on page 4 of the text). Two students' representations were then discussed among whole class. | What did today's class help you understand? |
| 10/15/92 | Lesson began with 10-minute discussion of the problem of the day from textbook involving combinations on a dart board. Jackie focused the discussion on how they | Asked at the close of the lesson: |
| Three digit addition, emphasizing place value | could know they had all the possibilities. During the main part of the lesson, the students used place value mats to represent and add three-digit numbers. The central tasks involved modeling and explaining the place- value exchange that is made when regrouping to add. | Describe something you learned about trading today. |
| 10/22/92 | The entire lesson focused on the students' proofs of three-digit addition problems. The students were to show the regrouping process by using place- value blocks, expanded | Asked at the close of the lesson: |
| Modeling three-digit addition with regrouping | notation, and the standard addition algorithm. | What do you know better about place value? |
| 10/29/92 | The focus of the lesson was subtraction with regrouping using base-10 materials (paper versions of cubes, rods, flats). Jackie presented students with a three-digit subtraction | Asked at the close of the lesson: |
| Three-digit subtraction, emphasizing place value | problem that the students were to solve in groups. The class then discussed and modeled each problem. Student confusion about subtraction during the discussion. | What is 203 minus 94? |
| 2/1/92 | Problem: Harry collects rocks. He had 12 pieces of granite, 18 pieces of flint, and 6 pieces of quartz. He traded one half of the quartz and one third of the granite for 1 | |
| Problem of the day comparing discrete fractions | piece of alabaster. How many rocks does he have now? The class spent an hour discussing and comparing fractions. Students drew pictures on the board to support their positions. | |

Table 4.1 (Continued)

| 4/5/93 Jackie had students ansert then discussed their ansert then discussed their ansert and suggestions in the margory chapter Chapter As a class, they discuss class. Jackie closed clast fraction 22/22. 4/6/93 Jackie presented the clast hundred-meter dashes. Fractions as parts of a group solve this and related proceed. Some discussion, the student of the stude | Jackie had students answer four questions about fractions in their journals. The class then discussed their answers to these questions for 22 minutes. Jackie followed suggestions in the margin of page 316 to introduce the chapter theme and the topic of fractions. She polled students to determine how many participate in various sports. As a class, they discussed how to represent the results in fractions of total number in page 3 food to the product of t | What are fractions? |
|--|--|---|
| nction to fraction ns as parts of a group of 15) | to their answers to these questions for 22 minutes. Jackie followed in the margin of page 316 to introduce the chapter theme and the topic of he polled students to determine how many participate in various sports. hey discussed how to represent the results in fractions of total number in a charged closed by the pollogical charging for the charges. | |
| ns as parts of a group of 15) | he polled students to determine how many participate in various sports. hey discussed how to represent the results in fractions of total number in | What do you know about fractions? |
| ons as parts of a group of 15) | a alone describer about a students to consider the meaning of a | What things are divided into fractional parts? |
| ns as parts of a group of 15) | class. Jackie closed class by chancillaing students to consider the incannily of a fraction 22/22. | When do you use fractions? |
| | Jackie presented the class with the problem: Shawn won one third of the 1500 hundred-meter dashes. How many races did he win? Students used chips to model and | $\frac{1}{6}$ of 18 $\frac{1}{3}$ of 18 |
| | solve this and related problems that Jackie posed. After discussing solutions, Jackie | |
| some discus | posed several similar problems (that she made up). One problem was $\frac{1}{4}$ of 15. After | $\frac{1}{9}$ of 18 $\frac{1}{2}$ of 18 |
| similar prot | some discussion, the students agreed that it could not be done. Jackie posed four similar problems as journal work. | |
| 4/7/93 Lesson began with five | Lesson began with five journal questions. Jackie then placed a Hershey's candy bar, | Are all fractional parts same size? |
| | ie sections in the central of each team and assect them whether they wanted in sixth, or one twelfth. After students responded to these questions in | What is the word name for $\frac{2}{5}$? |
| $\frac{1}{2}$, $\frac{1}{4}$, | | Draw a picture to show $\frac{3}{12}$ |
| $\frac{1}{3}$, $\frac{1}{6}$, and $\frac{1}{12}$. each fraction. | Agreed about now much of the 12 pieces of the candy bar was designated by i. | 1 1 |
| | | Which is greater, $\frac{1}{4}$ or $\frac{1}{2}$? |
| | | Put in order from least to greatest: $\frac{1}{2}$, |
| | • | $\frac{1}{6}$, and $\frac{1}{3}$. |
| 4/8/93 Students wo Jackie bega | Students worked in groups to find different fractional amounts of a group of chips. Jackie began with one third of 24. The class discussed the solution in some detail | Asked at the close of the lesson: |
| Fractions as parts of a before going group, comparing unit and apparent wh | before going onto the next questions: two thirds of 24. Student confusion became apparent when they were asked to find non-unit fractions. | The bottom number of a fraction tells me Use a picture to |

Table 4.1 (Continued)

| Date and lesson topic | Lesson summary | Notebook question |
|---|--|--|
| 4/12/93 | Jackie began the lesson with a class discussion of different fractions of 12. Jackie had the students use graph paper rectangles to compare different unit fractions. At the end | Asked at the close of the lesson: |
| Comparing fractions with different denominators | of class, she had the students glue and label the rectangles in their journals. | Use graph paper rectangles to show $\frac{1}{2}$, |
| | | $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$, $\frac{1}{7}$ $\frac{1}{12}$ of 12 |
| 4/13/93 | In groups students used chips to show different fractional amounts of groups. As | |
| Meaning of numerator and denominator | students explained their answers, Jackie focused on the meaning of the numerator and denominator. | |

Following the Text or Following Students

Jackie began the school year with the intent of using the text closely. Even though the general mathematical topics of her curriculum matched the chapters in the text, the specific contents of each did not match. She found that she was repeatedly pulled away from the content and tasks of the textbook lessons by her sense of what her students needed most. She was pulled away from the place-value unit, a topic she had taught frequently, and the unit on fractions, a topic with which she was less familiar. The following two stories illustrate her tendency to look to her students and her sense of what they needed to learn in order to determine much of the actual contents she focused on within each topic.

Following the Text

Jackie started the year following the text. She began with the first chapter, entitled "Place Value: Developing Number Sense," taking one page at a time. As the September 16th lesson illustrates, classroom discourse also had become a central element of each lesson. She found that it took several days to complete each page. After the lesson described above, I asked her about her choice to structure the entire lesson around a single example in the text. She explained that she had planned to complete several more problems but found that incorporating discussion into her instruction took more class time: "We don't do that many problems when you're discussing things" (Interview 9/24/92).

At first Jackie did not seem discouraged by this slow pace. Even though she joked about how long it was taking them to get through each page, she was pleased with how the lesson had gone. She said that she liked what she was seeing, particularly the degree to which the students were able to "verbalize exactly how they were thinking" (Interview, 9/16/92).

At the end of the September 16th lesson, Jackie looked at what she had planned to do that day and assessed how well the students understood the concepts. The plans

she had made for the day touched on about half of the tasks suggested on the two-page spread that outlined the lesson. The class had completed less than one fourth of Jackie's plans. Still, Jackie was not convinced that all students understood the relationship between tens, hundreds, and thousands: "I have a feeling that enough kids still need some more thinking on this" (Interview, 9/16/92). Thus, she planned to have students complete two additional examples before going on to a new page.

A week later, Jackie reported continued slow progress through the text but this time with greater misgivings. She had begun to worry about the pace: "Spending as much time as I am doing on one thing is a big risk. . . . I know there are a lot of things we aren't going to cover" (Interview, 9/24/92). By this time, Jackie had begun to consider selecting fewer items from the text; this was risky as well.

They have so many different things and I'm going to have to pick and choose more. In fact, I'm starting to. But it's really hard when you're first doing it because I'm saying, "Well, I don't think this is valuable," but then who doesn't know that later on that's going to really help with something else. (Interview, 9/24/92)

After less than a month of using the text, Jackie was finding it more difficult to integrate her desire to follow the text with her commitment to pursue ideas. Thus, she began to contemplate her options.

Following the Mathematics

An approach that Jackie considered taking was to jump temporarily to another chapter in the text (column addition and subtraction) and then return to place-value. This option was premised on her developing ideas about the importance of place-value in column addition and subtraction. She wanted her students to connect what they were learning in the place-value chapter with its application to multiple-digit addition and subtraction. A move to addition and subtraction made sense because regrouping rested heavily on the concept of place-value; it could extend the work they had already done. She considered a method of introducing multiple-digit addition that would emphasize

the role that place-value played in regrouping; that way, they could "still [be] working on it [place value] but working on it in a different way" (Interview, 9/24/92).

This decision may have been a turning point in Jackie's use of the text. Not only was she considering a move away from the text's defined curriculum by leaping to another chapter, but the leap was motivated by a connection she saw in the mathematics not made in the textbook. In the textbook, the conceptual foundation for place-value and multidigit addition and subtraction was treated separately; Jackie saw the two as related. Jumping to the second chapter would help her students see this connection and further develop their understandings of place-value. She said:

I was hoping they could actually see what carrying--what you were doing when we say carrying, you know regrouping—I wanted them to actually visualize what they were doing so they could actually see that when you have 10 of these you can exchange 10 of these for one of these. (Interview, 10/15/92)

Jackie moved the class into addition and subtraction of multidigit numbers, using pages on expanded notation in the place-value chapter as a bridge. Three weeks later (October 15th)⁵ the class crossed this bridge into addition. I learned later that her decision to change topics was motivated by a comment from a student the previous day. Following the Students

The student in this case was Randy. Jackie had given each student a place-value mat and plastic chips with which they were to represent various numbers by placing chips in the appropriate columns. In sharing his method for showing 24,000, Randy demonstrated to the class that 24,000 could be represented as 24 chips in the 1 thousand column or two chips in the 10 thousand column and four chips in the 1 thousand column: (see Figure 4.2). Jackie realized that this demonstration naturally moved the class in the direction she had intended: "It kind of hit me that that was kind of a logical jump from there to regrouping" (Interview, 10/15/92). Jackie took advantage of this

⁵Even though this lesson occurred 3 weeks after the September 24th interview, 1 week of that period was devoted to state-mandated testing, and another week was dedicated to preparing for the test. Jackie did not teach any regular math lessons during that time.

| 100 thousand | 10 thousand | 1 thousand | hundred | ten | one |
|--------------|-------------|------------|---------|-----|-----|
| | • | • • | | | |
| | | | | | |
| | • | • • | | | ļ |
| | | | | | |

Figure 4.2 Place-value mat showing one of randy's representations of 24,000

connection and constructed a task with the place-value mats she believed would lead students to make this logical jump.

October 15th: Connecting place value and regrouping. She began on October 15th, by putting a place-value mat on the overhead and placing a chip in the 10 thousand column. She then recalled Randy's observation from the previous day, restating the relationship between 10 chips in the 1 thousand column and one in the 10 thousand column he had noted. When she asked him, Randy confirmed that this was what he had said. Jackie invited the other students to respond. When a student agreed and added that the trade could be reversed, that the chip in the 10 thousand column could be exchanged for 10 chips in the 1 thousand column, Jackie seized the opportunity. "Let's look at this," she suggested. She led them in adding 10,000 and 4,000 by counting the 10 chips in the 1 thousand column by thousands until they arrived at 10,000. When many of the students agreed that the two numbers were the same, Jackie asked them when they would use this in math. Immediately Jordan suggested borrowing. With some nudging, Hillary volunteered "Plussing."

"Right, adding," Jackie told her.

With this response, Jackie took the class into addition. After some discussion, she gave them two numbers (493 and 363) to represent on their place-value mats and add together. A significant portion of the class discussion centered on how to deal with the 15 chips that ended up in the tens column. Even though the entire class agreed that ten of the chips in the 10 column equaled 100, they did not agree on how to move them to the hundreds column. Some believed that all 10 should be moved. Others thought that the 10 should be exchanged for one chip in the hundreds column, but were reluctant to drop the other 9, leaving them in the tens column. One student demonstrated how she exchanged 10 of the chips in the ten's column for 1 in the hundred's column, producing the number 856. Another student showed how he arrived at the same answer without making the exchange. He added the quantities of each column:

$$400 + 90 + 3$$

 $300 + 60 + 3$
 $700 + 150 + 6 = 856$

Jackie closed the lesson by asking them to get their math notebooks and write something they'd learned about trading. (Observation, 10/15/92)

When I asked Jackie if this lesson was drawn from a particular lesson in the book, she answered: "Yes and no." Even though it grew out of the previous day's activity suggested in the teacher's guide, the lesson I observed represented a significant step away from that particular part of the text and into the topic of the next chapter: "Originally we were working on [pages] 10 and 11," she told me, "and then, with what Randy said, I was kind of jumping" (Interview, 10/15/92). The use of place-value mats was not suggested on pages 10 or 11. She had taken that idea from a suggestion on one of the Link pages in the textbook and decided that being able to place "things" in the columns would make it easier for students to work with the idea of exchanging (Interview, 10/15/92). In essence, Jackie constructed this lesson by connecting ideas and representations in the text. Her choices of tasks were motivated by a student's observation and her desire for all students to make similar connections.

Even though Jackie had talked about moving to the next chapter, she did not use it in the lessons that followed. For several weeks Jackie created her own tasks on regrouping to add and subtract, drawing on base-10 manipulatives or models to illustrate the role of place-value. Table 4.2 displays the extent to which Jackie drew suggestions from the text during the lessons in the fall; it indicates a gradual move away from the lesson suggestions in the text. She continued to emphasize mathematical discourse during which she pushed students to see and explain the standard addition and subtraction algorithms in terms of the models used. During the lesson on October

Table 4.2

Summary of Jackie's Use of the Textbook: Fall 1992

| | | • | 10 | | |
|---|--|--|---|---|--|
| Role of text during lesson | Students looked at chart and example on page 4 before beginning drawings | Text was not present during lesson | Text was not present during lesson | Text was not present during lesson | |
| Items constructed by teacher | Central task: re-present 1,400 with base-10 blocks; notebook question | Discussion of dart problem; central task: model place value exchanges; notebook question | Central task: model 3- digit addition using base-10 blocks, expanded notation, standard algorithm; notebook question | Central task: 3-digit subtraction using paper base-10 materials; notebook question | |
| Items used from supplemental parts of teacher's guide | | Problem of the day 2.7: Place value mats from link page, 2A | | • | |
| Items used from margin of teacher's guide | Introductory activity suggested use of base-10 blocks | | | | |
| Items used on student pages | Example A, page 4 (showing different ways to represent 1,400) | | | | |
| Lesson topic | Relationship among ones, tens, hundreds, and thousands | Three-digit addition, emphasizing place value | Modeling three- digit addition, emphasizing place value | Three-digit subtraction, emphasizing place value | |
| Date | 9/16 | 10/15 | 10/22 | 10/29 | |
| | | | | | |

22nd, for example, she challenged students to solve the same addition problems using three methods: base-10 models, expanded notation, and the standard algorithm.

Jackie used her students to gauge whether to remain with a particular idea or go on to something new. After the lesson on October 22nd, she described how she would decide whether to move to subtraction: "I think tomorrow I'm going to hopefully get a sense. If the majority seem to understand it, we may go to higher numbers to make sure they really understand it, and then right into subtraction" (Interview, 10/22/92).

When asked where she was in the book, she said that she was not sure: "I think we're in the second unit." She laughed when asked if she was following the lessons in this chapter. In fact, it appeared that she had looked at it only briefly, if at all. She did not know whether it approached regrouping similarly. She looked to the text to define the topic and to start the unit, but she followed her own ideas and her students as the topic progressed: "When I realized that that's the direction we were going, I decided that I would work a little on what I wanted to do" (Interview, 10/22/92).

Jackie's rapid departure from the textbook during work on place-value was not surprising, but neither was her tendency to rely on observations of students and her own ideas about the math to guide her instruction. For a year she had been working to follow students' thinking in her teaching. These efforts superseded her earlier intentions to remain with the textbook. Furthermore, place-value and addition and subtraction of whole numbers were topics Jackie had taught in third grade. She was comfortable with the mathematical ideas, and she had a repertoire of ways to engage students in exploring them. She relied on these, rather than the text, to shape her instruction.

Jackie speculated that she would "rely on the textbook a little bit more" when teaching "things I'm a little more shaky on or feel less confident about" (Interview, 10/22/92). Fractions and decimals were two examples she gave of such topics. For this reason, I was interested in how Jackie would balance her commitment to follow students with her need to depend on the textbook as a mathematical guide during her instruction

on fractions. As it turned out, her dependence on the text was even more short-lived.

Her desire to construct lessons responsive to students drew her away from the text.

Fractions: Moving Away From the Text, Again

In April, I observed Jackie during the first 6 days of the unit on fractions. The pattern of her textbook use was surprisingly similar to the pattern I had seen in the fall. She began by selecting and altering activities from the margins of the teacher's guide, supplementing them with activities of her own design. She devoted a great deal of class time to the discussion that emerged from each task. Consequently, the class moved slowly through the beginning of the chapter, spending the first three lessons on the two-page spread designed to introduce the topic. Within a few lessons, Jackie had moved further away from the suggestions in the text, following her sense of where the students were going and what they needed to understand. By the 4th day of the unit, Jackie was constructing tasks entirely on her own. Table 4.3 displays what Jackie drew from the text for each of the fraction lessons; it shows a rapid move away from the text's suggestions.

The opening lesson on April 5th illustrates how she used activities constructed from the text's suggestions to serve as "jumping-off points." After discussing a set of questions on the meaning of fractions that she presented as an assessment, Jackie opened the textbook and proceeded with two introductory activities given in the margin. In the first, she introduced the health-and-fitness theme of the chapter. In the second, she asked students to think of fitness exercises they liked to do. As the teacher's guide suggested, she listed the exercises named by students on the board and then indicated the number of students who said they did them (20 swam, 18 played basket ball, 22 rode bikes, 8 jumped rope, and 15 ran). Once the class had listed five activities, Jackie suggested that they represent the amounts in fractions. Explaining that "fractions mean so many out of so many," Jackie introduced the term "denominator" as "the number of

Table 4.3

Summary of Jackie's Use of the Textbook: Spring 1993

| m Items constructed by Role of text during ts of teacher lesson e | Opening notebook Jackie read from questions margin of teacher's guide during most of lesson. | Follow-up questions Students followed involving finding along as Jackie read the discrete fractions; "Talk About It" notebook questions | Candy bar fraction Text was not present problem during lesson. | Central task: using Text was not present chips to show discrete during lesson. fractions; notebook questions | Central task: Compare Text was not present fractions using graph-during lesson. paper rectangles; notebook activities | Central task-Using Text was not present chips to show different during lesson. |
|---|--|---|--|--|---|--|
| Items used from supplemental parts of teacher's guide | | | | | | |
| Items used from margin of teacher's guide | Introduction to chapter theme and topic activities, p. 316 | "Think Ahead" activity, p. 317 | Notebook questions from "Connections" activity, p. 317 | | | |
| Items used on student pages | | "Talk About It" problem, p. 316 | | | | |
| Lesson topic | Introduction to fraction chapter | Fractions as part of a group | Comparing unit fractions | Fractions as part of a group (unit and non-unit fractions) | Comparing fractions with different denominators | Meaning of numerator and denominator |
| Date | 4/5 | 4/6 | 4/7 | 4/8 | 4/12 | 4/13 |

things it's divided into" and suggested that because there were 22 people in the class the denominator would be 22.

The task went smoothly until they tried to show that 22 of the 22 people rode bicycles. Students' confusion about how to interpret the numerator and denominator emerged when several students disagreed with the answer $\frac{22}{22}$. Jackie allowed the class to pursue at some length the question of what this fraction meant. Several students provided interpretations and, at Jackie's insistence, explained their reasoning to the class. Even though she played a central role in questioning students about their ideas, she did not acknowledge their suggestions as right or wrong. Without resolving the issue, she distributed graph paper and assigned students the task of drawing a picture that would show the number of students who jump rope for exercise.

The following day Jackie drew from page 317 of the textbook, companion to the page she had used the previous day. Again, she began with a task from the margin of the teacher's guide and allowed the remainder of the lesson to build on it. She started with the problem under the heading "Think Ahead" and then posed a series of similar problems she made up on the spot. Each of her follow-up questions involved finding a fraction of a group, such as $\frac{1}{3}$ out of 15. She ended the class by giving students four more problems to complete involving finding one sixth, one third, one ninth, and one half of 18. Most of the students answered these questions correctly.

The third day of the fraction unit was similar in that Jackie used a single idea in the teacher's guide to initiate a lesson of her creation. She began the lesson by having students respond to a set of questions in their notebooks that she had drawn from the margin of page 317 of the teacher's guide:

- 1. Are all fractional parts the same size?
- 2. What is the word name for 2/5.
- 3. Draw a picture to show 3/5.

- 4. Which is greater, 1/4 or 1/2?
- 5. Put in order from least to greatest: 1/2, 1/6, 1/3.

(HBJ, p. 317)

The class spent most of the lesson discussing the first five questions. Their answers revealed many areas of confusion about fractions, particularly about the meaning of the denominator and the relative sizes of fractions. Once Jackie managed to move the class to the final activity she had planned (using a Hershey bar to show various fractions), even more misconceptions surfaced. The students had trouble differentiating between a third and a fourth, since $\frac{1}{3}$ contained four pieces and was more than $\frac{1}{4}$, which contained only three. Only one student was able to show what one sixth of the candy bar looked like. Most insisted that $\frac{1}{6}$ was six pieces.

Jackie said that the lesson had revealed how little the class understood about fractions: "Yesterday, I thought they understood fractions and the denominator. But they had just figured out a pattern. That's all. Until they learn what a numerator and denominator are, they won't understand fractions" (Interview, 4/7/93). This concern seemed to underlie Jackie's choices for the next several lessons. Leaving the textbook completely, she constructed lessons that focused almost exclusively on the meaning of the numerator and denominator in discrete fractions. In each, she involved students in modeling fractions with chips or graph paper.

When I asked Jackie about these lessons, she explained that listening to students was making her aware of how much she had assumed they understood: "I figured a kid understood what a fourth was, but what they were understanding was a fourth only if something is divided into four equal pieces, without knowing that those pieces might still have parts of something in it" (Interview, 4/12/92). She explained that, because her students had primarily learned about fractions as pieces of whole things that they had difficulty extending their knowledge to include parts of groups. She gave this reason for creating lessons on discrete fractions. She said that she did not believe the book covered

them in the type of depth she had. Rather, she thought that it gave students a rule they could apply; it did not help them "understand" why $\frac{2}{3}$ of 24 is 16 (Interview, 4/12/93).

Managing the Tension Between Following Students and Following the Text

The shift that Jackie made in the spring lessons from drawing on suggestions in the textbook to drawing on personal resources to construct lessons appears similar to the shift she made in the fall. In both cases, she relied on the textbook to define the mathematical topic and to initiate their work, but she determined what students needed to learn within each topic and then invented her own tasks that responded to their interests and needs. Even though she anticipated that her limited knowledge of fractions would require that she rely on the text more during that unit, it was not the case. Jackie's tendency to move away from the text as she proceeded through a topic, even when she was initially unfamiliar with the content, illustrates how she managed the tension between her ideas about teaching math and those in the text. She chose to fashion her instruction around the students' thinking rather than the text.

Jackie's choice helps to explain why the HBJ textbook provided her with little day-to-day support. Given her commitment to following students, her case raises questions about how written curriculum materials can contribute to the continued learning of teachers in her position. Examining Jackie's teaching and patterns of interaction with the text can shed light on the type of resources she might find useful in a textbook. In the following section, I characterize Jackie's orientation to teaching and textbook use, and I describe how and when she used the text and to what ends. I then examine the impact of her orientation to using the HBJ text on her teaching and learning.

<u>Jackie's Orientation to Teaching and Textbook Use: Curriculum Improvisation</u>

The portrait just painted of Jackie's teaching illustrates her movement away from the text. In this section, I look in more detail at how and when she used the text. My analysis has been helped by Ben-Peretz's (1990) discussion of teacher-curriculum encounters. To a large extent, Jackie's encounters illustrate Ben-Peretz's characterization

of curriculum interpretation and reconstruction. Through these processes, she argued, teachers "read" the "curriculum potential" in written materials and transform them into actual learning experiences for students. The examples I use in characterizing Jackie's orientation to using her text are from lessons she taught over the year.

Despite the minor role the textbook played during the September 16th lesson, it contributed in two ways; it organized the math curriculum into topics that Jackie covered, and it offered the conceptual idea that she used to create the central task of the lesson. This was typical of Jackie's interaction with the text. Her tendency to use the book, not as a script or step-by-step guide but as a source of topics and ideas, illustrates her orientation to using such resources in mathematics instruction. She was an "improviser;" that is, she was not inclined to follow predetermined or generic protocols for lessons. Rather, she crafted lessons particular to the situation that started with a mathematical idea and were shaped by students' responses and input.⁷ Jackie's Starting Place: Underlying Ideas

Jackie's starting place for designing a lesson was a conceptual idea that she believed was important for her students to understand. She then selected or created tasks that followed the idea. She often drew these ideas from the text. For example, on September 16th, she was compelled by the relationships between the values of each place in the base-10 system represented in the text. The October 15th lesson illustrates an instance in which Jackie was compelled by an idea suggested by a student rather than the text. In both cases, the instructional tasks she created were born of mathematical ideas she believed were important for her students to understand. This approach is not

⁶The term "read" is taken from Ben-Peretz (1990) who talked of the different ways teachers read and interpret texts. In Chapter 6, I extend this notion of reading textbooks to include how teachers decide what suggestions to read and how to read them, in addition to the meanings. ⁷Yinger (1987, 1988) used the term "improvisation" to describe the best of what good teachers do. Others (Ball, 1993; Clark, 1988; Heaton, 1994; Huberman, 1993; Lampert, 1990) described teaching as an active process of listening to students, making the most of the unexpected, and reinventing one's curricular plans to navigate students' journeys through the content.

typical of many teachers, who tend to focus on tasks or activities in which goals or objectives are embedded (Borko & Niles, 1987).

<u>Curriculum Interpretation and Construction</u>

Jackie's tendency to create and select instructional tasks to further her mathematical goals illustrates one aspect of Ben-Peretz's (1990) view of curriculum interpretation that involves "reading" more in texts than the embodiment of the developers' intentions. She was often compelled by an idea underlying a task in the text but not by the task itself; thus she created her own tasks. On September 16th, for example, she created the place-value task involving base 10 blocks. She wanted students to understand the relationship between 1's, 10's, 100's, and 1000's but she did not believe the text's approach was sufficient:

[The book] gave some numbers like a thousand nine hundred and said show four ways of writing it. But I really felt that it was patterning, you know, they would just follow the pattern. I was hoping that they would start looking at it and thinking what a thousand is (Interview, 9/16/92).

On some occasions, Jackie drew actual tasks from the text but rarely from student pages. She usually found tasks in the margins or other sections in the teacher's guide that provided suggestions designed to supplement or complement the daily lessons. These tasks included nonroutine problems from the Problem-of-the -Day section and the conceptually oriented activities on pages found only in the teacher's guide. Jackie said that she liked these tasks because they challenged students. They "offer the kids problems that weren't just the common, everyday, where they [students] could just look at it and automatically figure out the answer" (Interview, 7/1/93). Tables 4.2 and 4.3 showed offerings in the text that Jackie tended to draw from, as well as the frequency with which she created her own activities. The tables revealed that, she only used student pages during two of the lessons I observed. In each case, the students used the text as a reference, not a source of exercises to complete.

When Jackie used tasks from the text, she used them in ways not intended by the text's developers. For example, the central tasks during the lessons on April 5th and 7th

were from the margin of the teacher's guide; both were offered as preliminary activities designed to be completed quickly prior to the main part of the lesson. Jackie, however, fashioned most of the lesson around each, using them to engage students in thinking about the meaning of fractions. She decided to use the tasks because she believed they would "make them [the students] think" (Interview, 4/7/93).

Jackie also drew ideas to visually represent concepts from the text. The base-10 blocks, place-value mats, and chips to represent discrete fractions were all used in the textbook. The place-value mats, for example, were used in an activity on one of the Link pages. When she saw them, they struck her as a useful way to illustrate regrouping while allowing students to make the exchanges: "I thought, it's much easier to have it where they can work on it; they just had it like this and I wanted it where they didn't just say the numbers; they could actually put things there" (Interview, 10/15/92). In using these mats, however, Jackie invented her own tasks rather than using those suggested in the text. This example illustrates how Jackie read the curriculum potential in the textbook's offerings and created instructional activities that transformed the written curriculum (Ben-Peretz, 1990).

<u>Curriculum Adaptation</u>

Another form of curriculum development central to Jackie's teaching was curriculum adaptation. Here, I am referring to the continual reshaping of her plans while implementing them.⁸ This type of <u>in-action</u> curriculum revision is not explicitly discussed by Ben-Peretz (1990). It is, however, consonant with her notion of teachers as curriculum developers who "reflect on their curriculum and reconstruct it" (p. xv). This description characterizes Jackie's interaction with her curricular plans regardless of their source. All of the tasks presented to her students, whether drawn directly from the text

⁸Curriculum adaptation is not unique to Jackie. Because of its inherent uncertainty (Jackson, 1986; Lortie, 1975), all teaching involves some degree of flexible adaptation of intended plans while they are being enacted in the classroom. The act of curriculum adaptation, however, is central to Jackie's ideas about good teaching, because they include being responsive to students. As Heaton's (1994) conceptualization of teaching as invention suggests, such a pedagogical stance becomes essential when the teacher makes responding to students central to her curriculum.

or constructed by her, underwent some adaptation or extension from their original design. Within each lesson, she frequently added questions or tasks in response to what she believed her students understood and where they needed to go. This type of improvising was most apparent in the way she structured discussions to focus on the students' ideas and solutions and in the follow-up questions she posed that built on what had already emerged.

Jackie's transformations illustrate how teaching that builds on students' ideas and responses is, in essence, ongoing invention (Heaton, 1994) because it calls for immediate construction and adaptation of curricular plans in response to students. For example, Jackie generally opened a class discussion by inviting a student to share a solution and then asked others to respond. Often, she did not know which solution the student would select, what types of ideas would be interjected into the conversation, or how others would respond. As the class pursued the child's solution, Jackie established the path the class would take by spontaneously deciding how to respond to these student-generated ideas.

An example of one of Jackie's spontaneous improvisations, inspired by her mathematical goals for her students, occurred when the class was discussing its solutions to one of the Problems of the Day. Before the actual mathematics lesson began on October 15th, Jackie gave her students the following problem to work on while she took roll:

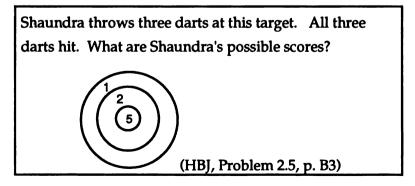


Figure 4.3 The October 15th problem of the day

After attending to several morning details and looking on as her students worked, Jackie turned her attention to math. She began with a discussion of this problem but not by asking students for their solutions. Instead, she posed a new question that took them beyond finding the possible solutions. She asked: "How do you know when you have them all?" In the discussion that followed, a few students tried to describe their strategies for systematically solving the problem, but few could articulate their approaches. Jackie repeatedly persisted with her question of how their approaches could help them decide whether they had them all. She later told me that her intent with this question was to encourage students to think strategically. Her observations of their work on the problem indicated that most had approached it haphazardly, often counting different permutations of the same three numbers as different combinations. She explained: "I'm hoping that they'll start seeing there are things that they can kind of build upon [when solving such a problem]. . . . Start by your own deciding how you want your pattern to work" (Interview, 10/15/92).

Jackie's spontaneous improvisations involved completely revising her original intent in response to what she learned from listening to her students. As she explained: "We went off on tangents all the time because of the questions or whatever the kids did" (Interview, 7/1/93). She followed the lead of her students on February 1st, when she gave the class a problem of the day that involved fractions. Jackie allowed the students to struggle together with the problem. In leading the discussion, she pursued ideas suggested by different students, interjecting her own questions from time-to-time. The discussion quickly moved away from directly solving the problem and focused more generally on fraction concepts; Jackie encouraged this exploration. Eventually, the discussion evolved into a comparison of thirds and halves, as the students tried to reconcile whether $\frac{1}{3}$ of 12 was more or less than $\frac{1}{2}$ of 6. Jackie followed the students' leads, pushing them to use what they already knew about fractions and to make drawings to help them make sense of new ideas.

Jackie also improvised during or after discussions by spontaneously inventing follow-up tasks to present to her students. The intent was to assess their understanding of a particular concept or to get them to look more closely at it. She did this on April 8th, at the end of a lesson on fractions focused on the meaning of the denominator. The lesson had produced more evidence for Jackie that students were still unsure about what the denominator indicated, particularly when the whole was a group. She, consequently, closed the lesson by asking students to complete the following sentence in their notebooks: "The bottom number of a fraction tells me ______"; she then drew a picture to explain.

Jackie's commitment to creating lessons responsive to her students and that helped them make mathematical connections often led her away from curricular plans outlined in the text. She recalled at the end of the year:

Sometimes when I was doing something and I just realized that the kids weren't getting it or they brought up some kind of question and it, the book, wasn't at that point.... and I felt that it was a good learning place. And so we spent some time with it" (Interview, 7/1/93).

As I described above, Jackie made spontaneous decisions during both sets of lessons I observed. In the fall, she changed her original plans when a student made an observation that provided a logical connection to the topic of the next chapter. Later in the year, Jackie dropped the plans she had made in the fraction chapter to address conceptual difficulties the students had with the previous lesson. These changes in course were motivated by what she believed students needed to understand and what she learned from listening to them during class. After the fraction lesson revealed students' difficulties, Jackie confessed: "I sure learned that I have to go back and do some things a lot more than I thought" (Interview, 4/8/93).

Jackie's tendency to look to her students and the mathematical ideas in deciding where to go next is reminiscent of Yinger's (1988) view of teaching as improvisation:

"The teacher is cast as an actor in a three-way conversation between teacher, students, and problems" (p. 86). The text contributed problems or mathematical ideas to this

conversation but did not steer or dominate it. As Jackie said, "It [the textbook] gave me the ideas. . . . Sometimes I came up with my own ideas, but a lot of times it was at least the jumping-off point and it did, at least, start me thinking" (Interview, 7/1/93).

<u>Jackie's Orientation To Textbook Use and Opportunities To Learn</u>

This examination of Jackie's teaching reveals two conflicts between what she brought to and expected from her textbook and what the book offered. Both involve contrasts between how Jackie used the text and how textbook use is imagined by developers and policy makers, and both influenced the extent to which the text could support her learning to teach mathematics for understanding. The first conflict was between her focus on ideas underlying the tasks in the text and the developers' primary vehicle for communicating its intent. As the analysis in Chapter Three suggests, the text's only method of communicating with those using it was through the instructional tasks it suggested. The second conflict emerged from her tendency to follow the lead of the students and, consequently, move away from the plan in the text. In both instances, Jackie's orientation towards the textbook allowed her to use the text in ways that ignored the developers' offerings.

From one perspective, Jackie's dismissal and revisions of the text's offering raise little concern. As Ben-Peretz (1990) described it, Jackie is fulfilling her role in the curriculum development process by transforming the written text into something beyond the developers' intentions. The tasks she created managed to stretch the offerings of the text beyond their initial capacity. This perspective, however, does not consider the text's role in this process Nor does it assume that texts might contribute to teachers' learning. The limited impact the text had on Jackie's teaching is more disconcerting for those looking to reform-oriented curriculum materials to stimulate change. Because Jackie drew on her own resources (mathematical and pedagogical knowledge) to construct tasks, any alternative used was restricted by the knowledge and vision brought to her teaching or developed through it. The content of the text had little

input. As a result, there were mathematical and pedagogical ideas in the HBJ text inspired by current reforms that Jackie missed. Following is a description of one of these missed opportunities.

Estimation: Missed Opportunity To Learn From the Text

By not using the tasks suggested in the text, Jackie missed an opportunity to reconsider the role of estimation in learning computation. Estimation has been included in mathematics textbooks for some time, but its role was minor. In general, it was taught after a given computational procedure as a set of steps that involved rounding numbers to the nearest 100 or 1,000 in order to compute with them quickly. Reform documents, such as the NCTM Standards, suggests a different view of estimation. Calling for increased emphasis on number sense and reasoning, reformers claim that estimation requires an understanding of the operation and number system to approximate a reasonable answer. In response, reform-oriented texts have made estimation more prominent. Developing appropriate estimation skills is one of the objectives stated in the HBJ text for 8 of the 13 chapters; in each case, at least one lesson is devoted to it. And, in most cases, the lesson comes before the actual algorithm is taught. For example, Lesson 2.3 in the chapter on addition and subtraction is devoted to estimating 3-digit sums and comes before the lesson on the steps of regrouping. The implication is that understanding the meaning of addition, developed through estimation, is an appropriate precursor to learning the actual addition algorithm. This, or any other rationale for the increased emphasis on estimation, is not given in the text. These ideas were suggested only through the tasks it gave teachers to use.

Following her own sense of how students should be introduced to 3-digit addition or subtraction, Jackie developed tasks that did not include estimation. Nor did she see it as a useful precursor to the topic. When I asked her about it, she said that she did not want to "confuse them" by introducing estimation before the students learned

the actual computational steps. She said: "I thought before they're ready to estimate, let's actually do some [addition]" (Interview, 10/22/92).

In this instance, Jackie's orientation to textbook use allowed her to ignore the text's efforts to present estimation as something other than an isolated skill used to check for computational accuracy. Her view of estimation as separate from computation was unaffected by the text: "They've been doing addition problems, and there was enough confusion. And I almost think that if I were then to jump over to estimating it would have just confused them. Sometimes adding one more thing just confuses them". (Interview, 10/22/92). Jackie saw estimation as an additional topic, not as an integral part of addition and subtraction. The HBJ text's only means of challenging this view was to provide estimation tasks for students to do. This, however, was not the idea that Jackie understood.

We cannot assume that, had Jackie followed the text's instructional suggestions, she would have seen the relationship between estimation and computation. However, we should not discount it as a possibility. In fact, the following analysis of Jackie's learning suggests that the events that provoked her to examine ideas more deeply and to see new mathematical connections were those that occurred within her teaching. As she attempted to develop students' understandings of various topics, she found herself seeing new connections. Thus, if Jackie had tried the estimation tasks at the beginning of the chapter, she may have found herself reconsidering the role of estimation.

Opportunities To Learn From Teaching

The HBJ text did not have a significant impact on Jackie's teaching, but she did not end the school year in the same place that she began. Over the year, she made mathematical and pedagogical gains that affected her teaching and influenced her relationship to the text. These instances of learning and their influences on her teaching can provide insights into the type of resources that might support her growth. In the following sections, I have tried to characterize this growth observed through her

teaching and conversations over the year. I use the word "try" because capturing and describing learning is an indistinct task. Even though Jackie seemed more conscious and open to her own learning than many adults, she found it difficult to articulate: "Sometimes it's hard to put your finger on it [what you have learned]. . . . or you may feel that it is so little that it doesn't count" (Interview, 10/15/92). As these descriptions suggest, even small and illusive, what Jackie learned through teaching had a substantial impact on her.

Seeing mathematical connections. The growth that Jackie experienced in her mathematical knowledge did not include acquiring a range of new concepts or procedures. Rather, it involved deepening her understanding of the mathematical ideas embedded in topics she had taught for years, seeing new connections. Russell et al. (1995) argued that recognizing this new learning about old content is an important part of extending one's definitions of learning mathematics in ways likely to have pedagogical impact. Their extended definition includes:

An ongoing and gradual process in which understanding of familiar content is deepened as one makes new connections and distinctions. A new representation of mathematical relationships may illuminate an aspect that was previously invisible even though that relationship was already known or understood. (p. 2)

In place-value and fractions, Jackie initially felt unsure about the central ideas. Her knowledge was not as procedural as the preservice teachers Ball (1990) studied, but was just as fragmented. Through the process of constructing and adapting her curriculum, Jackie's understanding of the mathematical ideas deepened and became more connected. As she struggled to create instructional tasks that engaged students in representing, exploring, and talking about mathematics, she developed her own sense of the key ideas and relationships students needed to understand. Through teaching, Jackie developed a primary component of pedagogical content knowledge (Shulman, 1986), an understanding of the subject matter that is integrally connected to how it might be taught.

At the beginning of the year, Jackie expressed concern about her own mathematical knowledge. Her readings of documents such as the NCTM Standards indicated to her that good mathematics teaching called for strong mathematical knowledge. She knew that she did not fit this description. "I agree that you really do need a good background," she told me during our first interview. "I have a pitiful background in math" (Interview, 9/11/92). She further explained that she had not realized how weak her mathematical background was until she had begun to reexamine her teaching. She wanted her students to understand mathematical ideas and their interrelationships and to use this knowledge to solve problems. Because this image of teaching was foreign to her experience, she had little to draw on in accomplishing this vision. As it turned out, Jackie's understanding of familiar and unfamiliar mathematical concepts deepened through her efforts to create learning opportunities for her students that focused on underlying meanings.

An early example of Jackie's learning about a familiar topic occurred during the place-value unit. She began the year believing that if she understood place-value and its role in column addition and subtraction. She described the time she devoted to it as "a good investment." If they understood it, "other things would come more easily" (Interview, 9/24/92). Despite her understanding of the relationship between them, she seemed to view place value and computation as two distinct topics, the first as a precursor to the latter. When contemplating a jump from place value to addition and subtraction, she said that she needed to "get off that topic for a while . . . but, somehow, come back to it later" (Interview, 9/24/92). Through selecting and designing tasks and listening to her students describe their understandings of the number system, Jackie began to see stronger connections between these two topics. A key turning point was Randy's description of the relationship between 24 thousands and 2 ten thousands and 4 thousands. She realized that the connection Randy was seeing was moving them into

regrouping. From this point, these topics became less distinct. In essence, their move into the next chapter was a way to continue working on place value.

Jackie began to see place value as a powerful idea underlying all computational processes. This understanding was evident in her response to my question about what she intended to pursue after column addition and subtraction:

I'm hoping that from there we could try making sense out of multiplication, which is funny because I never thought of what multiplication was too much until I started doing this. And I'm trying to think, well how am I going to make sense of this. (Interview, 10/30/92)

As I questioned her further, she described a new realization about multiplication problems such as 43 times 51. She had always taught her students to multiply 1 times 3 and then 1 times 4. Now, she realized that "it is really 1 times 40," and she wanted her students to understand this as well. "So they're actually seeing that it's not 1 times 4; it's 1 times 40" (Interview, 10/30/92).

Sometimes observing what her students did not do, rather than what they did do, prompted Jackie to recognize a mathematically significant idea that she had not considered; this occurred on October 15th as she watched her students work on the dart-board problem described earlier. Even the problem involved finding the possible scores one could get with three darts, Jackie started the class discussion with a new question: "How do you know you have them all?" She later explained that she had asked this question to push them to think logically and systematically about the actual question. However, it was not until she had observed her students' unsystematic and varied solutions that she realized the importance of such a question. "Some of them were not looking at all the possible solutions," she explained, "and others were looking at all the possible patterns. . . . at all the possible ways of combinations" (Interview, 10/15/92). Jackie showed me that several students had written down the following permutations as three different possibilities: 5-5-2, 5-2-5, and 2-5-5. When she saw these solutions, she realized that it was important to consider whether these "would be the same solution or would they be three different solutions to the same problem"

(Interview, 10/15/92). Thus, she constructed a question that she believed might help them "see that the order didn't make a difference" (Interview, 10/15/92). Jackie had not selected this problem to address this idea. It was a problem of the day that had caught her eye because it had more than one solution and because "they would have to think a little bit more" in order to solve it (Interview, 10/15/92). In other words, it was through helping her students make sense of the problem that she began to consider the mathematical complexity embedded in it.

Jackie also learned from teaching unfamiliar topics. Early in the fraction unit she shared concern about her knowledge of fractions and whether she was addressing the important ideas: "This year it's kind of like I'm learning right along with them what is important. I think they are getting some really big ideas here, but am I touching on all the big ideas?" (Interview, 4/7/93). Exploring the topic with her students led Jackie to look deeper into the concepts underlying the rules that she believed she understood. It was as though she was seeing relationships in new ways:

Things are dawning on me. "Oh my god, that's what this all is!"... never thought that... one half was the same as five tenths. I mean, I did equivalent fractions because I had to, but I don't think it really dawned on my mind what that meant... It's actually making more sense. I am starting to see why I did the things... I didn't necessarily think it was important to do all this. If you learned the rules and can do it, that was fine... [Now] I definitely disagree with it. I think the more they make sense out of it, 'cause then they can go on and do tougher things on their own. (Interview, 4/7/93)

Similar to the other instances of learning, Jackie came to understand the meaning of equivalent fractions through attempts to help students explore them; the opposite was true as well. As Jackie's understanding of the mathematical ideas she was teaching deepened, her ideas about teaching and her sense of self as a teacher also grew.

Gaining pedagogical confidence. Jackie's increased understanding of these topics influenced her ideas about teaching and tended to boost her confidence in her pedagogical abilities. These changes mitigated her trust in the authority of the text,

leaving her to draw on herself more and the text less. This was first evident in the fall when Jackie dropped any doubts she had about skipping items in the text.

Initially, Jackie hoped that the textbook might effect change in the way mathematics was taught in the district or, at the very least, assist her in teaching mathematics for understanding; this did not happen. Early on, she realized that she could not pursue each topic in the text at the depth she believed was appropriate. By the middle of October, she had developed skepticism about the developers commitment to the goals of student thinking and understanding. These concerns were triggered by the amount of content in the text. As she confronted the need to skip more and more suggestions, she began to question the extent to which real understanding could be achieved while covering the many topics in the text:

If they really want understanding, then they're really asking too much. . . . It's a question of we can teach all those things they want, but if you really want them to understand it. . . . I couldn't even cover the old book back when we did it the old way where you taught the lesson and they did X amount of practice pages and taught the next thing. . . . I certainly am not gonna get through a book if I'm teaching for understanding. There's no way if they're really going to interact with each other and learn from each other. There's no way we could get through that much. (Interview, 10/15/92)

Jackie's increasing pedagogical confidence gave her ground on which to assess the text.

At this point, however, she still believed that skipping textbook suggestions was a risky path. Her limited knowledge of upper-level mathematics disadvantaged her in making wise decisions about what was essential and what could be eliminated: "I never took trig. . . . and calculus, I mean I have no idea at all what calculus is. . . . I'm not a strong mathematician" (Interview, 10/15/92). Thus, she considered skipping "a big risk" primarily because she believed she might inadvertently eliminate a "critical piece" of the curriculum, something that might "help them later with algebra or geometry" (Interview, 10/15/92).

Up to this point, Jackie had expressed trust in those responsible for the text to guide her through the fourth-grade curriculum. However, as she examined the contents of the text to pare the offerings down, doubts about their intentions emerged:

Here are these people who really know math," she commented, referring to the authors pictured in the textbook with PhDs after their names, "and here they are saying these are important things to know. And I'm saying, well I really don't think this is so important.... A lot of times I think they write a lot of things in here just to try and cover and please everybody, whether it's important or not" (Interview, 10/15/92).

Jackie's diminishing faith in the text also was fueled by her developing understanding of the mathematical ideas described above. As she began to believe that the tasks she was designing actually engaged students in productive ways of thinking, she began to develop more faith in her choices. For example, when I asked her about her decision in October to move into column addition and subtraction after less than half of the place-value chapter, Jackie explained that the direction they were headed made sense to her: "When I realized that that's the direction we were going, I decided that I would work a little on [it]" (Interview, 10/22/92). On October 30th, after observing that the third lesson in 3 weeks was constructed entirely by Jackie, I asked her if what she was doing fit with what was in the textbook. Her response illustrates the confidence in the choices she had made: "Well, if it does, I don't know that. 'Cause, I just kind of had in my mind how I wanted to do this math and go with the manipulatives. . . . I just haven't bothered to look at it" (Interview, 10/30/92). Over a 6 week period, the uncertainty that Jackie felt about her choices to omit various subjects in the textbook and select others was replaced by confidence in her capacity to make appropriate selections and to create worthwhile lessons.

As Jackie began the fraction unit in the spring, some of the uncertainty about making appropriate decisions resurfaced, but only briefly. Early in the unit she told me that she was learning right along with the students, and she confessed that she was not sure what the "big ideas" for fractions were (Interview, 4/7/93). She drew tasks from the margins of the teacher's guide to shape the first few lessons. However, as she

focused on helping her students "make sense" of the meaning of fractions, her sense of the big ideas began to take shape. This focus guided her in creating tasks to help students confront them. For example, she believed that the book presented fractions narrowly: "They look at a fraction in only one way. . . . For instance, here [pointing to a diagram on page 321], this is two sixths and that's all they want. I'm hoping that they [the students] will also see that that could be one third. I am wanting them to get beyond that fractions aren't just necessarily written one way" (Interview, 4/7/93). This goal, which Jackie was unable to articulate before she began teaching the unit, seems related to her deepening understanding of the meaning of equivalent fractions.

By the second week of working on fractions and after several lessons that revealed students' misconceptions, she had developed clear ideas about what they needed to understand and what was difficult for them. At the top of her list was understanding the significance of the numerator and denominator: "They really need to understand what a denominator means and the numerator" (Interview, 4/12/93). The lessons she constructed focused on this concept and were not inspired by the text.

As Jackie watched her students "make sense" of the meaning of fractions, she found that the pedagogical approaches suggested in the text did not compliment her goals. For example, she was critical of the book's tendency to give the students rules. "One of the things I'm trying to do more and more. . . . is have them come up with the rules" (Interview 4/7/93). Thus, instead of following suggestions in the text, Jackie gave students problems she believed would illustrate these rules and then used whole-class discussions to explore them more fully.

By the end of the school year, Jackie no longer had doubts about veering too far from the text and omitting important ideas. Reflecting on her use of the textbook over the year, she laughingly confessed: "Whenever I didn't feel that it was doing what I wanted to do, I did my own thing" (Interview, 7/1/93). The confidence that she had developed pushed the text further away from her, limiting what it was able to offer.

Orientation of the Text and Opportunities for Jackie to Learn

Even though the text was a limited resource in Jackie's learning, it did not limit what she was able to learn from her teaching. Jackie learned through the processes of constructing and adapting curriculum ideas, not from following them in the text. She drew on the HBJ text to guide particular aspects of her teaching. By creating or recreating tasks from the text or her own ideas, Jackie engaged the text in a level of conversation that it was unable to return. As discussed in Chapter Three, the HBJ textbook communicated with teachers through the tasks offered. The text did not talk to them about these tasks or the ideas underlying them. Jackie's attention to the ideas she saw underlying the tasks allowed her to use the text while not engaging its central vehicle for communicating with teachers.

This examination of Jackie's teaching illustrates how her ideas about teaching shaped her use of the HBJ textbook and its consequent impact. Still there were other contributing factors. A look at the context in which Jackie taught reveals a number of circumstances that contributed to her beliefs and allowed them to play a prominent role in her teaching. The following section examines the impact of two uncommon features of the context in that she taught which provided opportunities for collegial interaction about her teaching and curricular flexibility; both enabled her to follow her mathematical ideas rather than the text.

Other Influential Factors: A Context of Support

While typical in many ways, Jackie's school had one less-common feature that significantly contributed to her growth even before she began using the HBJ textbook. As a PDS, Kipling offered teachers a range of opportunities to pursue their own development and to experiment with innovative practices. Jackie enthusiastically took advantage of several opportunities. Two PDS activities, in particular, influenced the way she used the textbook: (a) involvement in the math study group, which created a structure for collegial support, and (b) experimentation with teaching students for 3

years, which offered greater flexibility in how she addressed various pieces of the curriculum.

Collegial Support

Jackie's involvement in the biweekly math study group provided her with an opportunity rare in the work lives of most elementary teachers, that is, an opportunity to talk with other teachers about their teaching. During these regular meetings, the group discussed and reflected on struggles and successes they had in their classrooms, exchanged ideas, and shared with one another small or large instances of growth. For Jackie, these meetings provided a vital form of support already in place when this study began:

I think that having meetings and things with each other to talk about math and what we need in different ways [were] very supportive. I feel like talking with [the participants in the study group] was very helpful. It was encouraging me and rewarding me for trying something different. And I think those are the kinds of things that people need. They have to have that. (Interview, 7/1/93)

For Jackie, this collegial interaction and opportunity to work with university educators countered the isolation and lack of support that she felt when trying new approaches.

Curricular Flexibility

Another difference in Jackie's teaching situation that had an unexpected impact on her mathematics instruction was that she had this particular group of students from third through fifth grade. The purpose of the project was to experiment with creating a learning community that lasted over several years. Jackie found it to have other, unanticipated effects. It freed her from one of the most overwhelming pressures she felt as a teacher, that is, the pressure to "cover the curriculum" in a single school year.

In the past, Jackie found that she was always conscious of her obligation to prepare students to meet the expectations of their next teachers: "The teacher that they're getting the following year is going to expect them to have certain things that they've already mastered" (Interview, 7/1/93). Thus, she believed she had to address all topics, which allowed little time to dig deeply into any. This year, knowing that she

would have the same students next year, gave her a level of curricular flexibility that she had not experienced. As she explained: "Knowing I'm having them for a longer period, I can spend more time and get more kids to really figure out what they're doing" (Interview, 7/1/93). It also allowed her to organize the curriculum over a 3-year, rather than a 1-year, period.

Jackie cited the concentrated work on place value and basic operations as well as the extensive work on fractions, as specific examples of how this freedom impacted the decisions she made. She was committed to developing students' understandings these topics, but she admitted that she would have spent less time on them if she had felt pressure to prepare students to meet expectations of their fifth-grade teachers. "I couldn't have," she speculated. "I would have had to make sure that they had had more on decimals. I would have had to make sure they had more on geometry. Yeah, I think that really has made a big difference in being able to make some of those decisions" (Interview, 7/1/93). Jackie explained that she was planning to concentrate more heavily the following year on topics that received less attention this year.

Learning To Improvise and the Role of the Textbook: Issues Raised by Jackie's Case

Jackie is a teacher whose efforts to teach mathematics for understanding drew her from the HBJ textbook. Her case illustrates a version of teaching and change that involved a recursive relationship between the processes of curriculum construction and the development of knowledge for teaching (Heaton, 1995). Her commitment to developing students' understandings led her to construct classroom events that facilitated the type of exploration and talk she believed necessary. The process of constructing and adapting these events led her to examine mathematical ideas and students' understandings more carefully, adding depth to her ideas about teaching and, in turn, influencing her pedagogical choices. The HBJ text offered representations and student tasks that Jackie could draw from, but it had a minimal impact on her teaching or learning.

Jackie's case raises two questions about the role of curriculum materials in reform in mathematics education. The first question examines the nature of textbooks, that is, what they offer and the way they interact with teachers as readers. It asks what a textbook would need to look and be like in order to connect with a teachers such as Jackie in order to contribute substantially to her teaching. The second question involves the nature of the pedagogy implicit in the reforms and the extent to which any text is likely to provide support for such teaching. It asks what a text is unable to do. The current reform-related emphasis on mathematics instruction that makes student thinking central necessarily assumes the type of improvising and adaptation that permeated Jackie's teaching. How can a textbook guide teachers in such improvisations? As Jackie wondered, "A textbook could never sit there and know for sure what questions kids are going to ask. . . . That's something I don't know that any textbook could ever do" (Interview, 7/1/93).

CHAPTER FIVE

HELPING STUDENTS BE SUCCESSFUL: THE CASE OF CATHERINE MCKEEN

Catherine McKeen was typical of many elementary teachers and potential textbook users today. As an experienced teacher, she had well-developed and fairly conventional ideas about what learning math included. Computational mastery was at the core of her instructional goals; careful guidance and repeated practice defined the route through which it was to be attained. At the same time, Catherine had received the message that there was more to learning math than computation. That is, students needed to learn to think and to apply computational knowledge in a range of different problem-solving situations. She found many of the ideas compelling, and she wanted to incorporate them into her teaching, but not at any expense. Her hope was to attend to the reform agenda without abandoning her commitment to helping students obtain success through computational mastery. Like many teachers in this position, she saw the new textbook as a likely tool to help her do so.

This process of implementation did not go as smoothly as Catherine had anticipated. Almost immediately she found that following suggestions in the text threatened her effort to ensure her students' success, raising doubts for her about the appropriateness of some reform ideas. Responding to her students' difficulties, however, presented her with a different perspective on these tasks and her students' work on them. Her experience provides a useful site to explore the role of students in a teacher's interaction with a reform-oriented textbook. After introducing Catherine and what she brought to her use of the textbook, I proceed with the story of Catherine's first year of using the text.

Introduction to Catherine

Catherine McKeen was raised in the Mapleton area and began teaching at the age of 22, immediately after graduating from the nearby university. She had taught in the Mapleton district throughout the 31 years of her teaching career and had been at McKinley Elementary School for 24 years when this study began. She has taught third-, fourth-, and fifth-grade classes. After spending the last several years with fourth-grade students, she found it to be an age group with which she felt comfortable. There was much about the students that she enjoyed and that confirmed what she remembered from her own experience with mathematics. I describe Catherine's accounts of these experiences and the ideas that grew out of them below.

Catherine's Experiences With Mathematics

Catherine brought to her use of the HBJ textbook definite ideas about the substance and nature of mathematics, how it is taught, and how it is learned. These ideas developed through her experiences with mathematics as a learner and as a teacher. The following experiences have impacted her and have played a role in shaping her ideas about teaching and learning mathematics.

<u>Catherine's Experiences as a Learner of Mathematics</u>

Catherine's experiences as a student were similar to those of many women who are elementary teachers (Ball, 1988, 1989; Remillard, 1993). For the most part, her mathematics classes left her feeling discouraged and incompetent. Her interpretation of these experiences, however, is less common. She attributed them to inappropriate teaching rather than to her lack of ability: "It almost seemed, like when I was growing up, you learned the math by yourself. It was introduced and you learned it" (Interview, 11/19/92). Learning math by herself meant struggling to figure things out on her own rather than being taught how to do them. Consequently, she remembers frequently feeling frustrated and seldom successful.

She recalled one instance that made her feel successful. She learned her multiplication tables and did not need to make marks on her paper in order to perform computational tasks: "It was a real relief," she recalled, "to be able to do it without having to make marks" (Interview, 11/19/92). Other than this instance, she could not recall feeling successful or like she really understood what she was doing. Even though she took math through high school and managed to learn what she needed to pass each course, this was all she felt she learned: "As far as learning how to do the problem, you know, I could do that. But give me a story problem that involved more than one step . . . it was just that I didn't have the skills to solve them" (interview, 11/19/92).

Catherine's experiences as a student of mathematics influenced her ideas about teaching it. She believed that people who are good at math are not necessarily good math teachers because they "don't understand the child that needs to be taught" (Interview, 11/19/92). As an "average math student" herself, she claimed that she had been one of those children.

Catherine's Experience as a Teacher of Mathematics

Catherine's experience teaching mathematics confirmed this hunch. Because she was an average student, she believed that she understood the needs of the average student. As a teacher, she concentrated on providing the instruction that these students needed in order to be successful. She found that she was able to help many of her students gain the computational proficiency necessary to achieve that feeling of success. For this reason, mathematics was her favorite subject to teach: "I love to teach it because . . . it's something that they see as concrete, and there's a right and wrong answer, and they feel more growth in math than they do in, say, reading" (Interview, 11/19/92).

Catherine also felt that her understanding of mathematics had grown through teaching it: "The things in math are a lot more clear to me the longer I teach than they were when I first started teaching." She believed that, through years of teaching, she had matured and gained experience that broadened her understanding of mathematics and

students' learning. In particular, working with children helped her to determine "where they are going to have problems" and what types of mistakes they are likely to make: "I think it's not only the children that as they mature they understand more; I think that is true for the teachers, too" (Interview, 12/19/92).

Catherine's Experience With Current Reforms in Mathematics Education

Over the last few years, Catherine noticed that problem solving and application of computational skills were receiving greater attention in mathematics, while age-old maxims were being challenged. The increased availability of calculators, for example, was bringing into question the need for primary emphasis on computational skills.

Catherine learned about these changes through a number of channels and, for the most part, she believed that she was responding to them. The increased emphasis on problem solving, for example, was brought to her attention several years earlier through the 1983 edition of the Addison-Wesley textbook, which was used in the district between the mid 1980s and 1992. This text placed some emphasis on problem solving, providing various strategies to employ and a checklist of steps to follow when solving problems. Catherine incorporated these strategies and steps into a bulletin board display in her classroom, which she has continued each year. Communications within the district and state about policies and assessment also placed emphasis on the application of mathematical skills. Not only had the district recently purchased a set of calculators for each classroom, but changes in state-level curriculum and testing placed increased emphasis on the application of skills and the use of calculators as tools.

Catherine also learned about changed emphases in mathematics education through conversations with colleagues. One of the fifth-grade teachers in the school, who was president of the district math committee, played a role in communicating district- and state-level concerns to other teachers. As a result, Catherine explained, she heard a lot about undertakings and concerns in the district through lunchroom

conversations. Thus, Catherine believed that she had been aware of some of the ways mathematics was changing before she encountered the new textbook.

When the district prepared to adopt a new elementary mathematics textbook, Catherine found herself confronting many of the ideas of the current reforms in mathematics education directly. During the 1991-92 school year, she agreed to pilot two of the four textbooks being considered for adoption by the district. As a pilot teacher, she attended Math Committee meetings during which the strengths and weaknesses of the different texts and the goals of the district were discussed. Catherine could not say exactly what the goals of the district were, but it was evident that one expectation was that the textbook selected should reflect emphases that were part of national reforms. As Catherine described it, they wanted a text that could "meet the criteria of the new math" (Interview, 11/9/92).

Catherine's School Context

McKinley Elementary School was an average to small elementary school in the Mapleton School District, with two classes for each grade at the upper elementary level. Interactions among teachers seemed to occur by chance rather than by design. According to Catherine, most of the substantial interactions with her colleagues occurred during lunch and at monthly faculty meetings. The updates on the district math committee's work, passed on by her colleague, Joyce, comprised the extent of her interactions about math. Even though the two fifth-grade teachers in the school worked closely, exchanging students for math and reading and sharing ideas, this seemed to be the exception rather than the rule. Catherine rarely spoke about the other fourth-grade teacher, and she claimed to know little about her colleagues' mathematics instruction. Conversations about teaching did not seem to be a part of the McKinley culture.

The experiences described above helped to shape the personal resources that Catherine brought to her use of the text. As with Jackie, these resources take the form of mathematical and pedagogical knowledge and understandings, ideas, beliefs, personal

theories, and commitments. The following descriptions characterize resources that figured in her interactions with the HBJ text.

What Catherine Brought to her Teaching of Mathematics

The categories used to organize the personal resources that Catherine brought to her math teaching are taken, to a large extent, from Schwab's (1978) notion of curricular commonplaces, which include subject matter, teaching, learners, and context (in which the context considered is the reform context). These, he argued, are the necessary areas to be considered by developers in "making a defensible curriculum" (p. 368). These categories also reflect Shulman's (1987) conceptualization of pedagogical content knowledge in that the content of the learning and teaching categories is tightly intertwined and is specific to the subject matter. Catherine's ideas about student learning and her role as teacher also reflected Grimmett and MacKinnen's (1992) conceptualization of pedagogical learner knowledge, because her pedagogical perspectives were so connected to her ideas about learners and how to "deal rigorously and supportively" (p. 287) with them. As the following descriptions reveal, Catherine's ideas about learners and learning framed her perspective on teaching, as well as her response to the HBJ text.

Catherine's central goal in teaching mathematics was for her students to feel and be "successful." She wanted them to make specific and measurable gains in learning math that they could build on and apply. She wanted them to feel good about learning so that they would want to learn more. She wanted them to be successful in other domains that might require mathematical skills. These desires, and her ideas about what students needed to achieve success in mathematics, were predicated on the following ideas and understandings that she brought to her teaching.

Catherine's Ideas About Mathematics

Catherine viewed mathematics as composed of a list of discrete topics that matched the titles of the chapters in the textbook. Each topic fit into one of two

categories: computational and other noncomputational topics. The computational topics, which were essentially the four basic operations, she called "processes." These processes, she believed, were at the heart of mathematics. What she referred to as "other skills" were the subjects of the noncomputational chapters in the textbook, such as fractions, time, measurement, geometry, and place value. These skills, she believed, provided contexts for the processes to be applied and tended to be more interesting to students. However, they "were awfully easy to just kind of ignore when you were just doing computation kinds of things" (Interview, 11/19/92). In fact, it was Catherine's opinion that, until recently, these topics had been ignored in elementary math: "In the past, it's been mostly a computation kind of math where, you know, you just worked on computation," she explained. "[Now], they're stressing so much problem solving and the different skills" (Interview 11/9/92). In response, Catherine began to emphasize these skills more in her teaching.

Still, she differentiated between computational processes and the other topics by the expectations she had for her students' learning of them. She believed that students should learn about each topic in the textbook, computation had priority. Learning these processes "sets the foundation for any higher math" (Interview, 12/17/92). Thus, the four processes needed to be "mastered" whereas the other topics were "talked about each year and eventually they may just sink in as the maturity level hits" (Interview, 12/17/92).

Catherine also had strong views about the nature of mathematics. She saw mathematics as concrete, factual, and procedural, consisting of correct steps and having unequivocally right answers. As a learner, she found it reassuring when she made tangible steps in learning facts or procedures because this progress was visible. These characteristics made teaching mathematics appealing.

¹The terms "processes" and "skills" are Catherine's. She consistently used them to describe the way she classified the curriculum. Her use of the term "processes" refers to what many would call computational skills. At the same time, many of the items under her category, "skills" (the noncomputational items in the curriculum) are sometimes referred to as processes.

Catherine's Ideas About Students' Learning of Math

Catherine also brought views about students and learning to her teaching in the form of assumptions about the learning process. Many of these views were interwoven with her ideas about the substance and nature of mathematics. For instance, because the most important things for students to learn were computational processes, Catherine viewed learning as a process of being shown what to do and then practicing specific procedural steps. Consequently, as my descriptions of her teaching illustrate, she built heavy doses of practice into lessons on computation as well as noncomputational topics.

Catherine also held particular conceptions of students that influenced their learning. She believed that students needed to feel successful in math in order to be interested in continuing to learn. She recalled feeling discouraged when she was not successful in math. In her teaching, she noticed that students were encouraged when they made visible progress in learning. She also observed that being overly challenged without clear evidence that they were making progress discouraged them. She worried, for example, about students like Justin, who seemed unable to memorize the multiplication tables: "He's a positive child," she told me, "but I could see, as the years went on, that probably he would get very, very discouraged" (Interview, 11/19/92). This concern led her to give him a multiplication grid to keep on his desk and to use as a reference: "At least he feels some success instead of zero success," she explained.

Because she believed that students' feelings of success impacted their motivation to learn mathematics, Catherine preferred to give them tasks that they could accomplish without becoming discouraged along the way. She believed that arithmetic facts and computational procedures were safe bets because learning them involved a level of thinking the students had at their disposal. She was cautious about presenting students with tasks that they were not "ready" to do to avoid discouraging them.

Catherine's idea that what students are able to learn was determined, in part, by their readiness was another stance that Catherine brought to her mathematics teaching.

Even though she never described it as such, it seemed grounded in developmental theory. In other words, she believed that students' development or maturity played a role in their abilities to learn particular things. Thus, she was not concerned that some of her students could perform the steps in multiplication but did not understand them: "I think, sometimes, that comes with maturity, you know. Some of them are not gonna understand it in the fourth grade" (Interview, 11/19/92). Consequently, she worried that the new emphases in mathematics were expecting students to accomplish tasks that they were not developmentally ready to do. The complex problem-solving and thinking questions were likely to challenge students beyond a comfortable level, placing their feelings of success at risk: "I think it's good to problem solve, but I also think that sometimes, at this level, they're just, maturity-wise, they're not ready for that, and they can become very, very discouraged if they don't also learn to do some computation" (Interview, 11/9/92).

Catherine's Ideas About Teaching

The ideas about teaching and the teacher's role that Catherine brought to her use of the textbook were closely related to her ideas about students and their learning. She believed that the teacher's role was to "teach" rather than to leave students to figure problems out alone. This conviction corresponded with her view that students learn from being told or shown, and it stems from her belief that she was never "taught." It also fit with the value she placed on learning computational processes, since they lend themselves to showing procedural steps. During our early conversations, Catherine often recalled her experiences as a student of mathematics to support her views on teaching. After explaining that she never felt as if she had been taught and describing the frustration that accompanied this feeling, she said, "I would like them [her students] to be able to feel like they had been taught, you know, instead of just being introduced and then you just kind of struggle through it on your own" (Interview, 11/19/92).

For Catherine, teaching involved "showing them how to do something" and carefully examining their work to determine "exactly what they've done wrong" (Interview, 11/19/92). This type of teaching, she believed, required the willingness to go over the material until the students understood. Given all the topics that had been added to the mathematics curriculum in recent years, Catherine believed that many teachers felt pressure to advance to the next topic before students were ready.

Catherine's Views of the Reforms in Mathematics Education and the HBJ Textbook

Catherine saw the reforms as additive rather than transformative. That is, she believed they were attempts to add tools and topics such as calculators, problem solving, and manipulatives to mathematics instruction and the curriculum rather than to propose a fundamental revision in how mathematics was taught or viewed. She frequently used the phrase "the new math" or "the new definition of math" to refer to national and state efforts to reform mathematics instruction. The main message of these efforts was "that children should be able to problem solve in math! (Interview, 11/9/92), but they also included increasing emphasis on the noncomputational topics in the textbook.

In general, Catherine was not opposed to these topics receiving greater emphasis. She acknowledged that students needed to learn how to solve problems, to apply their computational skills, and to use artifacts of modern technology such as calculators. In fact, she felt these ideas were reminiscent of goals that had always been valued:

I think that the emphasis on problems solving, which involves more thinking, has been within the last few years. But I think we always had the feeling that they should be able to apply what they knew, which involved more thinking. I think that's always been one of the things. . . But I think that suddenly the textbooks and the people that are writing the math curriculum, whoever those people are, have suddenly decided that we really need to work on that. (Interview, 12/17/92)

She seemed to be convinced that making problem-solving and other thinking-oriented topics part of the explicit curriculum could help children by increasing their understanding: "I think math is easier if you really understand what we're talking about" (Interview, 11/19/92).

Catherine also recognized that the use of manipulatives in instruction was a fundamental part of the proposed changes. This was one aspect of the reforms she admitted that she had not embraced. When I first talked to her, she had not used any of the manipulative suggestions in the text: "I'm not used to working with manipulatives," she explained, "and to be perfectly honest, I need to stop and go through what I have in manipulatives" (Interview, 11/9/92). Catherine also believed that the role of manipulatives, like training wheels, was to support temporarily students' understandings during the learning process. Thus, she only saw them as necessary when students were having difficulty grasping particular ideas. On several occasions, she explained that she did not "need" to use the manipulatives suggested in the text because "they [the students] understood it" without them (Interview, 11/9/92).

Catherine had two main concerns about how the new ideas in mathematics were represented and taught. The first concern was that the increased emphasis and time allotted to noncomputational topics was "at the cost of computation." She believed that many interpreted the changes in mathematics education as an attempt to eliminate computation: "In the new definition of math, a lot of people think they don't need to know their facts" (Interview, 11/9/92). This view was not hers nor that of many of her colleagues at McKinley. She believed students did need to memorize addition and multiplication facts, and they did need to learn to perform the four basic processes or operations. Speaking for herself and her colleagues, she explained: "We'll do more problem solving and everything like that, but we feel they do need to know their multiplication tables" (Interview, 11/19/92).

Catherine was also concerned that the new ideas in mathematics did not necessarily consider what students were ready to do:

I just think that someone, someplace, came up with this new definition of math, and they're making all these decisions about what children should be able to do. And I think they've always done that, you know. I mean, any textbook will say in fourth grade you should be able to do this and, and sometimes the children just aren't ready. (Interview, 11/9/92)

She believed that some of the nonroutine, multistep problems were examples of these, as well as other questions on the student pages that asked them to generalize beyond what they had been taught rather than to practice it.

Of the four textbooks piloted by the district, Catherine believed that HBJ had been the best choice. While not being too extreme (like one text), it represented a notable change from the old text. She admitted that she had not been dissatisfied with the old Addison-Wesley textbook. She also liked the new edition of the Addison-Wesley textbook but realized that it did not have the potential to facilitate change in the way the HBJ text did, which is why she voted for HBJ: "I liked Addison-Wesley; I felt very comfortable with Addison-Wesley because it was so much like the old one. And I thought that's not, I guess that wasn't what we really needed if we were trying to change" (Interview, 11/19/92).

Other than the emphasis on manipulatives and the tendency to ask too much of students, there was little about the HBJ textbook that Catherine found unsettling; much of it seemed familiar: "It kind of goes through things just the way the other book does. It covers the same things" (Interview, 11/9/92). It also had much to recommend it. She was particularly impressed with the "Problem-of-the-Day" section, as well as the general emphasis on problem solving woven throughout the lessons.

There's a lot of problem solving in here. . . . I think they present it quite nicely. I think that they present it in an interesting way to the children. Like, I don't remember ever seeing any tallying like, say, on this page in the other textbooks. . . . They have them answer questions about, about what they see, it isn't just how many. . . . They don't just teach them how to tally, they ask them questions where they have to use some thinking, some problem solving. (Interview, 11/9/92)

At the same time, she did not believe that computation was being compromised. "This book isn't asking us not to teach computation, you know. . . I like this book because of that [it teaches both computation and problem solving]" (Interview, 11/19/92).

Catherine and the HBJ Textbook: A Gradual Journey Through New Terrain

Catherine's view that the HBJ textbook valued the ideas of the reform without throwing out what had always been central to math figured powerfully in how she used it. From the beginning of the year, she structured her practice to incorporate new ideas in the text without sacrificing others. This involved adopting certain elements of the text when she believed them to be reform-inspired; it involved relying more heavily on her own resources in areas she believed the reforms didn't speak to. Initially this structure enabled her to embrace the text and the reforms without substantially challenging her ideas about teaching or learning mathematics. It was not long however, before Catherine encountered conflicts between the ideas in the text she was trying to implement and what she believed to be good practice.

Embracing the New While Maintaining the Old

When I first spoke to Catherine, she had been using the HBJ textbook for approximately 7 weeks. She claimed that she liked most aspects of the book and gave the impression that she had fit it comfortably into her teaching. She told me that, even though she had not always relied heavily on a textbook, she believed that it was important to give this new book a try. She later explained: "I want to do it with the book mostly this year and then, I think, then I'll have a better idea of what's gonna work" (Interview, 11/9/92).

During the six-week period in the fall that I observed and interviewed Catherine, I learned that what she meant by "do it with the book" differed according to the topic taught. Her mathematics instruction had three distinct layers (computation, non-computational topics, and problem solving), each of which was open to revision to a different degree. Consequently, each layer was influenced by the text differently. In the descriptions that follow, I provide a glimpse of how Catherine integrated the HBJ text into each layer of her teaching and of the conflicts that arose as a result. First, I describe the components of the text she used; then I discuss, in greater detail, how she used them.

Teaching Computation and Noncomputational Skills

My first observation of Catherine's mathematics teaching and the conversation that followed illuminated the distinction she made between computational processes and noncomputational skills, as well as the role this distinction played in her use of the textbook. During that November 5th lesson, Catherine closed the class' work on the first chapter on place value by reviewing the answers to a test the students had taken earlier that week. She then skipped the next two chapters on addition and subtraction and multiplication and advanced to the first lesson in Chapter 4 on Time, Graphing, and Data. Catherine later explained that the jump from the first to fourth chapter was part of her strategy for giving the other topics emphasized in the reform movement appropriate attention. In the past, she tended to spend more time on computation, leaving little time to devote to other skills. This particular year she was trying to devote more time to the noncomputational chapters in the text. She made the time to do this by relying on her own approach, rather than the text's, to teach computation.

In the past it's been mostly a computation kind of math.... Because they're stressing so much problem solving and the different skills and everything, I've just decided that I wanted to cover these kinds of things in this book [noncomputational topics]. And then with the computation things, I think that those things can be taught quite quickly... and then you can go on to things that are harder to remember and spend more time on that. (Interview, 11/9/92)

Catherine attended to both groups of topics by focusing on one topic from her computation ("processes") category and one chapter on "other skills" concurrently. Even though she sometimes devoted an entire lesson to computation or a lesson in the text, she claimed that more often she had the students spend time on each in a single lesson.

In teaching computation, Catherine did not use the chapters in the HBJ textbook:
"I'm not necessarily using the textbook for teaching the whole number computation
kinds of things," she told me. Rather, she relied on her own repertoires to teach basic
processes. Through her years of experience, she had developed ideas about what
students needed to know in order to compute and how they best learned it. This
knowledge, rather than the textbook, guided her in teaching the processes. The focus of

this instruction was on the mechanics or steps of the process, and it involved ample repeated practice. Sometimes she drew on the practice problems in the new textbook or those in the old textbook. More often, though, she designed her own practice sheets or put problems on the board. Catherine looked only minimally, if at all, at the chapters on teaching addition and subtraction or two-place multiplication. She knew few details about how these problems were addressed in the textbook.

Catherine did not view her approach to teaching computation as a rejection of the text. In her eyes, the changes brought on by the reforms were added to computation and had nothing to say to that layer of her instruction. She also believed that not following the textbook to teach computation facilitated her use of the text in other ways that were responsive to the reforms. It allowed her to move the students through the basic operations quickly, affording more time for topics emphasized in the "new definition of math."

I have been more apt to hit things that I haven't hit other years because in the past, like I said, the emphasis was on computation, and you know we have to change our way of thinking. And so I think within the last two or three years is when I started doing both things in the same hour. . . . What I found since I've been doing it this way is I'm spending more time on these kinds of chapters . . . like the measurement and um, geometry, some of the things that were awfully easy to just kind of ignore when we were just doing computation kinds of things. (Interview, 11/9/92).

Thus, in order to embrace the topics receiving increased emphasis, Catherine dismissed the textbook's guidance on teaching the computational processes.

In teaching the other topics, Catherine relied on the new textbook to provide tasks and structure for the lessons. She felt free to omit items from the lessons, skip some lessons all together, and rearrange the sequence of others. The following descriptions of two of Catherine's lessons exemplify how she distinguished between computational processes and noncomputational skills in the fall. The lesson I observed on November 19th was typical of the way she taught both processes and other skills in a single lesson. It also illustrates her reliance on her own strategies to teach computational processes in contrast to her use of the text to teach the "newer" topics. The second lesson

I observed (December 3rd) illustrates, in more detail, how Catherine relied on the text to shape her teaching of noncomputational topics:

A lesson combining multiplication and time. On November 19th, Catherine taught a lesson that combined work on estimating time from lesson 4.3, with instruction and practice on multidigit multiplication. It began at 1:30, the usual time; she started by giving the students a 2-minute timed test on multiplication facts. After collecting their papers, she opened her teacher's guide to page 114 and proceeded with a very brief introduction to the lesson. She followed several of the suggestions from the Teach section in the teacher's guide, posing questions about the relationships between various units of time, like "How many months in 2 years?" She then went right to the suggestion at the end of the lesson that presented sentences, like "Christmas comes once a _____." It only took a few minutes for Catherine to ask these questions and get the correct answers from her students. She then skipped the introductory tasks on page 114 of the student text. These introduced the idea of estimating time with questions that focused on selecting the units of time most appropriate to estimate the times of various events. Instead, she instructed the students to get into their groups, which were determined by whether they were working on one- or two-place multiplication. While Group Two was getting settled on one side of the room, Catherine distributed a page of multiplication exercises that she had produced by hand to Group One and instructed them to complete it before answering the practice questions on page 115 of their textbooks.

Catherine then moved to Group Two and told them: "We are going to practice our two-place multiplier multiplication problems." She went on to explain that many students were not consistent in their steps. Sometimes they multiplied rather than adding on the last step. She wrote:

756

x 63

on the board and walked among the 13 students as they worked silently on the multiplication exercises. She then carefully went over each step of the procedure with the entire group, reminding them that they put a zero when they were multiplying by six because: "six is really not just plain old six. It's 60." She stopped frequently and asked the students if they had done particular steps correctly. When students admitted mistakes, she asked: "Can you put into your own words what you did?" Students answered by explaining what they had

done incorrectly. She continued this sort of practice for 18 minutes and then distributed a page of similar exercises for them to complete before they went on to page 115 in the text. She monitored their practice for almost 20 minutes, pointing out incorrect answers that they should check later and making suggestions like: "Don't forget to draw your line under your partial products."

Once these students were well into their practice, Catherine moved to the seven students in Group One and monitored their work on one-place multiplication for about 10 minutes. She then called the entire class back together and spent the last 4 minutes of the lesson going over answers to the "board work" problems that the students had done earlier that morning. These included both multiplication and telling time tasks. (Observation, 11/19/92)

The lesson's primary focus was directed practice of the steps of the multiplication algorithm. Catherine drew on her pedagogical repertoire, as well as her knowledge of common student errors, to form the questions asked and the guidance offered. As was always the case, Catherine was gentle and supportive with her students. She wanted them to "understand" each step of the process so they would not forget it. Her approach seemed to be influenced by her experience:

When I used to do math.... I just did what I was told to do, and I memorized the process without really understanding that those two partial products are just part of the answer and why they were only part of the answer. I think these children understand that better. (Interview, 11/19/92)

Even though combining a textbook lesson with some amount of computational instruction or practice was typical of Catherine's instruction, she did not always devote as much time in a single lesson to computation as she did on November 19th. The following lesson from December 3rd, was drawn almost completely from the textbook. It illustrates patterns in the way she structured lessons, regardless of whether or not they were drawn from the text.

Doing it with the book: A lesson on using tables and schedules. The December 3rd lesson on using a table or schedule was one of the two problem-solving strategy lessons per chapter. Like all problem-solving lessons, the first student page was devoted to instructing students on the steps of using the featured strategy, in this case "using a table or schedule." The second page contained a series of tasks labeled "Apply," which drew on the strategy taught in the lesson.

The example problem on the first page involved using a schedule to determine which movie two girls could see, given particular time constraints. The apply page had a train schedule at the top and was followed by six questions that required using the information from the schedule. The next section, entitled "Mixed Application," contained four story problems. The students were to select from a list of three problem-solving strategies, introduced earlier in the text, to solve the problems.

Catherine began the lesson with two preinstructional activities drawn from the margin of the teacher's guide (see Figure 5.1). First, she spent about 4 minutes on a set of four questions under the heading "Quick Check." Each had the students identify the time that was a given number of minutes before or after a specified time, like 45 minutes after 7:00. She then spent a few minutes on a modified version of the activity under the "Motivate" suggestion. The first step, which Catherine did, was to write a schedule for the school day on the board. She began by writing a time on the board and waited for the class to chime in the appropriate event or subject. The second part of the "Motivate" activity suggested that the students work in groups to write questions that could be answered using the schedule. Instead, Catherine directed the class to turn to page 120 in their books and to read the problem at the top of the page.

Catherine read aloud:

The Cinema 6 at the mall is having a cartoon movie festival. Sherry and Kathy want to see <u>The Little Mermaid</u>, <u>The Jungle Book</u>, or <u>Bambi</u>, but they must be home by 3:00. It is 12:30 now. It takes 15 minutes to get home. Which movie can they see?

She then followed the suggestions in the "Teach" section, which involved discussing the problem, going over the movie schedule provided, and noting that each movie lasted an hour and a half. Catherine then walked the students through each of the problem-solving steps described in the textbook--understand the problem, plan, solve, and look back by posing the questions in the teacher's guide. The students had little difficulty producing answers to questions like, "What are you asked to find?" and "How can you solve the problem?" They stuck their hands in the air and waited to see if their teacher would call on them to



Figure 5.1 HBJ teachers guide, lesson 4.6, pp. 120-121

answer. Once answered, Catherine guided them through the steps of adding an hour and a half to each starting time and to produce a list of ending times on the board before asking: "Which movie can they see and still get home before 3:00 or at 3:00?"

Selecting from six hands in the air, Catherine called on Russ, who said that they could see The Little Mermaid. She agreed and went on to the final problem-solving step, "Look Back," which posed the following question: What other strategy can you use to solve the problem? Catherine asked: "Can you think of any other strategies, besides figuring out the ending time?" The students had more difficulty with this question. With the help of specific, guiding questions from Catherine, one student gave something similar to the answer suggested in the teacher's guide—work backwards from 3:00. Catherine reassured them that "if you were doing this in real life, it wouldn't cause as much of a problem."

After completing this instructional activity, Catherine moved the class on to the tasks on the next page. As the teacher's guide suggested, she had them work in pairs on the practice problems on page 121, while she moved around the room watching each group. After 10 minutes, she called the students back together and spent about 10 minutes going over the answers to the six questions about the train schedule. Many of the pairs had difficulty with a question which asked for the length of the ride between two cities. She pointed out that they were really finding "elapsed time," which was something they had learned to calculate just a few days earlier. The only difference was, she stressed, that they had to realize that the time the train leaves one city was the beginning time and the time it arrived in the next city was "like" the ending time. "If they [referring to the text authors] had said it that way," Catherine reassured her students, "You wouldn't have had any problem."

Once they had gone over all six of the questions, Catherine sent them back to their partners to answer the four "Mixed Application" problems. After 5 minutes, she pulled the class back together and discussed each answer, as she had done earlier. Although the instructions for this section read, "Choose a strategy and solve," Catherine did not ask the students about the strategies they used. Rather, she focused on their answers, walking them through the steps of the more difficult problems. Catherine had the students spend the last 8 minutes of the lesson completing a set of multidigit multiplication exercises that they had copied from the board that morning. (Observation, 12/3/92)

Catherine regularly used the textbook lessons like the above example to guide her teaching of noncomputational topics. Table 5.1 provides a summary of all the lessons I observed throughout the year. Nevertheless, she continued to have concerns about how some questions were worded. She frequently confessed to me that the HBJ text tended to expect too much of fourth-grade students.

Problem of the Day: Trying Something New

Another reform-initiated activity that Catherine used consistently was the daily problem, drawn from the "Problem of the Day" section in the text. Catherine was motivated to use the "Problem of the Day" suggestions because she was convinced that the increased emphasis on problem solving was well justified. She agreed that children needed to learn to solve problems, and she believed that attention to problem solving was one of the strengths of the HBJ text. Thus, she looked to the textbook to help her incorporate more problem solving into her teaching.

Catherine added problem solving to her teaching without compromising other parts of her math instruction by building it into a different part of the school day. Each morning she copied a problem onto a specially designated chalk board. Even though math was after lunch, the students were to work on it when they arrived in the morning. She gave them approximately 5 minutes to work alone and then collected their papers before talking through the solution with the class. This process was brief and focused on a single approach, which usually was generated by Catherine. She rewarded students who had the correct answer by punching a hole in their punch cards.² She explained that she was reluctant to grade their solutions, because she suspected that attaching a grade to this activity would only discourage those who had difficulty.

This approach reflected the mixed feelings Catherine developed in the fall about the increased emphasis on problem solving and, in particular, about the selection of

²Catherine used the punch cards to reward students for various behaviors or achievements. Once they accumulated a certain number of punches, they were permitted to exchange them for designated treats such as extra computer time or other special activities.

Table 5.1

Summary of Observed Lessons Taught by Catherine McKeen

| | | | 158 | | |
|------------------------------------|---|---|---|---|---|
| Problem of the day (when recorded) | Write + or = for each [] so it is true. 1. 7 [] 2 [] 9 2. [] | How many seconds does it take for the minute hand to move from 12 to 1 on the clock? | Yesterday was not Friday or Wednesday. Tomorrow will not be Monday or Tuesday. Today is not Friday or Tuesday. What day is it? | Find value of circle and triangles: • $x \Delta = \Delta + \Delta + \Delta$ $\Delta x \Delta x = 100$ • $x \cdot \Delta = 80$ | |
| Lesson summary | After reviewing answers to test from Chapter One, Catherine introduced lesson on telling time to the minute. Instructional activities and student practice involved showing and reading times on analog and digital clocks. | After a 2-minute timed test on multiplication facts and a brief introduction to estimating times, Catherine worked with Group Two on 2-place multiplication, while Group One worked on 1-place multiplication problems and page 115, switching groups after 37 minutes. | Catherine started with quick check on p. 120, using clocks rather than having students write time. Class made daily schedule similar to Motivate suggestion. She walked class through problem-solving lesson on p. 120. Students worked with partners to complete p. 121. Then class reviewed it. | Entire class was spent on Motivate activity from p. 122. Students worked in small groups sorting and tallying letters. Whole class collected data and used calculators to arrive at totals. Students used teacher-made page for keeping tally of each letter. | Catherine told how standardized units evolved and had students list metric units of linear measurement. Reviewed questions on pp. 210 and 211 orally. Catherine asked questions that students answered by holding up cards with cm, km, or m on them. Students did p. 212 individually. |
| Objective (stated in text) | To tell time to nearest minute on analog and digital clocks using numbers and words | To choose the most reasonable unit of time for a given activity | To use schedule or time table to solve problem and determine elapsed time | To collect, organize, and present data on a tally table and on a frequency table | To estimate length in metric units and choose appropriate unit for measuring length |
| Lesson number: title | 4.1: Telling Time | 11/19 114-115 4.3: Estimating Time | 4.6: Problem SolvingUse a table or a schedule | 12/10 122-123 4.7: Collecting Data | 7.2: Length: Metric Units |
| Text Page(s) | 110-111 | 114-115 | 120-121 | 122-123 | 210-212 |
| Date | 11/5 | 11/19 | 12/3 | 12/10 | 2/16 |

Table 5.1 (Continued)

| Problem of the day (when recorded) | | | | Write a fraction for the shaded parts: A. B. B. O O | Suppose 9 out of 12 boys can do 75 pushups in a row. What fraction of the boys can do pushups? |
|------------------------------------|---|--|---|---|---|
| Lesson summary | Class used pp. 226 and 227 and practice sheet. Catherine moved students quickly through problems, mostly in whole group, some individually. | Catherine selected one of the problems from the multiplication chapter for this problem of the day: Each of 8 students made 8 mugs. Each student kept 1 mug and some broke in the kiln. These students donated | Catherine introduced fractions using many suggestions from margins that involved paper folding. Students did problem on p. 318 in groups. Catherine reviewed problems 1-8 on p. 319 orally. | Spent first 9 minutes on Quick Check on p. 320, elaborating on text's suggestions; followed Motivate suggestion; led students orally through p. 320; finally had students do activity in margin of guide, involving shading a circle of eighths and writing questions related to fractions. Students traded and answered each other's questions, then worked on p. 321. | Good part of lesson was spent on identifying fractions written on board. Students did one at a time while Catherine moved about the room and checked. Discussed them and drew pictures to illustrate. Had students go to front of the room for Motivate activity. Spent remainder of lesson on tasks in student text. |
| Objective (stated in text) | To estimate, measure capacity in metric units, and choose appropriate unit for measuring capacity | | To use fractions to represent part of a whole and a group | To read and write fractions as part of a whole | To read and write fraction as part of group |
| Lesson number: title | 7.8: Capacity: Metric Units | Problem of the Day | 10.1: Exploring Fractions | 10.2: Fractions: Part of Whole | 10.3: Fractions: Part of Group |
| Text Page(s) | 226-227 | | 318-319 | 320-321 | 322-323 |
| Date | 3/2 | 3/24 | 4/5 | 4/6 | 47 |

Table 5.1 (Continued)

| Problem of the day (when recorded) | | | There were 21 problems on a page. Kevin did 6/7 of the problems correctly. How many did Kevin get correct. | There were 24 math problems. Sara did 3/4 of the problems correctly. Nick did 6/8 of the problems correctly. Who did more problems correctly? |
|------------------------------------|---|---|--|---|
| Lesson summary | Catherine gave each student a bag of M& Ms and had them write fraction of each color. After class discussion, students used counters to find various unit and non-unit fractions of 8. Students had difficulty with non-unit fractions. | Catherine constructed lesson to address trouble students had during previous lesson. She posed a fractions to students and had them identify the whole set and then what the fraction revealed about the number of groups. After much practice with counters, she introduced the two-step procedure for finding fraction of a number on p. 325. Students worked in pairs on p. 325. | Began by reviewing two-step process on p. 325 using $6/7$ of 21. Creates extra problems such as $\frac{2}{7}$ of $9 = 3$. Had students do 8-11 without counters. Students did #12 individually and discussed answers. Gave students quiz of 4 problems, all taking a fraction of a number. After quiz, students made fraction strips, as illustrated on p. 328. They used them to explore relations between various equivalent fractions. | Students used counters and p. 329 to illustrate equivalent fractions. Catherine gave them the reteaching page from p. 329. Then taught students steps for finding equivalent fractions (doing the math). Reviewed problems on page using the rule this time. Then followed the Check for Understanding suggestion on p. 329, through #12. |
| Objective (stated in text) | To find a fractional part of a group | To find a fractional part of a group | To explore equivalent fractions using models | To explore equivalent fractions using models |
| Lesson number: title | 10.4: Exploring: Finding a Fraction of a Number | 10.4: Exploring: Finding a Fraction of a Number | 10.6: Exploring Equivalent Fractions | 10.6: Exploring Equivalent Fractions (continued) |
| Text Page(s) | 324-325 | 325 | 328 | 329 |
| Date | 4/8 | 4/12 | 4/13 | 4/14 |

problems of the day. She found many of the problems intriguing and unsettling, but she liked them because they presented a vision of problem solving that went beyond the standard story problems found in the previous textbook. In fact, as early as mid November, she described how using these problems had broadened her view of problem solving: "We used to think that story problems were the problem-solving kinds of problems," she explained, comparing what Addison-Wesley and HBJ had offered in problem solving. Many of the problems of the day in the HBJ text, she pointed out, involved multiple steps and required several different operations. Many problems were not stated in a way that made the solution path obvious, such as the problem of the day on November 19th: How many seconds does it take for the minute hand to move from 12 to 1 on a clock? Other problems had more than one solution. Unlike the story problems she had been accustomed to, many could not be reduced to, and solved by, using a common algorithm: "You can't even put a mathematical sentence to [them]," she explained (Interview, 11/19/92). Some problems, she noted, did not even involve numbers but patterns that required logical thinking, such as the problem she gave the class on December 3rd:

Yesterday was not Friday or Wednesday. Tomorrow will not be Monday or Tuesday. Today is not Friday or Tuesday. What day is it?

At the same time, Catherine was skeptical about the appropriateness of many of these problems. Most problems, she believed, required too much of students before they were ready and tended to frustrate them. She found that students had difficulty approaching problems that did not have evident solution paths. They guessed, produced partial answers, or gave up. Thus, Catherine was not convinced that the authors understood the abilities and needs of young children in posing such complex problems: "I think it's good to problem solve," she told me, "but I also think that sometimes, at this level, they're just, maturity-wise, they're not ready for that" (Interview, 11/9/92). She questioned whether emphasis on problem solving was too idealistic: "Just because somebody says that these kids should be able to do this stuff

does not mean these kids can do it" (Interview, 12/17/92). Because of the importance she placed on her students feeling successful, Catherine worried that being asked to solve problems before they were ready would quell their interest and discourage them from trying.

Catherine speculated that her students' struggles with the problem of the day were partially due to lack of experience: "They are not familiar with problems that have three steps in them" (Interview, 12/17/92), she offered as an example. However, she did not like the text's approach of giving students experience by presenting problems to solve without teaching them how to solve them. She was unsure about how to guide them in solving such nonroutine problems. She also suspected that the text's authors were in the same predicament since the teacher's guide did not offer suggestions regarding how to help the students approach these problems: "I'm not always sure that the textbooks help us teach children how to think. I'm not sure they know how to teach children how to think" (Interview 12/17/92). Thus, Catherine faced the dilemma of how to give her students the necessary experience with such problems without leaving them feeling discouraged.

Despite these concerns, Catherine consistently assigned her students one of these problems daily. Only a few students were able to solve them successfully in the fall, but she hoped that, through experience, they would gain the abilities they needed without frustration. Occasionally, she put aside other morning activities and helped the students figure out each step of the problem. During these instances, most of the students eventually arrived at the correct answer, but not without considerable guidance. On December 19th, she described how she had coached the students through that morning's problem:

Today, when we were working on this problem, and they would come up with an answer, and I'd say: "This answer doesn't make sense. If you had only \$50 how could you end up with \$1,420, does that make sense?" I gave them longer to work on this than I usually do... I said: "Get your calculators out." So, they'd come up and show me their answers, and I'd say: "That's not it. You're in the right area...." I think it was more of a lesson in three-step problems.... This

morning we had time to do that, you know. We don't always have the time to ask them questions like that, that would help them say: "Well, that answer doesn't make sense, I never thought about that." (Interview, 12/19/92)

Even though she was pleased with the results of this "lesson in three-step problems" (Interview, 12/19/92) because it helped more students have success with the problem, Catherine believed that she could not afford to devote this much time to the problem of the day on a regular basis, and, most often, she did not.

Following the Text to Teach Noncomputational Topics

Because Catherine saw the reforms as targeting noncomputational topics and problem solving, it was in these two aspects of her teaching that she did <u>follow the text</u>. Others have observed, however, that there are multiple ways that teachers can <u>follow</u> a text (Stodolsky, 1989; Woodward & Elliot, 1990). Teachers not only select among a text's multiple options but they read into them mathematical and pedagogical aims that influence how they present them to their students (Stephens, 1982; Thompson, 1984). The description of the HBJ text in Chapter 3 indicates that each lesson contained many options. Even for Catherine, who hoped to "do it with the book," <u>following</u> the text involved selecting among these options, deciding on their intent, and determining how to incorporate them into her teaching. These choices were shaped by her ideas about students and their learning of mathematics. They, in turn, shaped the emphases and structure of her lessons.

In this section, I consider how Catherine <u>followed</u> the HBJ text to teach noncomputational topics during the fall and winter. I also examine what she attended to in the text, how she drew from it to shape her mathematics teaching, and how these choices reflected the ideas and commitments she brought to her use of it. In characterizing her use of the textbook, I draw on details in the lessons described above. The following analysis is significant for two reasons. First, it outlines aspects of Catherine's teaching and textbook use that underwent change throughout the year. Second, it illustrates her orientation to teaching and using the HBJ text, which played an

important role in stimulating the changes that occurred. An analysis of her orientation to teaching math and using the textbook as well as a description of how these influenced change, follow this section.

<u>Content of daily lessons</u>. Even though her lessons varied, patterns were evident in what Catherine attended to, used, and omitted in the text throughout the fall and winter observations. Each lesson was based on a single, two-page spread in the teacher's guide, which defined the lesson topic and from which she drew instructional suggestions and tasks to present to the students. Many of her choices reflected her views about the role of practice in learning math and her commitment to providing students with as much of it as possible. Her ideas about practice were apparent in the proportions of instructional and practice activities selected. Of the myriad student tasks offered in the teacher's guide, Catherine tended to draw sparingly from the instructional activities, which were found only in the teacher's guide. As a result, her introductions to the topic of the lessons were brief, allowing more time for the students to practice learned skills. Furthermore, the teaching suggestions she selected were concise and could be incorporated efficiently into a warm-up. Other suggestions were aimed at preparing students to do the work on the practice pages. She skipped or modified those suggestions that had the potential to take a long time, that involved manipulatives, or that were likely to unsettle the students from their seats. As a result, she often used the suggestions under the heading "Teach" and omitted or altered the preceding suggestions under the heading "Motivate."

The Motivate activity that Catherine chose to skip on November 19th (when she taught multiplication and estimating time in the same lesson) was both time consuming and involved movement around the room. She seemed to be focused on moving the students into their two groups as quickly as possible. Thus, she moved directly to the "Teach" section and gave the terse introduction described earlier before moving the students into the practice portion of the lesson.

On December 3rd, during the problem-solving lesson, Catherine used only the first part of the "Motivate" activity in lesson 4.6, which involved writing a schedule for the school day on the board. The second part of the activity suggested that the students work together to write questions that could be answered using the schedule. She said that she chose to omit it because it would have taken too much time. "This motivation would have taken probably 20 minutes if we had done it the way they suggested," she explained (Interview, 12/7/92). Instead, Catherine followed the suggestions in the Teach section of the lesson.

The Motivate activities that Catherine selected were short and involved teacher-directed, whole-class interaction. For example, she used the activity under the Motivate heading in lesson 4.1 on November 5th. The lesson was about telling time to the nearest minute. The Motivate activity involved drawing hands on clock faces to indicate specific time, which Catherine read aloud to the class. This task took only a few minutes because it was easy for the students. It also laid the groundwork for the remainder of the lesson on telling time to the minute and a set of similar practice tasks from page 110 in their texts.

As the above examples above indicate, Catherine almost always used the portions in the textbook designed to provide students with practice of the skill or concept just taught. Sometimes she supplemented the textbook exercises with practice problems of her own. On November 19th, she assigned students the practice questions in the text, as well as a page of multiplication exercises she had developed. On December 3rd, the students spent the second half of the class completing two practice problems provided in the text lesson. Catherine placed considerable emphasis on moving students through these practice activities. To her, "do[ing] it with the book" involved facilitating students' practice of the skills taught in each lesson. Related instructional activities, such as those from the Motivate suggestions, were secondary.

Table 5.2 displays the activities she selected from the textbook during each of the lessons during the fall and winter.

Structure of daily lessons. The selections made from the textbook and the way

Catherine incorporated them into her instruction resulted in a fairly consistent lesson
structure which included three types of activities: introduction, practice, and review.

The characteristics of, and time devoted to each of these activities reflected her views on
teaching and her commitment to practice. She generally started with a brief warm-up
activity before moving into whole-class instruction on the topic of the lesson. She
followed this introduction with a substantial amount of practice and usually concluded
the lessons with a closing activity or review in a whole-class setting. Despite minor
variations from lesson to lesson this pattern remained a consistent reminder of her views
on how students learn math. Tables 5.3 and 5.4 display the structure and format of
Catherine's lessons during the fall and winter. Table 5.5 illustrate the general pattern
that emerged. I describe the characteristics of these three types of activities below.

The purpose of the <u>introduction</u> piece of the lesson was to teach students about the central ideas, concepts, or skills. It took place in a whole-class format and often involved introductory materials from the margin of the teacher's guide and the first part of the student's pages. Almost all of the introductions I observed during the fall and winter fit within Catherine's definition of "teaching;" that is: they were teacher-directed; they involved the teacher telling or showing students what they needed to know; they were also brief and to the point. Of the lessons I observed, Catherine devoted approximately one third of each to this type of instruction before moving the class into practice.

During <u>practice</u>, students answered questions and completed exercises on the pages in their texts or from other sources. Even though Catherine provided practice in a variety of formats, such as oral and written in individual, partner, or group settings, she always engaged students in using the instruction just given. Practice was central to

Table 5.2

Summary of Tools and Resources used in Catherine's Fall and Winter Lessons

| Lesson To | To | Topic | Items used in Teacher's Guide | Items used on student pages | Other items used | Other tools or resources used |
|-----------------------|------------------|--|--|---|--|-------------------------------|
| 4.1 Tellin | Telling | Telling Time | Motivate Teach Quick Check done as board work) | Warm-up Introduction Check for understanding, no. 1-6 | •Reviewed chapter test from Chapter One | •Model clocks |
| 4.3 Estimating | Estim | ating Time | •Teach •Double Check | •Page 115 (done after multiplication sheet) (Skipped p. 114, instructional page) | •Multiplication fact timed test •Multiplication practice sheets (teacher made) | |
| 4.6 Proble a table | Proble a tabl | Problem Solving using a table or schedule | •Quick check •Motivate (adapted) •Teach | •Pages 120-121 | One and two digit Multiplication problems copied from board | •Model clocks |
| 4.7 Collecting | Collec | cting Data | •Motivate (modified) | | •Teacher-made tally sheet | •Alphabet pasta calculators |
| 7.2 Lengt | Lengt | Length: Metric Units | Teach Meeting individual needs (basic/ average) | •All of pp. 210-212 | | •Meter stick |
| 7.8 Capac | Capac | CapacityMetric Units | •Teach •Meeting individual needs (basic/ average) •Practice sheet | •All of pp. 226-227 | | |

Table 5.3

Summary of Structure and Format of Catherine's Fall Lessons

| Date | Lesson | Topic of Lesson segment: | Nature of segment ^a Format of segment | Format of segment | Total time of segment | % of total |
|-------|--------------|--|--|-----------------------|--------------------------|---------------|
| 1/5 | 4.1: | 1. Review place value test | Review/instruction | Whole class | 15 min. of 62 | 24 |
| | Time telling | 2. Intro. To 4.1 | Instruction | Whole class | 32 | 52 |
| | | 3. Reading/writing times | Practice | Independent and whole | 12 | 19 |
| | | 4. Closing | Review | Whole class | 3 | 5 |
| 11/19 | 4.3: | 1. Multiplication timed test | Practice | Independent | 6 min. of 58 | 10 |
| | Estimating | 2. Intro. To 4.3 | Instruction/review | Whole class | 2 | 3 |
| | Time | 3. Instruction in one-place multiplication (group 1) Instruction in two-place multiplication (group 2) | Instruction | Partial class | 5 18 | 9 |
| | | Practice of one-place multiplication (group 1) Practice of two-place multiplication (group 2) | Practice | Independent/group | 4 19 | 33 |
| | | 5. One/two-place multiplication; estimating times | Practice | Independent | 37 | 49 91 |
| | | 6. Review of boardwork | Review/instruction | Whole group | 4 | 7 |
| 12/3 | 4.6: Problem | 1. Quick check/motivate | Practice | Whole class | 4 min. of 64 | 9 |
| | Solving: Use | 2. Instruction using p. 120 | Instruction/practice | Whole class | 18 | 28 |
| | a Table or a | 3. Pair work, p. 121, intermixed with review | Practice/review | Pairs/whole class | 34 | 53 |
| | Schedule | 4. Work on multiplication | Practice | Independent | 8 | 13 |
| 12/10 | 4.7: | 1. Introduction to task | Instruction | Whole class | 5 min. 61 | ∞ |
| | Collecting | Motivate task in groups | Explore/practice | Small groups | 34 | 26 |
| | data | Compile and discuss results | Instruction/review | Whole class | 22 | 36 |

^a Frequently, Catherine mixed review and instruction or instruction and practice. I have labeled these segments as both, but have put the category that predominated first. For the purpose of analysis, I have used the predominating category as the segment's nature.

Table 5.4

Summary of Structure and Format of Catherine's Winter Lessons

| Date | Lesson | Title of Lesson segment: | Nature of segment Format of piece | Format of piece | Total time of segment | % of total |
|------|-------------------|---|-----------------------------------|-----------------------------------|--------------------------|---------------|
| 2/16 | 7.2: Length: | 1. Instruction on m, dm, cm, km, mm | Instruction | Whole class | 14 min. of 60 | 23 |
| | Metric Units | Oral work on pp. 210-211 | Practice/instruction | Whole class | 18 | 30 |
| | | 3. Written work on p. 211 | Practice | Independent | 5 | ∞ |
| | | 4. Oral practice choosing appropriate units | Practice | Whole class (individual response) | 8 | 13 |
| | | 5. Written work on p. 212 | Practice | Independent | 14 | 23 |
| | | 6. Closing question | Review | Whole class | 1 | 2 |
| 3/2 | 7.8: | 1. Introduction to topic; instruction on I and ml | Instruction | Whole class | 11 min. of 61 | 18 |
| | Capacity: | 2. Oral work on p. 226 | Practice | Whole class | 4 | 6.5 |
| | Metric Units | 3. Oral practice choosing appropriate units | Practice | Whole class | 2 | 3 |
| | | 4. Written work on p. 227 | Practice | Independent/whole class | 26 | 43 |
| | | 5. Written work on practice page | Practice | Independent | 11 | 18 |
| | | 6. Review of practice page | Review | Whole class | 9 | 10 |
| - | | 7. Summary of lesson | Review | Whole class | 1 | 1.5 |
| | Patterns in struc | Patterns in structure and format across Fall and Winter | | | Average %a | |
| | | Introduce in whole class | Instruction | Whole class | 31 min. of 61 | |
| | | Practice alone or in group | Practice | Individual/pair/group | 51 | |
| | | Practice alone or in group | Explore | Group | 6 | |
| | | Review or conclude in group | Review | Whole class | 8 | |

Table 5.5

General Patterns in Structure and Format of Catherine's Fall and Winter Lessons

| Date | Lesson | Instruction | Practice | Exploration | Review | Total lesson time |
|---------|---|----------------------------|----------|-------------|--------|-------------------|
| | 4.1 Telling Time | 82% | 19% | | 29% | 62 minutes |
| | 4.3 Estimating Time | Group 1 12% Group 2 34% | 81% | | 7%L | 58 minutes |
| | 4.6 Problem Solving: Use a Table / Schedule | 28% | 72% | | | 64 minutes |
| | 4.7 Collecting Data | 44% | | 26% | | 61 minutes |
| | 7.2 Length: Metric Units | 23% | 75% | | 2% | 60 minutes |
| | 7.8 Capacity: Metric Units | 18% | 20% | | 11% | 61 minutes |
| Average | | 31% | 51% | %6 | 8% | 366 minutes total |

Catherine's teaching. Whether she was teaching one of the computational processes or a lesson from the text, she believed that a substantial amount of time must be devoted to repeated practice in order to facilitate learning. In fact, one of the complaints she frequently cited about the HBJ text was that "they don't give a lot of practice" (Interview, 11/9/92). Her commitment to practice was apparent in the amount of lesson time she devoted to it, for example, as much as three quarters of the time on November 19th. On average, Catherine devoted more than half of her class time to this type of practice during the fall and winter lessons.

Unless they ran out of time, Catherine followed independent practice with a whole-class <u>review</u>, during which she reviewed some or all of the problems students had completed. Typically, she read each question aloud and called on students to share their answers, stopping only to attend to students' questions or difficulties. As the December 3rd, lesson exemplifies, Catherine folded the review into the practice portion of the lessons by following each section of practice with review.

Emphasis of each lesson. During each portion of her lessons, Catherine placed primary emphasis on arriving at correct answers. In general, she did not encourage students to consider why their answers were correct or pay attention to the process of making sense of a problem in order to solve it. Her focus on correct answers was evident in the nature of the interactions in the class; students provided answers to the questions she posed or read from the text. Catherine's role, it seemed, was to help them arrive at the correct answer, which she often accomplished by rephrasing or reasking questions, asking if someone could "say it a different way" (Observation, 11/5/92) or providing hints and guidance until the students produced the answer she was after.

The answer she wanted most often was the one printed in the teacher's guide of the textbook. For example, during the December 3rd lesson, described earlier, when the students could not arrive at an alternative way to solve the problem, Catherine asked the following series of questions, which led them to the answer in the text. The initial

question she asked was whether they could think of any other strategy to solve the problem. The alternative strategy offered in the text was "work backwards from 3:00. . . . So they can see any movie starting by 1:15." Catherine asked: "Can you think of any other strategies besides figuring out the ending time?" Several students raised their hands:

Student: Figure out the starting time.

Catherine: We knew the starting time.

She accepted a few more responses, none of which seemed to be what she was looking for. So, she asked more pointed questions:

Catherine: What other things could we have done? What time did they have to be

home?

Students: 3:00.

Catherine: So what could we have done with the 3:00 idea?

Student: We could have subtracted fifteen minutes from 3:00.

Catherine liked this response. She repeated it and then probed for more:

Catherine: That would tell you the 15 minutes it took them to walk home. That would be 2:45, right? Then what would we have to do to find out what movie they could see?

Students: [No answer]

Catherine: How long is the movie?
Students: An hour and 30 minutes.

Catherine: So if you take an hour and 30 minutes away from. . . two what? (She paused briefly, but continued after no response from the students.) two forty-five.

What would it be?

Student: One fifteen.

Catherine agreed and then wrote:

2:45 --1:30 1:15

and then showed the students that 2:45 minus 1:30 was 1:15. "Okay?" she asked the class, as if she was checking to be sure they understood. There was no response. She then concluded: "So that schedule would help you." She reassured them that if they had

been doing this problem in a <u>real</u> situation, it would have been much less difficult before moving on to the next task.

Catherine appeared relieved that a student finally had given the correct answer, not because the correct answer indicated that he understood this alternative strategy but because arriving at the correct answer enabled them to move on. Her comments later substantiated this assumption:

I just had the feeling that I got one child to say to count backwards. And I think I remember one child did say that, but I did not feel that even with the explanation that they were really understanding that a great deal--going backwards. And I thought that maybe that was something that was not necessary at this point--that they need to understand that. So I went on so that I could get on with the lesson.
... But a lot of what I thought was that more explanation would just muddy up the water more. (Interview, 12/7/92)

Muddying the waters would not only add more confusion to the lesson but could detract from Catherine's goal of moving through the questions in the text successfully. As a teacher aiming to help students be successful in math, she was hesitant to add more confusion to the proceedings of a lesson, particularly when someone had given the correct answer.

An exception to the pattern. I observed one exception to the patterns described above in Catherine's use of the text and in her general lesson structure. On December 10th, Catherine constructed an entire lesson on collecting data from the Motivate activity for lesson 4.7. The Motivate activity suggested dividing the class into groups and giving each a small bag of alphabet macaroni to sort by letter and then record the number of each letter collected. The text suggested that all the groups' results be combined in a frequency table and then discussed. Catherine had her students sort the macaroni in groups before combining their data in a table on the overhead. She then elaborated the end of the activity, creating a whole-class lesson on making, reading, and using a frequency chart. She created questions on the spot that engaged students in reading the table and using calculators to compare the quantities of different letters. In addition to asking students to explain the difference between a tally sheet and a frequency table,

which are located in the text, she asked her own questions that involved examining and comparing data.

When I asked her about the lesson, Catherine said she was pleased with it, but her comments reflected the general emphases of the other lessons described earlier. She was concerned that the activity took more time than expected; she had hoped to have the students do more of the practice activities in the lesson. "We just got so involved," she said, explaining why she allowed the activity to proceed (Interview, 12/17/92). She described this lesson as atypical, since she did not often have time to devote an entire lesson to such an activity. Still, she said, she did not regret it, and she would probably do it again next year. If she did, she told me: "I would give them far less alphabets to work with . . . and I might have given them more direction on how to count up the tally, because that took quite a long time" (Interview, 12/17/92).

The fact that Catherine found this activity appealing, even though she believed it took too much time, reflected her mixed feelings about the changes advocated by the reform agenda. She believed that many were of some value, but they took time away from direct instruction and much-needed practice. Thus, she tended to stay away from such time-consuming, exploratory activities.

Mixing the Old and the New and Teacher Change

As these descriptions of Catherine's use of the text in the fall and winter suggest, what it meant to "do it with the book" differed depending on the aspect of her mathematics instruction involved. How she made sense of the suggestions in the HBJ text and embraced them in her teaching varied for problem solving, noncomputational topics, and computational skills. Because she saw the reforms as additive in nature, she opened her practice to content additions such as problem solving and increased emphasis on noncomputational topics. The elements of her instruction that were more integrally connected to what she saw as the core of mathematics (those that led to computational mastery) were not open to revisions offered in the text.

Catherine's tendency to embrace selectively some of the new ideas offered by the text, while standing firm on those that comprised the foundation of her mathematics instruction, is not atypical. Many reformers have argued that curricular and pedagogical change in mathematics instruction requires a fundamental shift in one's thinking about teaching and learning math (Cohen & Ball, 1990; Lappan & Theule-Lubienski, 1992); however, observers of teachers responding to these calls for change have noted that wholesale shifts are unlikely. It is more likely in their initial response, that teachers will mix reformed approaches with the status quo (Cohen, 1990). In Catherine's case, this mixing of the old and the new eventually had an impact on her view of teaching and learning math.

Catherine's teaching did not undergo fundamental shifts as the year progressed, but it was evident that changes in her mathematics goals and use of the text to accomplish them had begun to occur midway through the year. These changes appeared to be stimulated by her attempts to uphold two competing commitments. The first commitment involved her orientation to teaching mathematics, and the second involved her specific orientation to using the HBJ textbook. I discuss these two competing roles below. Then I examine how the tension between them stimulated learning and change.

<u>Catherine's Orientation to Mathematics Teaching and Using the HBJ Textbook:</u> <u>Catherine's Larger Agenda</u>

From her initial encounters, Catherine saw the HBJ textbook as a tool to promote change in her mathematics instruction. Reform-initiated change was not her only focus. Sosniak and Stodolsky (1993) found that texts were not "driving forces" in teachers' instruction as much as they were "props in the service of managing larger agendas" (p. 271). Similarly, attending to the reforms was only part of Catherine's larger instructional agenda; the central focus in her teaching was to help students be "successful" as learners of mathematics. In her view, success included producing correct answers to math

problems without experiencing too much frustration. These two aspects of her agenda were often at odds with one another, particularly when the solutions to the problems suggested in the text were not readily accessible to her students. These two goals, however, guided her teaching and shaped the ways she made sense of the text. Examining Catherine's commitment to each of these competing roles is critical to understanding how the tensions they created in her teaching served to stimulate change. I describe each of these goals below and then discuss the impact they had on her teaching.

The Teacher's Role as Advocate of Students

Whether using suggestions in the text or her own approach, Catherine believed that it was her responsibility to "teach" students the steps and procedures they needed to know, not leaving them to struggle alone. She believed that providing careful guidance and asking students only what was within their reach was the best way to ensure their success. In this sense, Catherine viewed herself as an <u>advocate</u> of students. This role often involved structuring lessons to provide students with appropriate guidance and support. During the November 19th lesson, for example, she focused students' attention on each part of the multiplication algorithm and made sure they knew how to do each step. In order to help them successfully learn these procedures, she limited the amount of steps they needed to remember by having them work with one type of algorithm at a time.

At other times, Catherine's role as advocate required that she mediate the students' interactions with the math or the text in order to circumvent their frustration. She often interpreted questions to help them arrive at the correct answer. This tendency was evident on several occasions during the December 3rd lesson, when Catherine led the students to the answer in the text and explained their difficulties by suggesting that the question was poorly phrased. When her students had difficulty using the train schedule to find the time it took to travel between two cities, Catherine speculated that

more students would have been successful if the text had indicated that they were actually calculating elapsed time. Later, reflecting on the source of their struggles, Catherine offered: "I do really think they know how to *do* elapsed time, but I'm just not sure they know how to <u>apply</u> it to an actual situation" (Interview, 12/7/92).

Catherine's Role as Implementor of the Text

The fact that Catherine posed questions to her students because they were suggested in the text, regardless of whether she believed they were useful or appropriate, is illustrative of the second item on her larger agenda: her orientation to using the HBJ textbook. The reform context in which she was teaching presented goals she saw as valuable. Furthermore, a revised district test, the adoption of a new textbook, and other activities in the district indicated that responding to these calls for change was prudent. Because she believed that the HBJ text encompassed the reform agenda, Catherine looked to it to guide her efforts by defining the noncomputational topics that her students should learn and designing the tasks and activities that would help students learn them. Even though she felt free to pick and choose from the offerings in the text and even alter some, she treated the items selected as though they were the ideas and intentions of an external authority. In this way, she saw herself as an implementor of the authors' ideas and intentions. Catherine said that she was paying more careful attention to the suggestions in the margins than usual "so that I can try to teach it the way the book feels is the new approach to math" (Interview, 12/7/92).

Competing Agendas

As the previous descriptions suggest, Catherine's attempts to implement selected aspects of the text conflicted at times with her role as advocate of students. Thus, in implementing the text, she was led by her role as advocate to guide students toward success by teaching them what they needed to know, providing them with practice, and guiding them to the correct answers. Doing this required paying close attention to their work on the task at hand. Over time, reconciling these dual roles had an impact on her;

it provided her with a vantage point that stimulated learning and change in her ideas about mathematics and in her teaching of it. The section that follows examines this process and its effects.

Effects of Competing Orientations on Catherine's Practice: Sites for Learning

Over the year that I observed Catherine, her use of the textbook resulted in changes in her teaching and ideas about mathematics content and pedagogy. She began to talk differently about her mathematical goals for students, she drew on different aspects of the text, and she structured lessons in ways that reflected her changing stance. These changes were inspired, in part, by the suggestions in the text that she added to her teaching throughout the year. Yet, the process that facilitated these changes and the role that the text played in her learning were not straightforward. The text provided Catherine with tasks to give students or suggested tools she might use in her teaching. However, these tasks and tools were not the only sources of Catherine's learning and change. In her dual role as student advocate and text implementor, Catherine analyzed these tasks and the students' work with them in order to make appropriate adaptations in her teaching. This process of analysis and adaptation created sites for learning by forcing her to reconsider many of the ideas she held about teaching or learning math. Examining the nature and generation of these sites is critical to understanding how the HBJ textbook contributed to Catherine's learning.

These sites had common characteristics that were related and that stimulated Catherine's learning: they occurred when she began using reform-related suggestions that were foreign to her. They involved her students' struggles because of these suggestions, causing her to pay additional attention. The results of this learning caused Catherine to make connections between aspects of the reforms she had previously treated in isolation.

These sites for Catherine's learning occurred in a particular order that corresponded with different layers of her teaching. As the following descriptions reveal, she began by entertaining new instructional ideas in problem solving, an area that was far outside computation, which was the core of her mathematics instruction. The changes that resulted led her to reexamine layers closer to the center of her instruction. In the following two accounts, I describe and explore the two sites for learning that had the greatest impact. Each site was prompted by a specific textbook component into which another reform-related instructional tool was integrated. The first, which provoked her to reexamine her conceptions of and purpose for problem solving, occurred through her use of the Problem of the Day suggestions and involved the use of calculators. The second, which focused her attention on developing student understanding, occurred through her use of the textbook to teach fractions and included the use of visual models.

Problem Solving

The Problem of the Day was the first textbook component that served to create a learning site for Catherine, and it was the first element of the new textbook that she embraced; that is she added it to her daily routine rather than making a significant change in her mathematics instruction. Even though her students' early encounters with problems raised questions for her about their appropriateness, her commitment to this aspect of the reforms led her to continue to use them. At the same time, problem solving remained peripheral to the core of her mathematics instruction; she did not integrate it into her regular lessons. Thus, adding this problem-solving activity to the first 10 minutes of the morning did not reflect significant change in what was central to her instruction. Over time, however, this activity's contribution to her learning had an impact beyond the first 10 minutes of the school day.

<u>Catherine's struggles with problem solving</u>. As I described earlier, Catherine was committed to problem solving, but she and her students struggled with the

problems of the day. The text offered no pedagogical guidance in using them, leaving Catherine frequently baffled about the authors' expectations. She said: "I sometimes wonder how they think children come to this conclusion. . . . The book doesn't go into a lot of ideas on how to get the children to come to this conclusion" (Interview, 4/3/93).

Ironically, it was this feature of the text (providing the teacher a collection of nonroutine problems with no guidance) that stimulated a crucial feature of the learning site. Because it was her role to help students solve these problems, Catherine found herself examining them closely. She began to see and appreciate the type of nonprescriptive reasoning they called for.

Changes in Catherine's view of problem solving. I began to notice changes in the way Catherine talked about the problems of the day during my visits in the winter. She seemed to be more accepting of them generally, and she talked more adamantly about the need for students to be able to solve a range of different problems: "Now, problem solving has become very important to me," she confessed during one of our conversations (Interview, 3/11/93). This shift initially seemed stimulated by instances in which students were unable to solve problems, even when she allowed them to use calculators. The act of "walking" students through the process of selecting and using a strategy and then thinking about whether their results were logical stimulated Catherine's respect for the type of thinking required. The fact that her students were unable to think through this process, even when they used calculators, demonstrated the necessity of these abilities; "The more they're working on the problem solving, the more important it's becoming to me. . . . The pressure is on us to help them think through these kinds of problems" (Interview, 4/3/93).

The nature of the problem-solving tasks provided in the textbook also contributed to Catherine's learning by confronting her with problems appreciably different from others she had used or imagined. As a student and as a teacher, Catherine had always believed that there was a single solution path for each problem

that needed to be taught and practiced: "When I grew up, it was always just a certain way you had to do it. That's what we were led to believe. We had to do it the way the teacher did it" (Interview, 4/3/93). The problems in the HBJ text that did not always have obvious solution paths challenged that view. The problems were multistep, and many could be approached in multiple ways. Many were not easily reduced to readily solved equations. Solving them involved more than following a known procedure or applying a formula; it involved selecting or developing a solution method. Many of the problems also required a flexible understanding of mathematical relationships that Catherine had not developed.

I was the kind of person . . . if I learned a rule and then you always gave me all the same kinds of problems, I was set. But, if you would just change it so I had to find, like for example, 4 times 4 is 16. If you gave me 4 times 4, I would always know the product. But if you gave me 4 times blank equals 16, when I was younger, then that would have just thrown me into a big tizzy. (Interview, 4/8/93)

Catherine realized that many of the Problems of the Day required flexible thinking, but she lacked strategies for helping her students develop this flexibility.

Catherine's limitations, however, did not stop her students from creating and sharing their solution strategies. Thus, Catherine's students also contributed to her learning. As more of them gained confidence in their own problem-solving abilities, they began to offer them to the class, which opened her eyes to the multiple ways most problems could be solved:

When we would do the problem of the day, they would do it, and we'd talk about it. And then I'd show them, you know, how we got the answer that we got on the board, and inevitably I'd have two or three kids say, "This is what I did." And they would have a different way of doing that and then some children would do an equation, and some people would draw a picture. (Interview, 6/25/93)

Intrigued, Catherine eventually built opportunities for students to share their strategies into the daily discussion of the problem of the day. She continued to walk them through an algorithmic approach to solving the problem, but she would always follow with:

"Did anyone solve it a different way?" The responses to this question demonstrated to

her that, indeed, many students had solved the problem differently. Through these experiences Catherine gained respect for her students' strategies and seemed particularly motivated by their abilities: "I think it's kind of neat now that children can try their own way" (Interview, 4/3/93).

Catherine ended the school year having undergone a considerable shift in her view of problem solving, her sense of its importance, and her perception of her own and her students' abilities to solve problems. Through watching her students struggle with problem-solving, as well as observing the strategies and approaches used, Catherine gradually increased the value she attached to it. In our conversations later in the year, she placed problem solving more at the heart of what students needed to learn: "I always thought of [problem solving] as games, fun-time games, you know. It's not important. . . . I see the reason for these things now, even though there may not be mathematical words involved or a mathematical equation to solve; it still, it's a thought process that's important in math" (Interview, 6/25/93). This increased appreciation for the thinking that underlies problem solving provided a new lens for her to examine mathematical tasks, particularly those she remembered doing as a child: "When I was a child, we did do patterning some, but I never could see the reason why. . . . I'm more aware now of if you can pattern, your mind is working in kind of, in a mathematical way to see the pattern" (Interview, 6/25/93).

Catherine's changing view of the role of calculators in problem solving. The learning Catherine experienced regarding problem solving also was stimulated by her experimentation with another mathematical tool closely associated with the reform movement: the calculator. When I first spoke with her, she mentioned that she was trying to use calculators more in her teaching. As she incorporated them into many problem-solving situations, she began to see them as a viable tool. As her interest in problem solving increased, so did her enthusiasm for calculators.

Initially, Catherine's treatment of calculators was similar to problem solving. Seeing it as one of the many reform-related ideas that had merit, she followed the suggestions in the text, but not without reservations about shortchanging computation. She also incorporated calculators into lessons at her discretion, even when not recommended in the text. Over the six-week observation period during the fall, there was a noticeable change in the way Catherine incorporated calculators into her instruction and in the range of uses she believed they had in a fourth-grade classroom. When I began visiting her classroom, she had the students use calculators primarily to check their answers to computation problems:

We have a set of classroom calculators . . . and they've done quite a bit with a calculator. Not, I mean you know when I say quite a bit I mean more than we would have done 2 years ago. There are times when I will assign them a page or something or give them 10 problems, and I'll let them check, after they've done the work, then I'll let them use the calculator to check it. (Interview, 11/9/92)

This approach provided a way for her to respond to the pressure she felt to introduce her students to these devices without facilitating their dependence on them: "I think the higher math is where you should be allowed to use the calculators, but I think down here they need to learn, they need to learn how to do the computation" (Interview, 11/19/92).

By the end of the fall data collection, Catherine had begun to talk differently about the role of calculators in learning mathematics; she encouraged students to use them when solving complex problems or performing other tasks that involved computation in a peripheral way. For example, during the December 10th lesson described earlier, she gave the students tasks that involved sorting alphabet macaroni by letter and recording the frequency of each. She had the students use calculators to consolidate data they had collected into a class chart. Catherine pointed out that the purpose of the lesson was to give students "hands-on" experience gathering data and making a graph, not two-digit addition; thus using calculators made sense. She also explained that she had allowed students to use calculators to solve a problem of the day:

"We had this problem of the day today. And it had some division in it. Some of the children in the room have had division, but the majority of them haven't. So we used [the calculator]. It's like a three-step problem and the first step is division" (Interview, 12/17/92).

The focus, for Catherine, seemed to be on helping her students figure out how to solve the problem, not on division skills: "I think, in certain kinds of problems, like thought problems, a problem that has three steps in it, you know, then I think it's very appropriate to use the calculators because they have to know which process to use" (Interview, 12/17/92). Her expanding view of problem solving seemed to be a response to and an initiator of changes in her perception of the role of calculators.

Catherine's comments during the winter suggested that her view of calculators continued to change. She was beginning to see that they allowed students to participate in problem solving without necessarily knowing all the mechanical steps of arithmetic: "I'm beginning to change my mind about, you know, when we've done problem solving. If you don't have to do it with paper and pencil, you can do it with the calculator, fine; you still have to know the process to do the problem-solving part of it" (Interview, 3/11/93). Her experience using calculators and engaging students in complex problems during the preceding months had led her to believe that just knowing how to solve a problem was a complex ability that students needed to develop. The calculators, she believed, facilitated this development: "With the calculators, they can at least do the thinking part of the problem" (Interview, 3/11/93).

Observing her students' use of calculators also placed the role of computation in a different light. She began to suspect that computational mastery did not necessarily lead to understanding: "I'm just thinking," she mentioned at the end of the year, "so what if you know how to do all this computation. That doesn't mean that you're going to be able to solve problems" (Interview, 6/25/93). By this point, Catherine seemed to be questioning the stance she had taken earlier in the year when she claimed that computational mastery "sets the foundation for any higher math" (Interview, 12/17/92):

[When I was a child,] you had to know how to compute and that was the most important thing. And then, somewhere, there was a magic time in your life that you were supposed to be able to take all this idea of the computation and put it towards problem solving.... In algebra, I couldn't associate these equations and how they were going to solve the problems, even think of maybe what the problem was about. Maybe that's the best thing with problem solving, especially the ones that don't deal with numbers, and that kind of thing that makes them think about how can I solve this problem? What would be a logical answer to that?" (Interview, 6/25/93).

Seeing her own students think through problems gave Catherine a different perspective on her experiences learning math, and it provoked her to reassess the way she prioritized mathematical skills.

Observations of her students' work on calculators also prompted her to stretch her ideas about student learning. She described an instance in which she believed that solving problems with calculators actually helped students begin to understand the computational process by seeing when and how it applied: "They can do the processes that they haven't even been taught particularly. And they're getting the idea of breaking into their different groups [referring to division]. . . . They haven't really been taught the process, but they can get the idea" (Interview, 4/3/93). Catherine still felt strongly that students needed to be taught the computational processes. But, her response to experimenting with calculators in problem-solving contexts suggests that she was broadening her views on how students learn.

Catherine saw these changes in her thinking and teaching as significant, and she credited them to suggestions in the textbook: "It put different ideas in front of me. . . I tried them, and I found that some of those things work" (Interview, 6/25/93). She believed that the text called for calculators more often in tasks that involved more than basic computation. Through using calculators she began to develop her own ideas about their value as a tool and about the problem solving they facilitated. In particular, she began to develop a view of math into which problem solving was integrated rather than an isolated topic.

Developing Student Understanding

The second learning site initiated by the textbook stimulated change in Catherine's teaching much later during the year but much closer to the core of her mathematics instruction. The motivator was her use of instructional suggestions in the textbook designed to develop student understanding of underlying concepts. These suggestions had been in the margins of the teacher's guide in each chapter, but it was not until midyear (after she had already started to reconsider her views of calculators and problem solving) that she began to try them. In February, for the first time, she followed the text's suggestions to incorporate manipulatives into her instruction, reporting this initial venture as a success. Then, in April, I observed the first week and a half of a unit on fractions, during which I noticed significant changes in her use of the conceptually oriented suggestions in the teacher's guide and in the way she structured the lessons. These changes refocused her lessons on developing understanding of mathematical ideas, reflecting changes in her conceptions of learning.

Prior to the fraction unit in the spring, I had observed little change in the way

Catherine used the text to shape her daily instruction of noncomputational topics. The
emphasis on correct answers and repeated practice predominated all but one of the
lessons I had observed earlier. When I asked her about suggestions in the margins that
she had omitted, she claimed that many required extra equipment or demanded more
time than she could afford. On several occasions, she explained that the suggested
manipulative activities were unnecessary because the students did not "need" them.

Later, Catherine also admitted that attempts to use manipulatives in previous years had
resulted in disorder and confusion for the students and frustration for her: "I can get
really rattled with manipulatives." She explained:

Sometimes when I'm working with manipulatives the children could say something to me and I would think, yeah, that's true, and I know it can't be. . . . They'll say something and because I'm not that familiar with what I'm doing. . . I get real flustered because you know it's not right and then I can't explain. . . . I haven't done it enough so that I feel really comfortable enough with it. (Interview, 3/11/93)

In mid February, Catherine decided to try one of the manipulative-based activities suggested in the text. She followed the suggestion at the beginning of the chapter that involved using base-10 blocks to model the conceptual underpinnings of the division algorithm (see Figure 5.2). As with problem solving and calculators, her decision to use the suggestion was motivated by her commitment to implementing the text. As advocate of students, she observed her students' encounters with the activities closely, looking for signs of confusion or frustration; she did not find them. Rather, when she examined what was happening in her classroom, she saw mathematical relationships and procedures more clearly. She was particularly impressed with how well the base-ten blocks demonstrated the mathematical concept underlying "bringing down" the next digit of the dividend in the division algorithm:

When I taught bringing down in division and I used the blocks of ten, it was really interesting.... What happens here is you have a long ten and three little blocks. So they break these up and they take 10 of the individuals to show how they got the 13.... So it was really neat. They understood. I had never done that before. (Interview, 2/16/92)

Catherine enthusiastically reported this incident as her first successful attempt using manipulatives. She was proud of herself because she had confronted some of the anxiety she felt about them. "The hardest part is making yourself use manipulatives when you don't feel comfortable with them. And I think it's good to have made myself do it" (Interview, 4/3/93).

It was not just trying the manipulative-based suggestion that stimulated the site for Catherine's learning. Observing her students engaged with manipulatives provided a perspective on their role in learning that reading the text could not provide. This experience, together with the changes she had begun to make regarding problem solving, led her to reconsider her resistance to time-consuming manipulative activities.

By the spring observation period, Catherine had used some manipulative or model in six of the seven fraction lessons observed. Following the instructional suggestions in the textbook, particularly those in the margin of the teacher's guide,

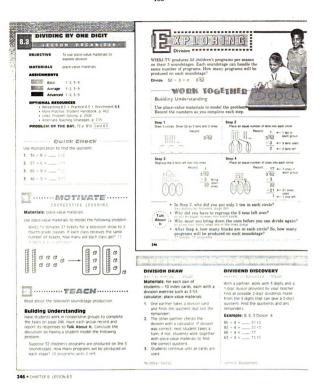


Figure 5.2 Manipulative-based division activity used by Catherine in February; HBJ teachers guide, lesson 8.3, pp. 246

Catherine had her students folding, shading, and cutting paper to represent and compare fractional parts and using counters to find discrete fractions. In our conversations, she explained that such extensive use of models was new to her. In previous years, she had not involved students in constructing their own models of fractions: "I've done the fraction pies and things like that. Usually the way I do it is draw on the board. With this [referring to the suggestions she used in the HBJ text] they [the students] have to do the manipulating. I think it means more to them than the drawing on the board" (Interview 4/8/93).

The increase in Catherine's use of instructional suggestions that involved visual models was only one of the changes evident in her use of the textbook in the spring. Other suggestions that altered the way she interacted with students also stimulated her learning by placing greater emphasis on the meaning of underlying concepts. During the lessons I observed in April, she used a range of exploratory and conceptually focused suggestions in the introductory part of the lessons which she tended to omit during earlier observations. The result was a change in the focus and structure of her lessons, in which more time was devoted to whole-class instructional activities and less time to independent practice. During the instruction, Catherine seemed concerned that her students could understand and visualize concepts taught in the lessons. She even began to add her own elaborations to the suggestions in the text, focusing more on understanding. The following description of the lesson Catherine taught on April 6th, the second day of the unit on fractions, characterizes her use of the textbook in the spring:

April 6: A typical fraction lesson. The hour lesson was drawn from pages 320 and 321 in the textbook, entitled Fractions: Part of a Whole. Catherine began with the Quick Check on page 320 of the teacher's guide, which reviewed the distinction introduced the previous day between discrete fractions and those that were part of a whole. "Yesterday we were looking at things and deciding

whether a part of something was part of a whole or part of a group," she began, directing them to look at the first of three pictures she had copied on the board. "Tell me whether the shaded-in circle is part of a group or part of a whole."

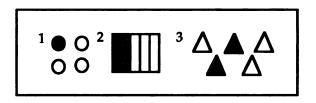


Figure 5.3 Questions from Quick Check, HBJ teachers guide, p. 320

Several hands went up. Catherine called on Joseph, who said: "Part of a whole-no, I mean part of a group." Rather than affirming his correct answer, Catherine asked about his midstream change of mind:

Catherine: Why? Why did you change your mind?

Joseph: Because they're not touching.

She accepted his answer and then went on to the next two diagrams. In each case, she called on students to give the answer and explain why. After they had agreed that the third picture represented part of a group, Catherine commented, in passing, that "it would be hard to put triangles into a whole." Immediately, several students began to suggest possibilities, which she accepted and responded to, allowing the class to digress for several minutes. One student suggested: "You can make one big triangle." Another said: "You can put some upside down." Catherine agreed that these were possibilities, but she insisted that it would be hard, especially with <u>five</u> triangles.

This response prompted more students to make suggestions about how the five triangles could be put together to be part of a whole. She drew a rectangle on the board and for several minutes followed students' instructions for dividing it into triangles. After several attempts that produced only even numbers of triangles or triangles of different sizes, Catherine suggested that it might not be possible to get five triangles that were "all the same size." She then directed the class back to the three pictures on the board. Even though they had completed the activity suggested in the teacher's guide, Catherine continued with a set of questions of her own, which involved telling which part of the fraction was shaded and which part was not shaded.

At first, the students had some difficulty with this new task. Catherine and the class spent several minutes reviewing how to identify fractional parts.

For example, when Maura said that one third of the first figure was not shaded, Catherine reminded her: "Keep in mind, how many things were there in the whole group?"

Maura:

Four.

Catherine:

So the denominator has to be--?

Maura:

Four.

She then asked Maura how many were not colored in to arrive at the fraction three fourths. Once the class had agreed that the names of the fractional parts shaded and not shaded in the third picture, and Catherine had written $\frac{2}{5}$ and $\frac{3}{5}$ on the board, she allowed another student-initiated question to divert their progress through the lesson. Looking at the two fractions, Erin asked: "How can you add them?"

"This is a good question," Catherine told the class. "This is a question before its time, but we might as well answer it." She drew the students' attention to the picture of the group and reiterated that two of the five things were shaded, whereas three of the five things were not. "How many triangles are in the group?" she asked. The students agreed that there were five. Catherine then explained that they could determine for sure by adding the top numbers. "Only the top numbers, " she reiterated, "because you're still talking about a group of what?" In unison, several students answered "five." Catherine then explained that subtraction would work the same way; that is, you only subtract the top numbers because you are still talking about a group of five. She demonstrated how to subtract $\frac{2}{5}$ from $\frac{5}{5}$ and covered up two of the five triangles to show that

there were three left. The class had worked on the Quick Check activity and Catherine's additional tasks for approximately 10 minutes before they moved on to the next task, which was drawn from the Motivate suggestion in the teacher's guide. The task involved folding strips of paper into parts, shading some of the parts with two different colors, and using the models to identify various fractions. Catherine posed each of the questions suggested in the teacher's guide and followed each student answer with a brief explanation.

After approximately 8 minutes, Catherine instructed the students to put aside these papers and turn to page 320 in their texts. She then proceeded to introduce them to the central topic of the lesson by leading them through the information and questions on the instructional page in their texts. She read aloud the title, Fractions: Part of a Whole, and reminded them that these were

fractions with their parts touching. Then she read the sentences at the top of the page that told about three children sharing a pizza equally and then proceeded to ask the questions that followed. The students had little difficulty explaining why $\frac{1}{3}$ is one divided by three or identifying fractions from shaded drawings on the page. The only question that posed some difficulty was the last: How many eighths are in one whole? At first Maura said that she thought one eighth was in one whole, but Catherine reminded her of the pizza they had talked about earlier in which three thirds were in the whole. Once Maura produced the correct, answer Catherine wrote on the board:

$$\frac{8}{8}$$
 $\frac{3}{3}$ $\frac{4}{4}$ $\frac{100}{100}$

She reiterated: "Whenever you have a fraction whose numerator is the same thing as the denominator you are talking about—?" Several students filled in the blank she left at the end of her sentence by saying: "One whole."

Rather than moving the class onto the next page in the text, which contained practice exercises, Catherine introduced a task offered in the margin of the teacher's guide under the heading Meeting Individual Needs. The instructions, which she had already written on the board, directed the students to fold a paper circle into eight equal parts and shade some one color, some another color, and leave some unshaded. Students were then to write four questions about their circle that could be answered with a fraction. Catherine gave the students approximately 8 minutes to fold, color, and write their questions before she instructed them to give their questions to a friend to answer. When Catherine called the class back together, she read aloud several students' questions with the answers that were given for the class to discuss. With this completed, Catherine instructed the class to do the exercises on page 321, which involved identifying fractional parts of figures. Because they had only 8 minutes of math class remaining, she told them that they would need to finish the page for homework. (Observation, April 6, 1993)

<u>Changes in Catherine's use of the HBJ textbook</u>. Compared to the lessons described earlier, this lesson represents several significant changes in the structure and emphasis of Catherine's instruction related to her use of the text. As the data indicate, the textbook continued to play a central role in Catherine's instruction; it still defined the

topics she taught, and she continued to rely on each two-page spread to shape most lessons. The differences were in the types of items she selected from the text and how she used them to structure her lessons. She selected more conceptually oriented tasks, and she ordered the activities in the lessons to devote more time to conceptual development.

On April 6th, Catherine spent the first 10 minutes of the lesson on the Quick Check activity, followed by another 8 on the Motivate activity. Both activities involved using or making fraction models, and she added her own elaborations to both. This was typical of the spring lessons. Catherine began four of the seven lessons with the Quick Check and Motivate activities suggested in the text, and she began a fifth lesson with only the Motivate activity. Many of these activities involved manipulating counters, folding and cutting paper to make fraction models, writing questions, exchanging papers with a partner, and having students go to the front of the room. As she did on April 6th, Catherine regularly extended these activities beyond what was suggested in the teacher's guide, asking students additional questions, creating pictures or inventing situations to illustrate the fractions involved, or allowing related digressions to divert class attention from the immediate task at hand. Unlike her tendency to stay away from such time-consuming activities in the fall and winter, Catherine seemed to have little hesitation about spending more than one third of a math lesson on these activities during the spring. Table 5.6 indicates the suggestions she drew from the text during the spring lessons.

Catherine's increased use of conceptually oriented activities from the textbook contributed to changes in the way she structured her lessons. The structure of her lessons in the fall and winter (brief instruction, followed by a healthy amount of independent practice, and closed with a short review)underwent considerable revision during the fraction unit in the spring. Even though the same lesson components were evident (instruction, practice, and review), Catherine organized and treated them

Table 5.6

Summary of Tools and Resources used in Catherine's Spring Lessons

| | I pecon/ | | Items used in | Items used on | | Other tools/ |
|------|--------------|---------------------------------|---|---|--|--------------------------------------|
| Date | text pages | Topic | Teacher's Guide | student pages | Other items used | resources used |
| 4/5 | 10.1/ | Exploring Fractions | Quick Check | Explore activity on | | Paper rectangles |
| | 318-319 | | Motivate | p. 318, p. 319 (1-8) | | for folding into |
| | | | Teach | | | fractional parts |
| 4/6 | 10.2/ | Fractions: Part of | Quick check (plus | •Pages 320-321 | | Paper strips and |
| | 320-321 | Whole | elaboration) | (except 16-19) | | crayons |
| | | | Motivate | | | |
| | | | •Teach | | | |
| | | | •MIN (average/ | | | |
| | | | advanced) | | | |
| 1 | 10.3/ | Fractions: Part of | Quick check | •Pages 322-323 | | |
| | 322-323 | Group | Motivate | | | |
| | | | MIN (basic/average) | | | |
| 4/8 | 10.4/ | Exploring: Finding a | Motivate | •Pages 324-325 | Paper rectangles for | •Counters |
| | 324-325 | Fraction of a Number | •Teach | (Making the | folding into fractional | |
| | | | | connection) | parts | |
| 4/12 | 10.4/ | Exploring: Finding a | | Pages 325 (Making | Paper strips and | •Counters |
| | 325-redo | Fraction of a Number | | the connection) | crayons | |
| 4/13 | 10.6/ | Exploring: Equivalent | Quick Check | Pages 328 all | | Paper strips and |
| | 328 | Fractions | •Motivate-modified | | | crayons |
| | | | ·Icacii | | | |
| 4/14 | 10/6/ 329 | Exploring: Equivalent Fractions | Reteaching sheet | •Pages 329 all | •Counters | •Counters |
| | | | | | | |

differently. Rather than beginning each lesson with instructional activities from the student page, she began all but the first lesson with a review of the work they had done the previous day. Most of these review activities originated from the suggestions in the margin of the teacher's guide labeled Quick Check. The tasks under this heading were designed to touch on previously taught concepts relevant to the lesson at hand.

Beginning with them facilitated the forging of connections between lessons from one day to the next, which I did not observe in the fall or winter. Even though I did not observe lessons on consecutive days until April, this was the first time that I observed Catherine linking ideas from a previous lesson to the present.

Another factor that contributed even further to the conceptual flow among the lessons in the spring was the amount of time Catherine spent on the review portion of the lessons. She spent as much as one fourth of the fraction lesson on review tasks, which was stimulated by suggestions in the teacher's guide but which she extended by creating more questions. The Quick Check with which Catherine opened the April 6th lesson, described above, is an example of such a review. She devoted 10 of the 60-minute lesson to questioning students about the three fraction diagrams.

After this review portion, Catherine would move into instruction aimed at introducing students to particular concepts, procedures, or ideas. This portion of Catherine's fraction lessons also had a different flavor than those observed earlier in the year. She devoted more lesson time to instruction (an average of approximately 60% per lesson compared to more than 30% in the fall and winter), and the instructional activities often involved as much exploration as direct instruction. These activities were designed to lead the students to realizing particular concepts or relationships. Catherine's role during exploration activities was to guide students to make observations and to draw conclusions rather than to tell or show specific facts or steps. Often, but not always, the activities oriented toward exploration were in the margins of the teacher's guide — not on the student page. Catherine used an exploration activity each day that I observed

except one. As she did on April 6th, she often took advantage of opportunities that arose to extend the exploration spontaneously.

Catherine's use of the practice portion of her lessons also underwent qualitative and quantitative changes in April. During the fall and winter, practice played a central role, taking, on average, half of each lesson. Even though she continued to use exercises from the student textbook during the spring, she devoted considerably less time to practice than she had earlier in the year. The nature of the practice changed as well. She devoted less time to independent practice, during which the students worked individually on a particular task, than earlier in the fall. She assigned students a task to complete individually on only three occasions across the seven lesson; the longest of these took 14 minutes. During the fall, students spent as much as 37 minutes (two thirds) of a lesson involved in independent practice. Tables 5.7 and 5.8 display the structure and format of Catherine's lessons in the Spring. Table 5.9 compares approximate amounts of lesson time devoted to each type of activity during the three rounds of data collection.

Table 5.9

Patterns in Instruction and Format of Catherine's Lessons Observed Across the Year

| Data | Number of | A | verage percentag | ge of time spent or | n: |
|----------------------------|---------------------|--------|--------------------|-------------------------|----------|
| collection period | lessons observed | Review | Direct instruction | Exploration instruction | Practice |
| Fall / Winter 1992 / 93 | 6 | 8% | 31% | 9% | 51% |
| Spring 1993 | 7 | 8% | 32% | 29% | 31% |

Another difference in Catherine's teaching of the fraction unit that contributed to her use of the text was that it was the first chapter that she taught unpaired with another. All the noncomputational units, to that point, had been paired with computational topics. By this time, she had satisfactorily covered each of the four

Summary of Structure and Format of Catherine's Spring Lessons

| | | | | | Total time | Jo % |
|------|-----------------------------|--|----------------------|--------------------------|---------------|-------|
| Date | Lesson | Topic of Lesson segment: | Nature of segment | Format of segment | of piece | total |
| 4/5 | 10.1: | 1. Introduction to fractions | Instruction | Whole class | 5 min of 62 | ∞ |
| | Exploring | 2. Folding fraction activities | Explore/instruction | Whole class | 19 | 31 |
| | Fractions | 3. Group exploring fraction activity on p. 318 | Instruction/explore | Small groups/whole class | 31 | 50 |
| | | 4. Oral work on p. 319 | Practice | Whole group | 7 | 11 |
| 4/6 | 10.2: | 1. Review of fractions, plus diversion | Review/instruction | Whole class | 10 min. of 58 | 17 |
| | Fractions: | 2. Naming fractional parts using models | Instruction/explore | Whole class | 00 | 14 |
| | Part of a whole | 3. Instruction: Parts of whole | Instruction | Whole class | 3 | 5 |
| | | 4. Oral work on p. 320 | Practice | Whole class | 9 | 10 |
| | | 5. Writing fraction questions | Explore | Independent/whole class | 22 | 38 |
| | | 6. Written work on p. 321 | Practice | Independent | 6 | 16 |
| 4/7 | 10.3: | 1. Naming fractional parts not shaded | Review | Independent/whole class | 12 min. of 61 | 20 |
| | Fractions: | 2. Naming fractional parts of group using students | Instruction/explore | Whole class | 13 | 21 |
| | Part of a group | 3. Introduction to p. 322 | Instruction | Whole class | 8 | 13 |
| | | 4. Written work on p. 322 | Practice | Independent/whole class | 8 | 13 |
| | | 5. Oral naming of fractions | Practice | Whole class | 9 | 10 |
| | | 6. Written work on p. 323 | Practice | Independent | 14 | 23 |
| 4/8 | 10.4 | 1. Identifying fraction of a group | Review/practice | Independent/whole class | 12 min. of 63 | 19 |
| | Fractions: | 2. Using counters to find fraction of a number | Instruction/explore | Whole class | 13 | 20 |
| | Part of a group | 3. Instruction on p. 324-325 | Instruction | Whole class | 38 | 19 |
| 4/12 | 10.4 (Reteach) Finding a | Instruction on finding fraction of a number using Instruction/practice counters | Instruction/practice | Groups and whole class | 40 min. of 57 | 70 |
| | fraction of a number | Instruction on finding fraction of a number using Instruction/practice arithmetic, p.325 | Instruction/practice | Whole group/ independent | 17 | 30 |
| 4/13 | 10.6 | Review/instruction on arithmetic method p. 325 | Instruction/review | Whole class | 4 min. of 68 | 9 |
| | Exploring | 2. Written work on p. 325 | Practice | Independent/whole class | 35 | 52 |
| | equivalent | 3. Written quiz: Fraction of a number | Practice/ assessment | Independent | 5 | 7 |
| | fractions | 4. Demonstration of student's method on quiz | Instruction | Whole class | 2 | 3 |
| | | Making models of equivalent fractions | Instruction/explore | Whole class | 22 | 32 |

Table 5.7 (Continued)

| Date | Date Lesson | Topic of Lesson segment: | Nature of segment | Format of segment | Total time of segment | % of total |
|------|-------------------|---|---------------------|----------------------------|------------------------|---------------|
| 4/14 | 10.6 Exploring | Instruction on equivalent fractions with counters, p. 329 | Instruction | Whole class | 26 min. of 76 | 3 |
| | equivalent | 2. Written work reteaching sheet with counters | Practice/review | Whole class/independent 27 | 27 | 36 |
| | fractions | 3. Oral and written work on p. 329 | Practice | Whole class/independent 23 | 23 | 30 |
| | Patterns in str | Patterns in structure and format across spring ^a | | | Average % ^b | |
| | | Review concept from last lesson | review | whole class | 8 of 64 min. | |
| | | Direct instruction on new or revisited concepts | instruction | whole class | 32 | |
| | | Introduction to topic through guided exploration | explore instruction | whole class/pairs/groups | 29 | |
| | | Practice concept or process alone or in whole class practice | practice | whole class/independent | 31 | |

 $^{\rm a}$ The general pattern in the spring lessons was less apparent than in the fall and winter. $^{\rm b}$ See Table 5.8

Table 5.8

General Patterns in Structure and Format of Catherine's Spring Lessons

| Date | Lesson Topic | Review | Instruction | Instruction / exploration | Practice | Total lesson time |
|---------|---|--------|-------------|---------------------------|----------|-------------------|
| 4/5 | 10.1 Exploring Fractions | | 8% | 81% | 11% | 62 minutes |
| 4/6 | 10.2 Fractions: Part of a Whole | 17% | 2% | 52% | 26% | 58 minutes |
| 4/7 | 10.3 Fractions: Part of a Whole | 20% | 13% | 21% | 46% | 61 minutes |
| 4/8 | 10.4 Finding a Fraction of a Number | 19% | %09 | 21% | | 63 minutes |
| 4/12 | 10.4 Finding a Fraction of a Number (Reteach) | | 100% | | | 57 minutes |
| 4/13 | 10.6 Exploring Equivalent Fractions | | %6 | 32% | 26% | 68 minutes |
| 4/14 | 10.6 Exploring Equivalent Fractions | | 34% | | %99 | 76 minutes |
| Average | | 8% | 32% | 29% | 31% | 445 minutes total |

operations, enabling her to devote the entire allotted math time, as well as her full attention, to fractions.

Changes in the emphasis of Catherine's lessons. The structural changes in Catherine's teaching contributed to related changes in the focus and emphasis of her lessons. During the fall and winter, Catherine placed primary emphasis on getting correct answers and giving the students as much practice as possible. In April, she focused more on helping students to explore and understand conceptual ideas, which was related to the increase in her use of exploratory and conceptually oriented suggestions from the textbook. The result was lessons aimed at developing students' understandings of the meaning of fractions. At the same time, the way she treated these activities and the amount of time she devoted to them imply that building students' conceptual understandings of fractions was her goal.

This aim was evident in the way Catherine made conceptually oriented additions to the tasks she used from the text. Often, as she did during the Quick Check on April 6th, she added more questions. At other times, the questions she inserted were sparked by things students did, that required explanations or justifications. For example, on April 6th Catherine questioned Joseph about his reason for changing an answer. Even though his answer was correct, she chose to use the opportunity to ask him to articulate his thinking. Then Catherine took advantage of another student-initiated diversion to reemphasize the meaning of the numerator and denominator. As Catherine said herself, Erin's question about adding $\frac{2}{5}$ and $\frac{3}{5}$ was "before its time." She decided to pursue it, however, and she did so in a way that focused on what the numerator and denominator represent.

When I asked Catherine about the apparent increase in her use of "why" questions as well as similar improvisations, she claimed that many of them were initiated by the text. "I think the book asks more why things," she told me. She further explained that the more she asked questions in the book, the more she saw their merit,

and the more she was inclined to insert her own questions. In order to illustrate, she pointed to the problem of the day written on the board:

There were 24 math problems. Sara did $\frac{3}{4}$ of the problems correctly. Nick did $\frac{6}{8}$ of the problems correctly. Who did more problems correctly?

"I made this problem up on the spot," she said, but "If I had been really thinking, I would have asked them how they knew or why they gave the answer they did." She explained that she wanted to ensure that they understood that the fractions were equivalent: "One of the things we've been working on is equivalent fractions, and that would just be, that would be making them put into their own words why they knew that each child had done the same number of problems" (Interview, 4/14/93).

The increased attention to student understanding seemed to be a result of her learning by using the text. Initially, she tried new suggestions sparingly. However, as she observed and participated in her students' encounters with activities that called for explanations, complex thinking, or modeling of concepts, she began to see these pedagogical approaches as valuable. At the end of the year, Catherine offered the following explanation:

When I started out in the fall, even though I had used this textbook as a pilot the year before, I still kind of tended to teach the way I did with the old book. I followed the old routine. But, as the year progressed, I began to use more of the ideas in the book, and, um, really found them helpful with the children, and used their ideas that they suggested instead of just kind of clinging to the old, my old way of doing things. (Interview, 6/25/93)

Consequently, Catherine looked for and used more conceptually oriented suggestions in the text, as well as creating her own, which she added to the offerings of the text. In essence, using the text created opportunities for learning that moved Catherine beyond the offerings of the text.

<u>Changes in Catherine's ideas about understanding and learning math</u>. Many of the changes observed in Catherine's teaching and use of the text during the fraction unit seemed to be related to her expanding ideas on what understanding mathematics includes and how this understanding is developed. Earlier in the year Catherine felt her students "understood" when they were able to complete accurately the tasks she gave them or to provide the correct answer. Catherine's use of conceptually oriented tasks during the fraction units, as well as the base-10 blocks when teaching long division, seemed to interject a new twist into her view of understanding. Procedural mastery still seemed central, but Catherine also believed that it was important for students to connect these procedures to underlying meanings represented concretely or pictorially. After a lesson during which she used counters to model finding discrete fractions (such as $\frac{1}{4}$ of 12) and then followed with teaching the symbolic notation, Catherine expressed concern that the students did not "understand that this [pointing to the algorithm] is the same as this [pointing to the representation with counters]" (Interview, 4/8/93). When asked why the connection was important, Catherine articulated her stance on the role of understanding in math, which was markedly different from her earlier emphasis on computational mastery:

I think that people that really are able to do problem solving and the higher mathematics are the ones that understand the connections. And then the people, like myself that just learned the processes when I was younger, had more trouble with the higher math later on because I really didn't understand a lot of the reasons why certain things worked. (Interview, 4/8/93)

Even though it was not evident that Catherine's understandings of mathematics grew through her use of the text, the changes in her teaching and her talk suggest that it stimulated learning about the nature of mathematical understanding.³

³Determining whether Catherine's understandings of mathematics changed was difficult because she seemed reluctant to talk about such instances whenever I broached the subject. For example, after she told me about using the base-10 blocks for the first time to model the division algorithm, I asked her if it had helped her understand the algorithm. She stated that she already understood it. She responded similarly when I asked if she felt she understood fractions better through the intensive work with various fraction models. In both instances, she seemed surprised that I would ask her about her mathematical knowledge. Even though Catherine may have understood these mathematical concepts but had never focused on them in teaching, it is also possible that she was uncomfortable discussing former or present holes in her knowledge of the mathematics she taught and, therefore, was not inclined to assess her own mathematical learning.

Computational Processes: A Domain Untouched

Catherine's learning did not have an observable impact on the way she structured the mathematics curriculum or thought about what was at the core of her instruction. Even though she began to see other mathematical topics as more interconnected and grounded in thinking and reasoning, as well as having priority over computation, she did not reexamine her views on what learning computation included. In fact, the ideas and perceptions about mathematics and the intent of the reforms that Catherine brought to her use of the text enabled her to dismiss most of the text's suggestions regarding teaching computation. Her view of mathematics, which consisted of two distinct domains (computation and noncomputational skills), remained unchanged. Catherine's perception that the intent of the reforms was to add noncomputational topics to the existing curriculum allowed her to direct her use of the text toward one part of the curriculum, shielding her beliefs about teaching computational processes from reexamination.

The likelihood that change in this fundamental layer of Catherine's math teaching would ever occur was unclear. Because her overall view of mathematics did not change significantly, one might speculate that the resiliency of her ideas about mathematics, and computation in particular, makes change in this domain unlikely. On the other hand, considering the order in which she was willing to entertain new ideas in other domains of her teaching, one might speculate that reexamining a topic close to the heart of her teaching might have occurred next. The changes that took place during her first year of using the text began at the periphery of her mathematics instruction and then moved inward. The first sites for learning, which began to take place mid year, involved problem solving, which was an activity that she treated separately from her daily lessons. The second sites, which involved some aspects of her daily instruction, did not begin until April. Catherine's learning from the HBJ text may have been on a trajectory that was gradually moving closer to the heart of her teaching.

While inconclusive, Catherine offered some evidence that might support this conjecture. First, in February, she ventured briefly into the chapter on division, drawing from it the activity that modeled the long-division algorithm with base-10 blocks. Furthermore, she was impressed by the clarity with which the model represented the underlying concepts to the students. She also was impressed with many of the conceptually oriented activities in the fraction chapter to the extent that she seemed almost willing to explore more of its offerings. In June, when I asked her if she believed that she would use the text differently next year, Catherine suggested that she would: "I didn't go through the book chapter by chapter and I almost think [that] maybe I need to do that next year" (Interview, 6/25/93).

Contextual Support: Opportunities for Experimentation, Reflection, and Conversation

As the descriptions suggested, the changes I observed in Catherine's teaching were stimulated by an interaction of personal and textual resources. Contextual resources also influenced the way she looked at the textbook and how she thought about its offerings. Some aspects of the context, like the pressure she felt to prepare her students "to go on to fifth grade," are typical for many elementary teachers. Other aspects were unique to Catherine's teaching situation. The most significant of these contextual influences was generated by the context of the study itself, which was Catherine's response to my presence in her classroom as an observer and the interactions we had in which she talked about her teaching. Even though the intent of my role as an observer and interviewer was to examine her encounters with the text, Catherine's cognizance of my interest and her intellectual response to my questions led her to gain a perspective on her own teaching, which was new. This perspective provided and supported opportunities for experimentation, conversation, and reflection that influenced the pedagogical choices she made about the text.

Even though the study was not designed to alter the teachers' actions in any specific ways, acknowledging and examining the role that my presence, as a researcher,

played in how Catherine made sense of and used the HBJ textbook is crucial for two reasons. First, doing so is essential to achieving what Lather (1991) refers to as <u>catalyst validity</u>, that is, "recognition of the reality-altering impact of the research process" (p. 68). Second, in light of the changes that Catherine underwent during the research process, examining this aspect of the context can provide insights into an unanticipated, but powerful, resource that influenced her choices. The way that the opportunities created by the study stimulated Catherine's growth has implications for the potential of similar opportunities to foster teachers' growth as they use new curriculum materials.

Catherine's school context provided few opportunities for her to discuss mathematics instruction or use of the HBJ textbook. Neither was she provided ongoing support or encouragement to try the new suggestions it offered. She reported occasional lunch-room conversations about the text with her colleagues over lunch. These conversations focused on criticisms of the text's fast pace and insufficient emphasis on practice. In fact, the conversations she had with me seemed to be the only consistent opportunities she had to talk about her use of the text. During the interviews that followed each observation, I asked Catherine about the choices she made regarding the text and why she made them. These conversations had the unintended effect of drawing her attention to the range of offerings in the textbook while providing her with a forum for discussing and reflecting on them. As the following descriptions illustrate, these opportunities contributed to how she used the text.

Opportunities for Experimentation

Catherine's response to my visits became evident at the end of the first round of data collection. As described, Catherine devoted the entire lesson on December 10th to the Motivate activity suggested in the teacher's guide of lesson 4.7. This data collection activity was significantly different in structure and emphasis than other lessons observed. Later, Catherine told me that she had saved that activity for a day that I visited because she believed I would like to see it: "I wanted to do this with you here for

you to see it," she told me; "I was going to do it and I thought, well, you might as well see it" (Interview, 12/17/92). Her interest in having me see this activity suggested that my presence had an impact on her choices.

This impact was the result of Catherine's response to my visit in two ways. First, her knowledge of my interest in reform-oriented texts made her even more conscious of her own use of the text and her reception of artifacts of change: "I didn't want to appear to be one of those teachers that was stuck in the same old groove, which is pretty easy. . . I've taught 31 years pretty much the same way" (Interview, 6/25/93). Second, the questions I asked about suggestions she had not tried in the text shaped her ideas about what I would be interested in seeing. Eventually, my visits and questions led her to look at the text more closely and encouraged her to try things that she might not have considered otherwise. "It [my presence] made me look at more of the suggestions," she later told me (Interview, 6/25/93), and it created what she described, in retrospect, as a "friendly pressure to try things" (Interview 4/14/93).

The "friendly pressure" Catherine felt from my observations and interviews made her uncomfortable at first. however, midway through the year, she welcomed my visits and said that she looked forward to our interviews. She believed they encouraged her to overcome what she called "the teachers' [sic] fear of the unfamiliar" (Written reflection, 4/93). For example, when I returned in the winter for another round of data collection, Catherine told me of a new activity she had tried during my absence. She used the suggestion in the text to model long division with base-10 blocks. She proudly reported it as her first "successful" encounter with manipulatives. Catherine linked her initial use of manipulatives to the friendly pressure she felt:

I probably tried that with the base-10 blocks with division because you were there and you were asking me about manipulatives. . . . I mean because you ask me these questions that makes me uncomfortable if I don't try some of the things. I would have tried some of them anyway, but it would have been much easier to do the same old thing that I've always done. (Interview, 4/3/93)

Moreover, she believed that the results of her experiments were positive. She gradually saw value in many of the suggestions in the text: "The more I use this book the more I like it" (Interview, 2/16/93), she said, after telling me about using the base-10 blocks.

Catherine was typical of many teachers whose work occurs behind the closed doors of the classroom, creating an environment of isolation and individualism (Jackson, 1986; Little, 1982; Lortie, 1975; Richardson, 1994). Opening her classroom to a stranger involved inviting in outside standards, perspectives, and pressures. As Catherine described it, the pressure she felt forced her to overcome her fear of trying new things: "I just think that because you were here I did things, and got over being afraid of new things" (Interview, 4/12/93). Catherine even described herself as "eager to try new ideas" as a result of her participation in this project.

Opportunities for Conversation and Reflection

Many of Catherine's comments during formal and informal interviews indicated that the nature of these interviews also prompted her reflection on her teaching. By design, the questions I asked were intended to delve into her pedagogical reasoning. Because these questions inquired into her thinking and decision-making processes, Catherine began to articulate positions that she had not explored previously. On several occasions, she started an explanation with: "I've never really put it into words before, but...." Essentially, the interview sessions asked Catherine to reflect on, and talk about, her practice, which she seldom had an opportunity to do. By spring, Catherine was articulate about the impact the interviews had had on her thinking. She looked forward to them, describing them as "a helpful tool in the continuing process of becoming better at what I do" (Written reflection, 4/93).

Catherine also recalled that she did not always see the interviews as positively as she did in April; at first, they were "somewhat unnerving." She remembered feeling "put on the spot, simply because I had never been asked to validate verbally my criterion for teaching a certain thing or why I had proceeded to teach it in a given manner" (Written

reflection, 4/93). In retrospect, she saw the discomfort that she had initially felt as useful, which led her to formulate and examine her views: "I began to question myself" (Written reflection, 4/93). For example, after I observed the class work on the problem of the day on March 24th, Catherine told me that she had found herself thinking about the questions I might ask, particularly because less than half of the students solved the problem correctly: "I knew that you were going to ask me about the problem of the day. . . and so I really had to, I thought about how I really felt about it" (Interview, 4/3/93).

My presence and questioning of Catherine unintentionally served as a resource for her teaching. Unlike many teacher resources that supply instructional guidance or helpful information (Sparks & Loucks-Horsley, 1990), I acted as an inquisitive other interested in what she did and why. The questions I asked became questions she asked herself as she interacted with the textbook. This impact is similar to findings of others who have noted the impact of ethnographic inquiry on the research context (Berkey et al., 1989; Florio-Ruane, 1986). Berkey et al., for example, described a project in which researchers, who generally function outside the school community, observed and asked questions of those on the "inside" about everyday practices or regularities (Sarason, 1982). This process had an impact on the teachers' perspectives. As one teacher wrote:

They asked us questions that we knew the answers to, but until they had asked us the question, we hadn't thought about the answers; that began to get us to question more things ourselves... By being asked questions and reflecting on them, we discovered ways that we wanted to change.... We began to question our own assumptions. (p. 13)

Similarly, my interactions with Catherine prompted her to reflect on and examine her choices.

Textbooks as Tools for Teachers' Learning: Issues Raises by Catherine's Case

As the preceding descriptions and analyses revealed, the HBJ text had an impact on Catherine's thinking and practice, albeit to a limited extent. As she struggled to fit

⁴I am grateful for Steve Smith's contribution to my understanding of this relationship. As he characterized it, Catherine had my voice in her head as she planned and taught mathematics.

new suggestions from the text into her practice and to ensure that her students met them with success, she found herself reassessing some of her own ideas about mathematics and students' learning of it. Her case suggests that textbooks and other curriculum resources might have the capacity to initiate or support changes in teaching by providing teachers with activities. On the other hand, the text did not impact all aspects of Catherine's mathematics instruction. Her use of the textbook and its consequent influence on her teaching were selective. Her view of the reforms as adding new topics and teaching strategies to the extant curriculum supported her in overlooking the computational chapters in the new text, thus enabling her not to reexamine her ideas about their place in the mathematics curriculum.

Catherine's case suggests that the relationship between a teacher's perceptions, beliefs, and understandings and her practice can flow in both directions.⁵ As studies of teaching in the context of reform have documented, teachers' views can be powerful lenses that shape how they interpret and use new information about teaching (Putnam, Heaton, Prawat, & Remillard, 1992; Rand Corporation, 1975; Sarason, 1982; Stake & Easely, 1978) and what they are willing to consider in a new textbook (Donovan, 1983; Putnam, 1992; Remillard, 1991c; Stephens, 1982; Wilson, 1990). However, Catherine's case also exemplifies the relationship between beliefs and practice in other, less frequently discussed ways. She tried new suggestions that prompted changes in her thinking, revealing that changes in practice can lead to changes in beliefs (McLaughlin, 1990; Remillard, 1992; Wiemers-Jennings, 1990). Catherine's case raises questions about when and under what circumstances. How did the text penetrate some aspects of Catherine's practice and not others? These are questions I explore in Chapter 6.

⁵The relationship between one's beliefs and practice is used often in the study of teaching, but it is not unique to teachers. This relationship applies to district administrators, staff developers, teacher educators, and educational researchers — all of whom are guided by their understandings of the world. Because the intent of the present study was to examine teachers' uses of and learning from texts, I focused on the relationship as it applies to teachers and teaching.





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CHANGING TEXTS, TEACHERS, AND TEACHING: THE ROLE OF CURRICULUM MATERIALS IN MATHEMATICS EDUCATION REFORM

VOLUME II

Ву

Janine T. Remillard

A DISSERTATION

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CHAPTER SIX

CURRICULUM DEVELOPMENT, TEACHER DEVELOPMENT, AND THE TEXTBOOK: A CROSS-CASE ANALYSIS

How do teachers interact with and draw on a reform-oriented text, and how does it impact their teaching? In what ways and under what circumstances can a textbook or teacher's guide support teachers in their efforts to change their mathematics teaching? These questions guided my examination of Jackie and Catherine's first year of using the HBJ text. The cases characterized each teacher's individual interactions with her textbook and how they played out in her practice. The purpose of this chapter is to look across both cases to consider what they, as a pair, imply about the role that texts might play in supporting change in mathematics education.

In this chapter, I take a different starting point than I did in the cases. Rather than focusing directly on the teachers' interactions with the textbook, I use the cases to examine what Doyle (1992) called the "curriculum process," that is, how the teachers enacted curriculum in their classrooms. I began with the curriculum process because it is by implication the key target of the current reforms in mathematics education. In order for students to learn mathematics differently, their classroom experiences must change. Consequently, textbooks designed to facilitate such change in teaching and in teachers must contribute to the curriculum development process. In this chapter, my goal is to develop an understanding of this process, as well as the various factors that shape it, in order to consider the roles that textbooks or other curriculum materials might play.

In doing so, I hope to draw together two domains of research discussed in Chapter 1. The first domain examines teachers' use of curriculum materials and

considers which aspects of texts they draw on (Freeman & Porter, 1989; McCutcheon, 1981; Stodolsky, 1989; Sosniak & Stodolsky, 1993), the factors that influence these choices (Donovan, 1983; Putnam, 1992; Remillard, 1991; Stephens, 1982), the impact texts have on teachers (Ball & Feiman-Nemser, 1988), and how teachers might overcome the restrictive control of published curriculum materials (Ben-Peretz, 1990). The focus is generally on the interaction of teachers and texts and how teachers make sense of their texts. The second domain focuses on curriculum processes in education (Doyle, 1992). Researchers from this perspective view the curriculum as the actual events teachers and students create and experience in the classroom as well as the teacher as the curriculum maker (Clandinin & Connelly, 1992). This research also examines the role of the teacher in creating or enacting curriculum in the classroom (Doyle, 1992; Golden, 1988; Lemke, 1990; Snyder, Bolin, & Zumwalt, 1992). Their focus is less on the teacher-textbook relationship and more on the teacher-curriculum relationship, that is the texts teachers write in the classroom.¹

Drawing these two domains of research together imposes twists on the conventional uses of several terms. These different meanings allow one to look at the activity of teachers from new perspectives. In using the term texts to describe what teachers write in the classroom, for example, I am referring to neither a material text nor the physical act of writing. Rather, I am referring to the nonphysical products of teachers' instructional actions and talk. My intent is to juxtapose them with the very concrete textbooks designed to shape or represent instructional activity. Similarly, researchers in these two domains often use the term curriculum differently. Curriculum in the first domain generally refers to the formal (Doyle, 1992) or planned curriculum (Gehrke, Knapp, & Sirotnik, 1992). In the second domain, it refers to that which is enacted in the classroom (Gehrke, Knapp, & Sirotnik, 1992; Snyder, Bolin, & Zumwalt,

¹In her analysis of how teachers enact curriculum in story-reading lessons, Golden (1988) referred to the teachers' instructional moves and themes as "instructional texts," which she contrasted with the written texts the teachers used to guide the lesson. Instructional texts, she argued, offer the teacher's interpretation of the written text.

1992). My use of the term <u>curriculum</u> in this chapter primarily refers to the experiences enacted by the teacher in response to students.

Central to my analysis is an extension of the term reading beyond its conventional usage. Generally, reading refers to making meaning through engaging written text. Scholars of reading describe it as a process that is dynamic and constructive, involving interaction between the reader and the text and situated within a particular context (Pearson & Stephens, 1994; Rosenblatt, 1994).² Reading is a process in which readers "use their existing knowledge and a range of cues from the text and the situational context in which the reading occurs" to construct meaning from written text (Dole, Duffy, Roehler, & Pearson, 1991, p. 241). This describes what happened when Jackie and Catherine read the textbook. The meanings they constructed grew out of interactions between their beliefs, as well as what they actually attended to in the textbook and were situated in the larger context of their teaching. The textbook, however, was not all the teachers <u>read</u> in the process of enacting curriculum. Their curricular decisions also were influenced by the meanings they made from observing and interacting with their students as they worked on mathematical tasks. In this sense, the teachers read students and their mathematical activities, as well as written suggestions in the textbook, in the process of constructing curriculum. As with all reading, the meanings they constructed affected the beliefs and knowledge they brought to their reading. Bloome and Egan-Robertson (1993) posited: "The meaning of an utterance or other language act derives not from the content of its words, but rather from its interplay with what went before and what will come later" (p. 309).

This chapter is divided into two parts. In the first part, I draw on the cases in order to articulate a model for teachers' curriculum development processes. My intent is twofold: to provide a theoretical frame for examining the various pieces of teachers'

²Reading scholars disagree about the extent to which reading is cognitive or social and whether meaning resides in the reader or the text. Most, however, describe it as dynamic, interactive, constructive, and contextually situated.

curriculum development and to consider what went inside this frame for the teachers in this study. This frame includes, but is not limited to, the role the textbook plays. Underlying this frame is my assumption that teachers mediate textbooks' contributions to students' mathematical learning. Thus, examining Catherine's and Jackie's activities within this frame allows one to look at patterns and distinctions across two different teachers. In the second, part I look at this dynamic from the other direction, that is, how the teachers' curriculum development processes impacted them and their teaching. This analysis is important because of the current reform context. If change is to occur in the curriculum that teachers enact in the classroom, it must do so through their curriculum development activities. Here, too, both teachers' reading played a significant role in stimulating change. Because my central question is about the role of textbooks, I include examinations of the textbook in light of my analysis. In these sections, I draw on my analysis of the HBJ textbook in Chapter 3 in order to consider how the nature of this particular text contributed to the teachers' reading and the related changes observed throughout the year. This analysis can lay the groundwork for speculating on how teachers might interact differently with differently designed curriculum materials.

The Teacher's Role in Curriculum Development

Despite the different ways that Jackie and Catherine drew on and used the HBJ text, their activity in relation to planning and teaching mathematics can be understood similarly as activities of <u>curriculum development</u>. This is the process by which teachers develop curricular plans and ideals and translate them into classroom events, including how they use resources such as textbooks or other curriculum materials. The way in which I am using the construct of curriculum development assumes a view of curriculum as the actual events enacted in the classroom with students (Doyle, 1992; Cornbleth, 1988; Posner, 1988; Snyder, Bolin, & Zumwalt, 1992), or, as Jackie and Catherine illustrate, "an evolving construction" that emerges from interactions among teachers and students (Zumwalt, 1989, p. 175). Thus, the curriculum development

process plans and shapes what students experience in the classroom. Because I address the mathematics curriculum, the discussion focuses on what students experience in the classroom that relates to learning of or about mathematics.³

The term "curriculum development" is often used to describe the work of people who write textbooks or materials designed to guide teachers in their teaching. Thus, in talking about teachers as curriculum developers, I suggest that the curriculum development process does not stop when textbooks are printed, rather, it continues with the teacher in the classroom. My hope in using the term is to build on Ben-Peretz's (1990) conception of the teacher's role in curriculum development. She argued that there are two levels of curriculum development. The first level is what curriculum writers or teachers do when conceptualizing curricular plans and then writing them in resources for teachers. Gehrke, Knapp, and Sirotnik (1992) called this the "planned curriculum." The second level is what teachers do when they alter, adapt, or translate textbook offerings to make them appropriate for their students. In her discussion of the teacher's role in curriculum development, Ben-Peretz referred to the deliberate actions of teachers who learned to "uncover the potential of curriculum materials so that these can be reconstructed for particular students and for specific classroom situations." Such a process involves seeing texts as "more than the embodiment of their developers' intentions" (p. xiv) and then translating curricular ideals that are planned or written by others into ideals that the teacher actually intends. Since curriculum is that which is enacted in the classroom, my observations of Jackie and Catherine suggest that the teacher's role as curriculum developer involves more than selecting and redesigning curriculum plans; it involves enacting them in the classroom with, and in response to,

³What the mathematics curriculum <u>is</u> is not "cut and dried." It includes, but is not limited to, students' experiences during the daily 45 to 60 minutes in the school day devoted to formal math. Students' learning of or about mathematics most likely is woven across the school day explicitly and tacitly. Students might learn math through related activities in other subjects such as measuring, counting, totaling, and comparing. They also learn about math through these activities, as well as how math is treated and situated with respect to other subjects. For example, Catherine's separation of problem solving from her more conventional math lessons likely represents ideas about what math is and is not to students.

students. In this process, the curriculum actually constructed is responsive, interactive, and emergent to the extent that it is impossible to capture it on a written page. Even a teacher who seems to be following the textbook suggestions as closely and carefully as possible is making curriculum development choices.

My aim in this section is to articulate a process of curriculum development that applies to both Catherine and Jackie. I use my analyses of these teachers to develop a model of the components of the curriculum development process that is relevant to teachers and mathematics teaching in general. And, at the same time, I aim to consider the issues that Jackie's and Catherine's activities within this model raise about the role of curriculum materials in reform.

My analyses revealed three arenas in which the teachers engaged in curriculum development: the design arena, the construction arena, and the mapping arena. Each arena defines a particular aspect of the curriculum development process about which teachers explicitly or implicitly make decisions. The design arena involved selecting and designing tasks for students. The construction arena involved the actual construction of the curriculum by enacting these tasks in the classroom and responding to students' encounters with them. The mapping arena involved choices that determined the organization and content of the planned curriculum. Unlike the first two, the mapping arena is not directly related to daily, classroom events, but it impacts and is impacted by them. For Catherine and Jackie, the activity of this arena was less apparent than that of the other two because it involved choices that were not always explicit and that the teachers made throughout the year. Their decisions in this arena created the mathematical contexts in which their activities in the other two arenas occurred. Even though I am using these three arenas to delineate distinct aspects of the curriculum development process, I do not intend to suggest that the decisions in each necessarily occur serially or distinctly. Making a particular task selection, for example, might have the effect of adjusting one's curriculum map. Similarly, the process of enacting a

particular task is likely to lead to further task selection, as well as possible changes in the curriculum map. Below I describe the domain of each of these arenas and then illustrate how they played out in Catherine's and Jackie's teaching.

Task Selection in the Design Arena

Task selection occurred in the design arena of curriculum development. It included selecting, altering, and constructing tasks — the activities teachers give students to do. These activities might be single problems designed to spark exploration or teacher-led paths through sets of straightforward questions posed in the text. The tasks that teachers select, regardless of the extent to which they differ from those described in the textbook, represent assumptions about content and pedagogy, that is, what students should learn and how they should learn it. Task selection, then, is the process through which a teacher gives purpose to a proposed activity in the text or creates her own. It is an on-going, teacher-mediated link between the planned (Gehrke, Knapp, & Sirotnik, 1992) curriculum, as conceived by textbook writers or policy makers, and the curriculum actually enacted by the teacher. The role of the teacher in this process is exemplified in the strikingly different ways Catherine and Jackie used the HBJ textbook.

In the following sections, I characterize and compare the two teachers' approaches to task selection and the role that the text played. In accounting for their differences, I argue that underlying them are different ways of <u>reading</u> the text. My intent is that in illuminating the meaning of reading, as it applies to these two teachers, I might develop a lens to examine and describe how teachers make sense of curriculum materials.

Two Approaches to Task Selection

Catherine and Jackie illustrate two distinct approaches to task selection that involved different ways of reading the text and, consequently, drawing different items from it. In the following descriptions, I use examples from each case. The classifications for task selection (appropriation and invention) serve as theoretical lenses for

understanding teachers' interactions with mathematics texts around the selection and design of tasks. Other ways for teachers to select tasks are likely, but these two provide one instance of the variation in reading and using a text in the design arena.

<u>Catherine</u>: <u>Task appropriation</u>. When teaching topics other than the four operations, Catherine constructed tasks by selecting and drawing them from the textbook and inserting them into her teaching. Her commitment to incorporating certain reform-related topics into her mathematics instruction, as well as her faith in the text to provide tasks that embodied these topics, impelled her to use tasks in the text. Task selection for Catherine involved a process of appropriating those she chose from the text. These tasks included the problems of the day, as well as many found in the noncomputational chapters. As I described in her case, even when she did not fully agree with or understand the intent behind the particular tasks, she used them because they represented aspects of the reforms she sought to add to her teaching. Through using them, she gave them her own purpose, which, in general, was for the students to complete them successfully, producing the answer printed in the teacher's guide. The only instances in which Catherine did not appropriate tasks from the text was when teaching computational topics. Then she relied on her own pedagogical repertoire to teach the procedural steps. In this discussion, however, I focus on her efforts to incorporate topics associated with the reforms into her teaching.

Catherine's approach to task selection can be described best as a process of appropriation because it implies taking possession of something or making it one's own. The central idea in task appropriation is that the teacher intends to draw the task from the text as is. Appropriation is often referred to as "following" the text. I have not used this term because, as I later suggest with Jackie, following the text does not necessarily involve appropriation. The problem that Catherine used on December 3rd provides a good example of her general approach. The textbook lesson was one of the two problem-solving lessons found in each chapter. Wanting to incorporate more problem

solving in her mathematics instruction, she followed the suggestions in the teacher's guide while walking the students through each step of the problem-solving process.

As I describe in greater detail later, appropriating tasks also involves bringing one's own meaning and purpose to them since giving concrete form to any task offered in a text requires making additions and adjustments. Thus, it is likely that teachers appropriating the same tasks from the same text would interpret and enact them differently. Figure 6.1 illustrates Catherine's approach to appropriating tasks from the text.

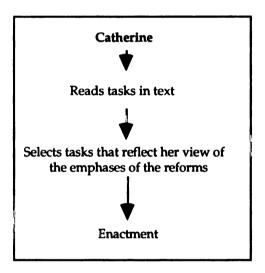


Figure 6.1. Catherine's approach to task selection

<u>Jackie: Task invention</u>. Unlike Catherine, Jackie did not select and use tasks from the text. Rather, she used the text as a source of mathematical and representational ideas from which she adapted and developed tasks for the class. These ideas ranged from mathematical concepts or relationships she believed her students needed in order to understand, to concrete ways to represent them or facilitate students' exploration of them. Because she believed the reforms were aimed at developing students'

understandings of mathematical ideas and relationships, she rejected tasks that required only rote skills. She drew on her vision of good mathematics teaching to invent tasks that focused on ideas she believed were important. As the descriptions in her case illustrate, the tasks she designed engaged students in exploring these mathematical ideas, discussing their understandings with one another, and inventing their own solutions to problems.

The task she designed for the September 16th lesson provides an example of her inventive approach. In preparation, Jackie reviewed the explanations, examples, and tasks on pages 4 and 5 of the text, concluding that the central idea on the page was the relationship between the values of the places in the base-10 system, and that 140 hundreds, for example, was another way to show 14,000. This idea, she believed, was crucial for students to understand, but the tasks on the page were unlikely to get at it since they merely asked students to show these equivalencies by filling in blanks such as 300 =_____ tens. She later pointed out that students could memorize the pattern, replicate relationships such as 14,000 ones = 1,400 tens = 140 hundreds, and be no closer to understanding why. Thus, she invented a task that required students to use drawings of base-10 blocks to illustrate and even "prove" the relationships written in the text. Her process of task selection is represented in Figure 6.2.

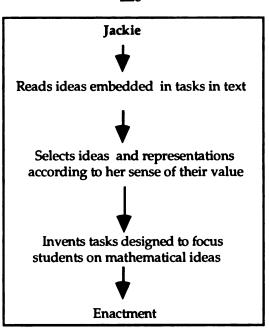


Figure 6.2 Jackie's approach to task selection

<u>Different Approaches to Task Selection: Different Readings of the Textbook</u>

Catherine and Jackie's approaches to task selection involved different ways of drawing on and using the text. Others have observed that teachers' ideas about mathematics, students, teaching, and learning influence what text suggestions they used (Freeman & Porter, 1989; Putnam, 1992; Sosniak & Stodolsky, 1993) and how they interpret and use them (Donovan, 1983; Remillard, 1991c; Stodolsky, 1989; Stephens, 1982). Examining what is at the heart of these differences can illuminate how teachers make sense of textbooks. My analyses reveal that these differences were outgrowths of how each read the textbook. In this arena, reading the text involved a series of implicit decisions about what to attend to or read in the text, as well as bringing meaning to what they read.

In addition to bringing their own meaning to what they read, Catherine and Jackie illustrate two other differences in reading the text. First, they read and paid attention to different parts of the text and dismissed others. At the beginning of the

year, Catherine tended to pay attention to suggestions that guided her in getting students through the exercises on the students' pages. She read the student text and the steps described in the margins of the teacher's guide. As her thinking changed, she began to read more exploratory suggestions, such as those under the heading Motivate. These suggested interactive tasks that related to, but did not involve, the student's page. She did not read the supplementary pages in each chapter that offered hands-on and exploratory activities related to the concepts in the lesson, and she did not read the chapters on computation. Throughout the year, Jackie read suggestions that engaged students in exploratory activities such as those that Catherine skipped. Recall both teachers' introductions to the fraction unit. Skipping the page that introduced the students to the chapter and various examples of fractions, Catherine started her class on the first lesson in the chapter, which included a page of exercises for students. Jackie and her class spent the first 3 days of the unit on exploratory tasks that grew from those suggested in the introduction to the chapter.

The second difference in their reading of the text was more subtle. They read the same words for different purposes. When Catherine looked at a suggestion in the text, she read it for tasks she might appropriate, steps to follow, and things to do. Most often she focused on exercises for students to complete or questions to ask them. Jackie read similar suggestions as attempts to address particular mathematical understandings through tasks. The task she read on page 4, for example addressed the relationship between the places in the place-value system. In reading the text, she focused on underlying ideas rather than on the task. Thus, her reading of the tasks on pages 4 and 5, which offered a series of fill-in-the-blank questions that equated ones, ten, hundreds, and thousands, suggested a particular relationship important for students to understand. Whereas Catherine's readings provided her with a set of activities to have students do, such as fill in each blank, Jackie's readings suggested a relationship they needed to understand. Even when she began to use more conceptually oriented tasks in

the text, Catherine focused on engaging students in a task such as using counters to find fractions of various numbers or writing and answering questions about fractions.

Catherine's reading is consonant with Borko and Nile's (1987) observation that teachers seldom begin with objectives or goals when planning. Rather, they tend to focus on activities in which objectives are embedded. Jackie's reading was the opposite. She focused on the objectives embedded in the tasks and started her planning with them.

The activities followed.

Factors That Shaped the Teachers' Readings of the Textbook

Accounting for the different ways these two teachers read the textbook illuminates key factors that shape teachers' readings and task selection. My analyses revealed two main factors that shaped these ways of reading the text: how each thought about the contents and nature of the mathematical terrain and the view each held about teaching and learning. Both grew out of their ideas about teaching, learning, and mathematics. The first factor — how they characterized the mathematical terrain — shaped the views they held about the reforms and what the text had to offer. These views figured in what they read in the text. The second factor — their ideas about teaching and learning — shaped how they learned from the text and what they believed it should provide. Each teacher established a relationship with the text that paralleled the teacher-learner relationship she constructed with her students. I discuss these two factors below, illustrating how they contributed to the differences in the teachers readings of the text. I then consider how differences in their teaching situations also contributed to this process. Figure 6.3 shows how these factors interacted with one another.

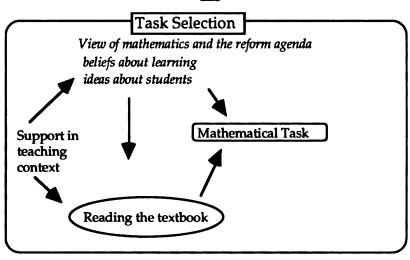


Figure 6.3 Task selection process

The mathematical terrain. Catherine and Jackie had different views about mathematics, the content and nature of the reforms, and what students must learn. These views figured in what they expected of the text and shaped the parts of it they looked at.

Catherine believed that math was a collection of topics. From her perspective, the reform agenda aimed to add new topics, such as problem solving, graphing, and geometry, to a curriculum that tended to focus on computational skills. She did not believe that the reforms suggested changes in topics currently taught. Thus, she did not believe that the text had anything to contribute to her teaching of them. This view influenced what she looked at in the text. She focused on the problem-solving tasks and the suggestions for teaching noncomputational topics such as data analysis, graphing, and fractions, while continuing to teach computational procedures as she always had.

⁴The lack of explicit attention to computational skills in the reform rhetoric was noted by Putnam and Geist (1994) as a trouble spot for many teachers attempting to make sense of the reform agenda. In her study of an elementary teacher struggling to respond to the reforms, Geist (in preparation) argued that the lack of explicit attention to where computational skills belong in the larger picture of teaching children to think mathematically may undermine reformers' efforts to paint a picture of mathematics understanding in which conceptual understanding and computational skills are intertwined.

The relationship between Catherine's ideas about the mathematics reforms and what she looked at in the text also was evident in the changes she made throughout the year. As she developed a greater appreciation for particular emphases of the reforms, what she was willing to try in the textbook lessons changed. Initially she concentrated on tasks that provided students with independent practice of skills they had learned. However, as she began to value reasoning and exploration in learning math, she started to select and appropriate more activities that afforded students opportunities to explore underlying mathematical meanings. Change was particularly evident during the fraction unit when she selected many tasks from the Motivate suggestions.

Jackie's view of math and the ideas underlying the reforms also shaped what she looked at in the text, as well as the mathematical ideas she was willing to consider. Rather than a sequenced list of rules and procedures, she saw mathematics as a body of related ideas and relationships that needed to be understood, not memorized. She believed that the reform agenda emphasized understanding concepts and ideas as opposed to memorizing procedures and, thus, called for significant revisions in how most people thought about what knowing and learning math included. In using the text to construct tasks, Jackie focused on ideas she saw in the text and invented tasks to accompany them.

Like Catherine, Jackie's view of math also determined the mathematical ideas she was not inclined to draw from the text. For example, in her perusal of the chapter on addition and subtraction, she noted, but skipped, suggestions to begin with estimation. She believed that estimation was an application of addition and subtraction rather than a vehicle to explore its meaning, which led her to dismiss the idea completely. She also believed that place value was at the heart of addition and subtraction.

<u>Constructing a relationship with the text</u>. Catherine and Jackie also constructed their own relationships with the HBJ text that determined how they read its suggestions, interacted with it, and drew on it in their teaching. In both cases, the relationship each

teacher created with the text as a resource paralleled the relationship she built with her students as their resource or guide. In short, the views of learning that shaped the type of teacher each aimed to be also shaped the type of teaching or guidance she sought from the text.

Catherine believed that students learn from being told or shown what to do.

Thus, she saw teaching as telling and showing. She believed that it was her responsibility to show her students each step to follow before she asked them to do it on their own. She even recalled feeling frustrated as a student when teachers left her struggling to figure out mathematical procedures. Similarly, she expected the text to provide her with the same sort of guidance in teaching new mathematical topics. She looked to the text to show her what tasks to give students and what steps to follow when guiding them in the process. In fact, Catherine was frustrated when the text did not provide her with sufficient guidance in helping students arrive at the conclusions it said they should. For example, she pointed out places in the text that suggested the teacher "elicit" a particular response from students but complained that it "doesn't go into a lot of ideas on how to get the children to come to this conclusion" (Interview, 4/3/93).

Jackie's ideas about teaching and learning were almost the opposite of Catherine's. She believed that learning occurred through puzzling over problems, inventing solutions, exploring relationships, and articulating them to others. Consequently, she saw teaching as putting students in complex situations and then allowing them to explore and construct their own understandings. She also believed that good teaching involved following students' thinking and building on their ideas rather than imposing a rigid curricular plan. In the relationships she constructed with the HBJ text, Jackie had similar expectations. She did not believe that the text should impose a particular sequence or set of pedagogical steps. Thus, she wove her own path through the mathematical terrain. Just as she used tasks or problems to spark exploratory activity in her math lessons, Jackie read the text to spark pedagogical ideas

in herself. She used the text as a "jumping-off point." She saw mathematical ideas and relationships that sparked her explorations of good mathematical tasks.

The Teaching Context

How the teachers viewed their classrooms and school contexts also played a role in their task selection processes. Different circumstances in their teaching situations placed the textbook in a slightly different light for each, which, in turn, played a role in shaping their expectations and perceptions.

In the Mapleton School District, the textbook was presented as a response to the reforms. How each teacher read it, however, depended on her stance toward the reform agenda and the encouragement she felt to pursue it. The factors in Jackie's teaching situation that contributed most to her stance toward the textbook were related to the professional development opportunities in her school. Through these opportunities, she had begun to rethink her views on math and students' learning. Her hope was that a new textbook would help her continue to move in the same direction. She read the text, looking for things that would guide her along this path and rejecting those less promising. For example, she read the nonroutine problems, as well as alternative teaching suggestions that were interactive or employed manipulatives. She tended to ignore tasks on the students' pages because they generally involved rote practice.

Catherine began the year relatively unfamiliar with ideas of the reforms and saw the text as a way to learn more about them. Furthermore, her involvement in this study played an influential role in her teaching context. My regular visits to her class encouraged her to try new suggestions that she might not have otherwise. Our conversations also prompted her to reflect on her ideas about mathematics and students' learning, since they called on her to articulate stances that she had not put into words. Unlike Jackie, for whom examining and discussing pedagogical choices had become familiar, conversations that probed such ideas were new to Catherine. As Figure 6.3

illustrates, contextual opportunities such as these influenced both teachers' reading of the text, as well as their ideas about mathematical goals for students.

Task Selection and the Role of the Text

As the above discussion illustrates, Catherine and Jackie read the same textbook differently in their curriculum design processes. Thus, the impact that the same text had on this aspect of their curricula varied considerably. What the HBJ text offered to each teacher differed according to what she read in the text and how she read it. In both cases, their reading was influenced by the ways they thought about mathematics, learning, and their teaching. These ideas led them to construct different relationships with the text. In short, the text's role in this arena was primarily a function of the ideas the teacher brought to it, which influenced their reading of it.

These ideas, however, were not the only factors contributing to the differences in the teachers' reading of the text. My analyses suggest that particular characteristics of the HBJ text may have created opportunities for varied readings. Examining the text's role in their reading illuminated particular characteristics of texts likely to engender the variation evidenced by these two teachers. Below I discuss two characteristics of the HBJ text that seemed to increase the possibility of varied readings by different teachers: the large number of disconnected options to select from and the way the textbook communicates with teachers.

Multiple options. In Chapter 2, I described the tremendous number of distinct options the text writers made available to teachers. Their intent appeared to be to meet the approval of a range of potential purchasers by offering many choices, some of which were related to the reforms, but many others that were more traditional. Each two-page spread displayed more possible activities than a teacher could use in a single lesson, plus each chapter contained several pages of alternative and supplementary suggestions. Furthermore, these activities were distinct from one another, forming a collection of tasks rather than a coherent path through a particular concept. The result was a

smorgasbord of possibilities without guidance from the text in sorting through and selecting among them. From one perspective, this variety is a strength because it increases the possibility that a range of teachers will find aspects of it appealing and useful. On the other hand, the variety increases the likelihood that different teachers will read different offerings weakening the text's ability to communicate a coherent or specific message.

<u>Talking through teachers</u>. Another characteristic of the text that increased the possibility that teachers would read its suggestions differently was a result of its very nature and purpose. Like most textbooks, the HBJ text was designed to shape the curriculum enacted in the classroom, and, like most textbooks, it did so by recommending instructional tasks and actions. These recommendations, however, have the potential to communicate more than mathematical tasks. Whether or not they were intended, these suggestions imply mathematical and pedagogical goals and assumptions. Consequently, textbooks carry multiple messages and can be read at many levels. A teacher like Catherine might read the task suggestion. Another, like Jackie, might read a conceptual idea underlying the task. Another might read larger learning goals. In other words, the messages that textbooks have to communicate are neither straightforward nor simple. Yet, like many textbooks, the HBJ text writers focused on the most visible part of this message: the instructional tasks teachers should give students to do. Texts tend to communicate with teachers by speaking through them, by dictating actions, and not to them about these actions. Thus, the HBJ text represented the reforms in terms of tasks or activities. In essence, this mode of guiding teachers oversimplifies the activity of teaching, reducing it to that which is observable. By not talking to teachers, the HBJ text did not explicitly attend to the less visible aspects of teacher decision making, leaving the teachers to extrapolate from its suggestions.

Task Enactment and Adaptation in the Construction Arena

A second arena of curriculum development involved decisions related to creating and sustaining classroom events around the tasks selected. This arena includes all interactions, planned or unplanned, in the classroom that influence, shape, or contribute to the enacted curriculum. Thus, it is an active, responsive, and "evolving" (Zumwalt, 1989) process through which teachers work with students to transform planned tasks into actual events in the classroom. The activity of the construction arena is therefore reminiscent of what Yinger (1988) called "a three-way conversation between teachers, students, and problem" (p. 86). Because the focus of my analysis was on the teacher's role in curriculum development, I will discuss the students' part in shaping curriculum through the eyes and actions of the teacher, including how the activities of students figure in teachers' responses and actions.⁵

Enacting curriculum involves presenting tasks to students and facilitating their interactions with them. Thus, it necessarily includes responding to students in unrehearsed situations. In fact, most of Catherine and Jackie's activity in the classroom were responsive to students. Regardless of the extent to which they used the text or their beliefs about teaching and learning, enacting tasks involved both teachers in onthe-spot decisions about, and adaptation of, their curricular plans in response to things that students said or did. Because of the interactive nature of teaching, adaptation is an inherent part of enacting tasks (Cohen, 1989; Jackson, 1986; Lortie, 1975). Nevertheless, as described below, the need for it was particularly prevalent in Jackie's and Catherine's classrooms because they were in the midst of making changes in their teaching. The new curricular and pedagogical ideas associated with the reforms, as well as the teachers' efforts to try them, increased the number of unanticipated events they confronted in their classrooms.

⁵My intent is not to dismiss the role students play in developing curriculum. Yet, since the focus of this study is on the role that texts or curriculum materials might play in reform in mathematics education through teachers' interactions with them, I focus on the teachers' perspective in this process. As will be seen, the role of students is not ignored.

Task Adaptation and the Reform Context

Both teachers hoped to make changes in their teaching in response to the reforms. Even though they had different interpretations of what this included, both were dealing with content or pedagogical approaches new to them and their students. The concepts and skills they were asking their students to learn or the tasks they presented were unfamiliar. As a result, most of their students' responses were unanticipated. Because neither teacher had established routines for how to respond, they created and revised their instructional texts continuously, relying on their assessments of students to guide this process.

Catherine created an unfamiliar terrain in her teaching by appropriating tasks and mathematical topics new to her and her students. Because their responses surprised her, leaving her unsure how to proceed, she found herself looking closely at her students, what they were struggling with, and understanding for clues. The most striking example was the Problem-of-the-Day tasks. Because her students were having difficulty and because it was important that they were "successful," she paid close attention to their activity in order to know how to help them. In contrast, when teaching computation, an area she believed remained untouched by the reforms, Catherine relied on her familiar routines. Even though she confronted instances in which students struggled, these were anticipated and she was prepared to address them.

Even though Jackie was more familiar with the reform agenda than Catherine, she also found herself exploring unfamiliar terrain, mathematically and pedagogically. Not only was she teaching fourth grade for the first time but she was making dramatic changes in her teaching. Because she wanted students to understand mathematical ideas, she focused her instruction on exploring these ideas rather than on the rules and procedures she had taught previously. Yet, these ideas were as new to her as they were to her students. Furthermore, she also was experimenting with a new pedagogical approach that involved using discussion to facilitate students' exploration of these ideas.

As a result, she was in unfamiliar terrain in two ways. Furthermore, she was feeling her way as the orchestrator of these discussions. The discussions unleashed a range of unanticipated student perspectives that she then had to navigate through.

Catherine's and Jackie's need to navigate through unfamiliar terrain illustrates two related challenges that current reforms place on teachers in the construction arena. First, as Catherine's case suggests, the nature of any change requires teachers to operate without familiar routines. Second, as Jackie's case demonstrates, the reforms suggest an approach to teaching mathematics that is highly dependent on students' ideas and insights (Ball, 1994; Cohen, 1989). In fact, much of the task enactment undertaken by teachers as they explore new practices may involve this type of adaptation. Thus, examining how teachers construct curriculum by adapting tasks can illuminate as much about the actual enacted curriculum as can analyzing curriculum materials or policy. Furthermore, in order to consider the role of curriculum materials in mathematics education reform, we need to understand the relationship between the enacted curriculum and the offerings of published textbooks teachers use as resources. With this aim, I now turn to a description of both teachers' processes of task enactment in their classrooms. Despite the differences in how and what tasks Catherine and Jackie selected, their adaptations had striking similarities.

The Activities of Task Enactment

For both teachers, enacting tasks included two types of activities. The first activity involved assessing what was evolving in the classroom by reading students' understandings or abilities with respect to the task and by reading the task itself to determine what it required of students. The second activity (improvising) involved creating and considering possible pedagogical alternatives for proceeding. Even though these activities were distinct in nature, the teachers did not always engage in them distinctly or sequentially. For example, both teachers occasionally invented tasks that served as ways to read their students further, as well as responses to unanticipated

events in the classroom. I characterize each of these activities below and describe the factors that influenced them (see Figure 6.4). In this figure, I used a concentric region to show that task adaptation is part of task enactment.

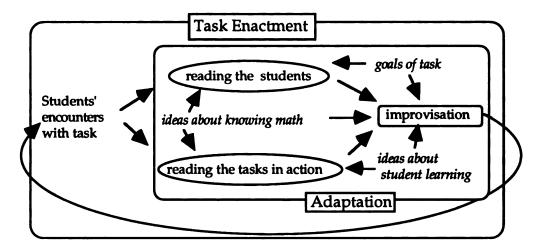


Figure 6.4 Task enactment process

Reading students. The most evident part of Jackie's and Catherine's task enactment activities was their reading of students. Even though their task goals varied, much of what the teachers did involved checking on students and reading their progress with respect to these goals and their ideas about what it meant to know math. These ideas and intentions were the lenses through which they read their students. Jackie focused on her students' understandings of particular mathematical ideas. She carefully noted their explanations for their solutions in order to plan how to challenge them further. Catherine's focus, particularly at the beginning of the year, was on helping students be "successful" in math. She carefully observed them as they encountered new tasks from the text. Because it was important for Catherine that students arrived at the correct answers without becoming too frustrated, she paid attention to what they were doing and how it did or did not fit with the task. Later in the year, as her perspectives on students' learning of mathematics changed, Catherine began to focus her reading on what students understood and what they were thinking. This change was particularly

evident when she veered from the suggestions in the text during the fraction lessons in order to probe students' understandings.

Reading tasks in action. In addition to reading students' understandings or activity, both teachers found themselves examining and analyzing the tasks, particularly when students were struggling. Because their readings were aimed at helping students through or with the task, they both read them with respect to their ideas about learning and what students needed to know. In order to help students confront some of the more complex problems of the day, Catherine spent a great deal of time thinking about them. She considered what they involved, how she would do them herself, and how she would articulate the nonalgorithmic approaches used to solve those that did not have straightforward solution paths. Jackie reexamined the tasks her students worked on primarily to help her interpret their errors. As I described earlier, most of the tasks she gave them had been designed and analyzed by her. However, sometimes her students' work on a particular task was so unexpected that she reexamined it for clues. On April 8th, for example, students who had been able to determine fractions of numbers had difficulty working the problem. Her analysis of the situation took her beyond the students to the tasks she had given them over the last few days. She realized that she had seldom asked them to find a nonunit fraction of a number, such as $\frac{2}{3}$ of 24. Jackie suspected that she had been fooled by the previous tasks into believed that they understood fractions when they had recognized only that they could arrive at the correct answer by dividing the total in the group by the denominator.

The contrast between what the two teachers looked at when reading tasks was similar to the contrast in their reading of the text. When Catherine assessed the tasks her students were struggling with, she focused on what they were being asked to <u>do</u> and what she could do to help them accomplish the task. Jackie focused on what the task demanded of, or suggested about, their understanding. She examined the ideas students were or were not understanding because of the task. These perspectives

influenced their interpretations of what was going on in their classrooms and contributed to what they decided to do in response.

Improvisation. The process of responding to students' encounters with the tasks posed involved a form of improvisation or on-the-spot curriculum construction for both teachers because they had to decide how to respond once they had assessed the situation (Heaton, 1994; Huberman, 1993; Lampert, 1990; Yinger, 1987, 1988). Figure 6.4 illustrates that Catherine and Jackie drew on the outcomes of their readings (what they believed students needed or understood with respect to the task), as well as their goals for the task and their ideas about learning and knowing math in order to make improvised decisions. As the arrow that circles back to the "students' encounters with task" in Figure 6.4 denotes, their improvisations often involved presenting students with a new task. Improvisation also involves deciding when to conclude the work on an particular task or idea; thus it could result in returning to the design arena.

In Jackie's case, I used the term <u>improvisation</u> to characterize much of her teaching. She wanted her instruction to be responsive to students and to follow their understandings and interests. Even though she began each lesson by presenting students with a particular task, its purpose was to launch a discussion about the mathematical ideas involved. Jackie used her assessment of her students' understandings to guide her actions. She listened to students articulate their ideas and then constructed and posed new questions to push them even further or to prompt them to reexamine their understandings. When Jared demonstrated his representation of 1,400 for the class on September 16th, Jackie questioned him about each aspect of his drawing, insisting that he "show me how you know that." The instructional text she created through her improvised questions was a response to her reading of Jared's demonstration. Similarly, on October 15th, when she gave her students the problem of the day (imagining that three darts had been thrown at a dart board and determining what the possible scores were), she was surprised by the haphazard and inaccurate

approaches students used. Jackie assessed what the task asked of students with respect to what she wanted them to learn and then constructed a new question: How do you know when you have them all? With this question, Jackie adapted the task to focus the students more directly on her goals.

Improvisation was not a deliberate characteristic of Catherine's teaching at the beginning of the year, even though she found herself in situations that called for it. For her, the need to improvise arose when she confronted student difficulties that she had not anticipated. For example, on December 19th, when many students struggled with the problem of the day, she distributed calculators and took the time to develop what she called a "lesson in three-step problems" (Interview, 12/19/92). This lesson was not motivated by the task from the text, or by the text, but by Catherine's assessment of her students' encounters with it.

As Catherine became more focused on student understanding, so did her improvisations. In fact, she began to invent and insert improvised questions into the lessons she drew from the text. On April 6th, she probed many students' responses even further. When Joseph changed his mind in the middle of giving the incorrect answer to the correct one, Catherine asked him to explain why he had decided to change his mind. Just a few minutes later she allowed the class to depart from the task at hand to explore the possibility of combining five triangles into a single polygon. This type of openness to improvisation was typical of all her fraction lessons during the spring.

Task Adaptation and the Role of the Text

A characteristic common to both teachers' adaptations of tasks was the minor role the text played. Regardless of their uses of the text to design curriculum, neither Jackie nor Catherine turned to it to guide their actual enactment of it. Rather, they drew on their own personal resources to assess students, examine the tasks, and improvise responses, even when they had drawn the original task from the text. Jackie, in particular, illustrates this tendency. Once she posed a task to students, she generally

initiated a series of improvisations that took the entire lesson. Catherine returned to the text for new tasks more frequently within a single lesson. Nevertheless, she also did not involve the text in enacting them.

This pattern is illustrated in Tables 6.1 and 6.2. Table 6.1 displays the task adaptations I observed in Jackie's teaching. These vary from entire class discussions to single instances inspired by a student's questions or comments. Table 6.2 displays the task adaptations from Catherine's observed lessons, which also vary in nature. The second column in each table summarizes the teaching situations that called for adaptation. As indicated in the summaries, all but 2 of the 18 instances described were stimulated by unanticipated student activity. The other 2 were results of the teacher's on-the-spot reading of the task. The third column summarizes the teachers' improvised responses, and it illustrates the extent to which both teachers relied on their readings of their students to construct responses. As indicated in the last column, the only way that the text could contribute to the construction process was to provide the task that initiated these situations, which occurred in 6 of Jackie's 9 instances and in all 9 of Catherine's.

Table 6.1

<u>Instances of Adaptation in Jackie's Observed Lessons</u>

| Teacher/date | Situation | Adaptation | Role of the text |
|--------------------|---|--|---|
| Jackie 9/16/92 | Class discussion on representations of 1,400 with base-10 blocks | Teacher used students' representations to shape the discussion. | Provided the idea for the task |
| Jackie 10/15/92 | While students worked on problem of the day, teacher noticed students' haphazard approaches to dart problem. | Teacher asked the question: "How do you know when you have them all?" | Provided problem |
| Jackie 10/15/92 | Student made observation about the relationship between 10,000 and 10 thousand. | Jackie constructed lesson to examine and build on students' observation. | Provided place- value representation used in task |
| Jackie 10/22/92 | Class discussion in which students used 3 different models for addition | Teacher used students' solutions to guide discussion | None |
| Jackie 10/29/92 | Students were to solve column subtraction problems with regrouping. Many arrived at different answers when using numerals and manipulatives. | Used discussion to push students to resolve different answers | None |
| Jackie 2/1/93 | Through listening to students' solutions to problem of the day involving fractions, Jackie found that students had misconceptions about fractions | Teacher moved discussion into exploration of meaning of fractions, encouraging students to make drawings to explore meanings. | Provided initial task |
| Jackie 4/5/93 | During introduction to fractions task, teacher realized that students did not understand the fraction 22/22. | Teacher closed class by asking students t draw a picture of 0/22. | Provided initial task |
| Jackie 4/7/93 | Discussion of journal questions and candy-bar task revealed that many students were not sure which was more: 1/2, 1/3, 1/6. | Teacher allowed class to argue this question for entire lesson, using pictures of rectangles in 12 pieces on the overhead to have students show their solutions | Provided part of initial task |
| Jackie 4/8/93 | Through watching students find fractions of a number of chips, teacher realized that many did not understand the meaning of non-unit fractions. | Jackie focused the discussion on finding and explaining non-unit fractions. | None |
| Summary N = 9 | All 9 instances were stimulated by unanticipated student activity. | In all instances Jackie relied on her own resource to invent responses. | For 6 out of 9 adaptations, the text provided the idea for the original task. |

Table 6.2

<u>Instances of Adaptation in Catherine's Observed Lessons</u>

| Teacher/Date | Situation | Adaptation | Role of the text |
|-------------------------------|---|---|---|
| Catherine Throughout the fall | Students had difficulty knowing where to start and how to proceed with multistep problems of the Day. | Teacher observed students and examined problems to determine how to help them. | Provided problems of the day |
| Catherine Late fall | Teacher began to notice that students had alternative solutions to the problems of the day. | Teacher began to ask students if anyone solve the problem differently. | Provided problems |
| Catherine 12/3/92 | Students had difficulty considering alternative solutions during problemsolving lesson in text. | Teacher asked students leading questions until someone produced the correct answer. | Provided the task and the question to ask |
| Catherine 12/10/92 | When consolidating data collected by students in a frequency chart, Teacher was intrigued by the potential the problem had to help students understand the table. | Teacher distributed calculators and asked students a series of questions that involved reading the table and computing totals. | Suggested task in margin of teacher's guide |
| Catherine 4/5/93 | Teacher was surprised to find that many students readily understood the paper/folding task in the introduction to fractions lesson. | Teacher took the problem further than was suggested in the text | Provided initia task |
| Catherine 4/6/93 | A student changed an answer from an incorrect to correct response. | Teacher asked student to explain why he changed his mind. | Provided initia activities |
| Catherine 4/6/93 | Many students disagreed when Catherine mentioned that it would be difficult to put 5 triangles together into a single shape. | Teacher allowed students to pursue ways to put 5 triangles into a single shape. | Provided initia activities |
| Catherine 4/6/93 | During review of fraction assignment, student asked about adding fractions. | Although it was "a question before its time," Catherine showed how to add two fractions with like denominators. | Provided initia activities |
| Catherine 4/8/93 | Task involved using counters to find non-nit fractions of a number; students had difficulty with procedure. | Teacher tried various ways to show them how to find fractions of numbers, returning to counters even though the text went on to a purely abstract approach. | Provided initia task |

Table 6.2 (Continued)

| Teacher/date | Situation | Adaptation | Role of the text |
|----------------------|--|--|--|
| Catherine 4/12/93 | Teacher invented her own lesson to teach non-unit fractions of a number, focusing on observed students' difficulties. | Teacher created a strategy for teaching students and continually assessed their understandings as she proceeded. | Provided idea for task |
| Catherine 4/14/93 | Teacher introduced equivalent fractions using suggestions in text that had students construct fraction bars; observed how well model illustrated relationships among equivalent fractions. | Intrigued by model, teacher elaborated questions with her own that assessed students' understanding of equivalent fractions. | Provided initial task |
| Summary N = 9 | Seven adaptations were stimulated by unanticipated student activity; two were stimulated by teacher's assessment of task. | In all instances Catherine relied on her own resource to invent responses. | In all 9 instances, the text provided the task or idea that initiated the need for adaptation. |

The minimal role the text played in shaping the activity in the construction arena seems characteristic of this aspect of teaching. In order to enact tasks, both teachers found themselves reading students and improvising in response. Because textbook writers cannot predict students' responses to tasks posed by teachers, their ability to directly determine and shape the enacted curriculum is limited. The HBJ textbook, however, focused on the enacted curriculum. As I described in Chapter 3, the text was designed to guide the activity of teachers and students in the classroom. Its approach was to offer a series of tasks and questions teachers could pose and then provide correct answers students should give in response. Both teachers' activities within this arena, however, were primarily improvisational and responsive to the situation at hand. The result was parallel curriculum development. The text developers outlined a particular plan, whereas the teachers enacted their own. Because the text did not attend to the

activities teachers actually engaged in when enacting curriculum, it was not set up to contribute to this arena of curriculum development.

This arena, more than the others, captures the interactive nature of teaching. The curriculum enacted is the product of teachers' interactions with students around particular tasks (Yinger, 1988) and cannot be predetermined by textbook writers or teachers. In other words, the tasks that teachers select in the design arena of curriculum development are not blueprints for curriculum. As Catherine and Jackie illustrate, planned tasks are only seeds. The paths that their growth take are determined by multiple, difficult-to-predict factors, which raises questions about how texts might contribute to teachers' activities during curriculum enactment. Since teachers read and respond to texts, students, and classroom events in the process of developing curriculum, it is the factors that shape their reading and responding that need to be better understood. I explore this issue in the second part of this chapter. First, I discuss the relationship between these two arenas and their impact on a third arena of curriculum development, curriculum mapping.

The Relationship Between the Design and Construction Arenas

As the above discussion suggests, the relationship between the design and construction arenas varied for these two teachers. The most obvious relationship was sequential; after selecting a task or tasks in the design arena, the teachers enacted and adapted it in the construction arena. What followed the activity in the construction arena was less straightforward. Different possibilities are represented with arrows in Figure 6.5. Improvisation involved impromptu designing or altering tasks to present to students, keeping their activity within the construction arena. Jackie, in fact, rarely moved out of the construction arena during a lesson. Rather, each lesson consisted of a series of improvised tasks based on her assessment of students. Catherine was more likely to return to the design arena and the text, for a new task during a lesson and in preparation for another, as is represented with the arrow marked Catherine. Thus, in a

given lesson, she generally returned to the design arena multiple times, including selecting tasks from the text.

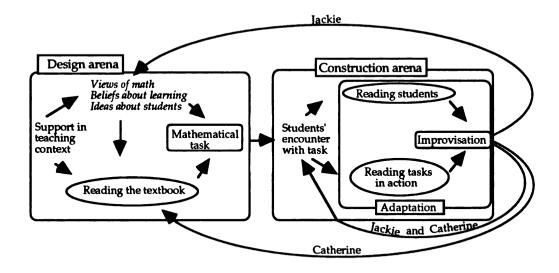


Figure 6.5. Interaction between the design and construction arenas

Jackie was more likely to return to the design process only in preparation for a new lesson. Furthermore, unless beginning a new topic, she tended not to return to ideas in the text but to information gleaned from reading her students and their activities in designing subsequent tasks. As a result, she tended to read less and less of the textbook as she proceeded through a topic. This was the case with both the place-value lessons and the fraction unit I observed. Even though she began each unit with ideas she read in the text, she quickly moved away from the text, inventing tasks related to ideas that emerged from reading her students and the tasks in action. This tendency is represented by Jackie's arrow in Figure 6.5.

This picture of the relationships between these two arenas represents a complex view of teachers' curriculum development by showing the multiple factors involved.

The picture also places the role of the text in perspective by showing how it fits into a

larger context. Even though models of these two arenas may look different for other teachers, the role that the HBJ text played with respect to other influential factors raises questions about its ability to directly shape the enacted curriculum. Furthermore, this picture of various resources and inputs the teachers drew on to make curricular decisions suggests the possibility of roles that a text might play other than provider of tasks. How might a teacher's guide, for example, support teachers' efforts to read their students or invent tasks in response to students' understandings?

The individualized arrows for each teacher in Figure 6.5 reflect a central difference between the two teachers that has implications for texts designed to promote reform in mathematics education. The difference was Catherine's inclination to return to the text when deciding where to go next as opposed to Jackie's tendency to invent tasks that followed her assessment of her students' needs. This difference is significant because it reflects a tension teachers are likely to face between attending to particular mathematical goals and student understanding. The emphasis that the current reform agenda places on both mathematical goals and students' understandings suggests that attending to one might mean neglecting the other. In Jackie's case, attending to students decreased her attention to the text. This tension also was apparent in the decisions the teachers made about their larger curriculum maps which I discuss in the following section.

The Curriculum Mapping Arena

The design and construction arenas, discussed above, involve the day-to-day decisions that directly impact the enacted curriculum; they exist within a third arenathe curriculum mapping arena--which provides the broader structure inside of which the other two fit. This arena involves decisions that effectively define and organize the mathematics curriculum as a whole and determine the content, sequence, and timing of its topics. Teachers' decisions that shape their curriculum maps often go unnoticed primarily because the mathematics curriculum is often assumed. Textbooks frequently

offer a curriculum map that organizes mathematics topics into chapters that include specific concepts or skills. Teachers map the curriculum when they decide how or whether to use this structure. For example, they might skip the chapter in the textbook on place value, spend twice as long on it, or combine it with another. They also map the curriculum when they elect to go through each chapter in the textbook, taking one lesson each day as the authors suggest, or when they abandon the text altogether and develop their own map of the curriculum.

Catherine's and Jackie's mapping activities were intertwined with daily, classroom events because the mapping process included decisions that were seldom explicitly made. Rather, these decisions were ongoing, and they occurred throughout the year as the teachers moved through the text. Catherine and Jackie mapped the curriculum when deciding what topics to teach, how to organize and sequence them, and how much time to spend on each.

This arena was the place in their curriculum development that both teachers' decisions matched most closely the offerings in the text. Thus, the role of the textbook was particularly evident. Neither teacher, however, followed the text completely in constructing her curriculum map. Below I describe the curriculum mapping process for both teachers.

Components of Curriculum Mapping

My analyses of Jackie's and Catherine's mapping decisions revealed two components of curriculum determination: (a) topic determination, which outlined how the mathematics curriculum was divided up or categorized, and (b) content mapping, which determined the concepts or skills addressed in a given topic, the sequence in which the topics were taught, and the amount of time spent on each. As Figure 6.6 represents, topic determination was a broad frame inside of which content mapping occurred. The day-to-day decisions that directly impacted the enacted curriculum took place within, and often influenced, this larger set of decisions. The teachers' topic

determination decisions were similar, whereas the differences in their content mapping represent a significant difference in how the text figured in their curriculum mapping.

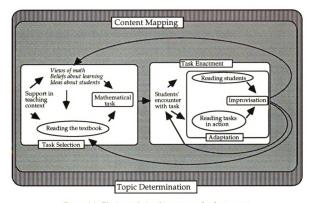


Figure 6.6. The interrelationships among the three arenas

<u>Topic determination</u>. The decisions made by both teachers determined the topics of the mathematics curriculum occurred almost invisibly. Both teachers accepted or agreed with the 13 chapters that organized the contents of the text. It was not clear, however, whether their acceptance was due to the text's influence on this aspect of their curriculum decision making or the close match that existed between the teachers' and the text's images of the mathematics curriculum; both seem likely. The view of the mathematics topics that each teacher held made many of the topics in the text familiar. Their ideas about the goals of the reforms and their views that the text was reformoriented also shaped the perspectives from which they read the text. Thus, even the

topics that were less familiar did not seem surprising. The topics in the text also fit compatibly with the calls for change and the more conventional expectations felt from their district. Figure 6.7 illustrates the interaction of these factors. The only evidence of incongruence between the text's and a teacher's view of the mathematics topics was Jackie's interest in connecting place value with column addition and subtraction. She seemed to disagree with the text's divisions between these two topics.

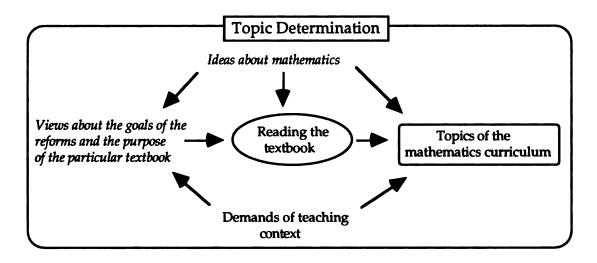


Figure 6.7. Topic determination in curriculum mapping

Content mapping. Decisions that the teachers made that shaped their maps of the mathematics content—the contents of the topics, their sequencing, and their pacing—primarily occurred during transitions from the construction arena to the design arena. At was at these points, depicted by the arrows in Figure 6.5, they made choices about how to proceed from one day to the next. As a set, these decisions had the effect of determining their content maps.

The similarity apparent in Jackie's and Catherine's topic determination processes was not evident in their decisions that mapped their contents. In this part of curriculum mapping, Catherine's decisions were strongly guided by the suggestions she read in the text and, in the case of computation, her own ideas about the mathematics content.

Jackie's decisions were less responsive to the guidance of the text. Rather, her reading of students, together with her ideas about the content, had the greatest influence in her decisions. This contrast had much to do with the differences in impact that the text had on their teaching.

Catherine's decisions about the larger mathematics curriculum were shaped by her ideas about mathematics and her views of the reforms. Her views that mathematics consisted of computational and noncomputational topics and that the reforms attended only to the latter determined what she read the text for. When teaching noncomputational topics, she generally guided students sequentially through the text's lessons. Thus, her reading of the text established the mathematical contents of these topics and how she sequenced and paced them. She covered one two-page spread each lesson, sometimes hurrying the class along in order to finish it or assigning what remained as homework. Except on a few occasions, she was careful not to select tasks from the text that would demand too much time; in fact, this was one of the concerns she had about the increased emphasis on problem solving. Because her students often had difficulty with the problem of the day, helping them took more time than the 10 minutes she allotted it in the morning. By spring she spent more time on exploratory activities, but she still completed a page a day, which frequently required skipping many exercises on the page.

When teaching computational topics, Catherine did not read the text. Rather, her ideas about the four operations and what students needed to learn, how, and in what order guided her content decisions. This relationship is shown in Figure 5.8. As the figure illustrates, Catherine's decisions in this domain also were influenced by demands she felt in her teaching context to respond to the reform initiatives and to meet the long-standing district goals. She looked to the HBJ text to help her attend to the reforms, and she relied on her experience to ensure that her students were proficient in the four operations.

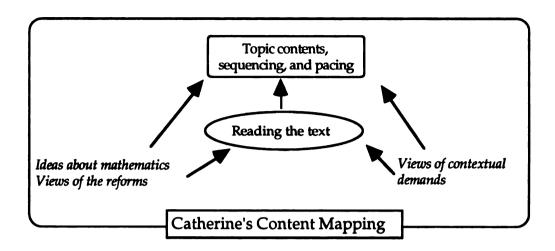


Figure 6.8. Catherine's content mapping

The text was not as central in this aspect of Jackie's decision making. Rather, she allowed her assessments of students and her own sense about the important mathematical ideas guide much of her content mapping. These assessments determined when and how she consulted the text. Jackie generally started a particular topic with ideas she found in the textbook but tended to veer from the text's guidance as the class work on the topic continued. As a result, many of her decisions about the mathematical contents of the topics, the sequence in which she addressed them, and the amount of time she spent on each rarely matched suggestions in the HBJ textbook. Once Jackie had launched a particular topic she seldom returned to the text to guide her in-action decisions.

This pattern is indicated by her arrow in Figure 6.5 that goes from the design arena to her own views rather than to the text. Her move away from the guidance of the text during the place value and fraction chapters, her jump from place-value to column addition and subtraction, and her choice to spend the first 10 weeks of the school year on these topics combined are examples of decisions that created Jackie's alternative curriculum map. When she drew suggestions from the textbook, she frequently spent

several days on one page. Many of these pages were not scheduled lessons but were offered to supplement or enrich daily lessons. She did not move on until she was convinced that the students understood the important concepts.

Several factors in Jackie's teaching context seemed to enable her extensive reliance on her own ideas and her reading of students to make these curriculum decisions. Her recent professional development activities had drawn her attention to student understanding, making it a focal concern. She had also broadened her understanding of mathematics to the degree that she felt able to make content decisions. Last, teaching students for 3 years freed her to think about the curriculum in a three-year, rather than single year, segment. Thus, she did not feel pressured to address all topics in the textbook in one year. The interrelationships of all these factors are illustrated in Figure 6.9.

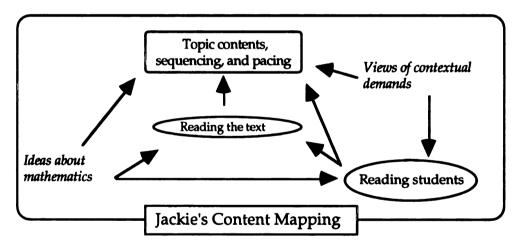


Figure 6.9. Jackie's content mapping

Curriculum Mapping and the Role of the Text

I concluded each of the previous two sections with a discussion of the role that the HBJ textbook played in that particular arena. The text's role in the curriculum mapping arena is more difficult to summarize because it varied considerably among different aspects of the arena, as well as between these two teachers. Furthermore, the

overlap between the curriculum map offered by the text and the view of the mathematics curriculum that each teacher held makes the text's role impossible to fully sort out. For example, matches with the text's curriculum maps suggest that the text played a significant role in both teachers' topic choices and almost all of Catherine's mapping decisions. Yet, the similarity between their views of the math curriculum and that represented in the text raises questions about the extent to which the text influenced their choices. Perhaps the familiarity of the list of topics in the text facilitated the teachers' use.

Despite the above uncertainty, the broad curricular structure that the text provided was, at minimum, a starting place for both teachers' curriculum maps.

Because neither teacher held a strong curriculum vision that might have served as an alternative starting place and because they both expected the text to help them make changes in their teaching. The text provided an initial path that they could follow or veer away from. Unlike the design arena, within which the teachers read, interpreted, and used the same text differently, the mapping arena seemed to offer fewer degrees of possibility for reading or following the text. The teachers used all or parts of the structure (topics, contents, sequence or pace) offered by the text, adapted it, or replaced it with their own. Thus, when the text was involved in any part of the teacher's curriculum mapping, its involvement was generally direct. Teacher mediation of various parts of the text's map was not apparent, except when the teacher replaced them with her own. Catherine, for example, did not use the text in mapping the contents of the four operations, but she used it entirely to map the contents of other topics.

The inflexible nature of the text's role in this arena, in contrast to the design arena, seemed to be a function of the arena itself. The curriculum map is a broad structure that organizes particular contents. Even though there are multiple ways to represent the contents, the structure itself is less malleable. Furthermore, the HBJ text was not designed to accommodate variation in its structure. In contrast to the

publishers' attempts to offer a variety of tasks within its chapters, the text contained a single curriculum map. Its segmented and linear design offered a particular path that the teachers did or did not take. It consisted of 13 self-contained chapters, each of which included a set of daily lessons. As a whole, this complete structure had the potential to reemphasize any pressures teachers might feel from their districts or schools to cover a prescribed curriculum. As a result, veering from the text could be considerable a risk for many teachers.

My comments have hinted at some fundamental differences among the three arenas of curriculum development. Although the arenas are closely intertwined, they involve substantially different components of the curriculum process. Thus, the types of teaching activities in each are not the same; nor are the ways a text might contribute to them. An understanding of the differences in the three arenas can inform reformers' efforts to improve mathematics teaching by delineating the nature of the various activities involved in curriculum development. This understanding also can provide a frame for examining the possibilities of teacher development through the process, which is the focus on the second part of this chapter.

The Role of the Curriculum in Teacher Development

As described above, curriculum development is a process in which teachers enact curriculum in their classrooms. It involves drawing on their views, beliefs, and knowledge while reading and acting on written curriculum suggestions and classroom events. This description paints a picture of a unidirectional relationship in which the perceptions that teachers bring to the text shape how they enact curriculum. This picture leaves little space for change or for the enacted curriculum to impact teaching, which was an important dynamic I observed in both teachers. Even though Jackie's and Catherine's readings shaped their role in curriculum development, this process also had an impact in ways that affected their subsequent readings.

This dialectical process is reminiscent of McLaughlin's (1976) observation that instructional policy initiatives often are implemented through a process of mutual adaptation. In the Rand Change Agent study, McLaughlin and her colleagues found that implementation of innovation is most effective when teachers and administrators engage in a process of adapting the project design to their particular circumstances. This process includes adaptation of the local setting and learning on the part of the participants involved. Successful implementation strategies included mutual adaptation in which "goal and methods [were] reassessed, refined, and made explicit during the course of implementation"(p. 348). This process, according to McLaughlin, fostered "learning-by-doing." Through the adaptation process, school personnel and the programs they had set out to implement underwent change. Even though I looked at individuals rather than systems, my analyses suggest that as a result of their efforts to respond to the reforms, both Catherine and Jackie experienced similar processes of learning-by-doing. Adapting their readings of the text to their readings of their students and classroom activities caused them to reconsider and adjust many of their ideas about teaching mathematics.

In this section, I examine the impact that the process of curriculum development had on the beliefs and understandings that guided the teachers' readings. Ironically, the key ingredient that served to stimulate their learning was the act of reading. First, I examine the effects of the two teachers' approaches on task selection. Catherine's approach provided her opportunities to learn about mathematics, whereas Jackie's prompted her to examine mathematical ideas more deeply. Neither approach facilitated the teachers' learning of or about new mathematical ideas. Then I discuss similarities in their learning that occurred during the adaptation activity of task enactment. Both learned about mathematics, students, and student learning. I do not discuss curriculum mapping as a distinct site for learning. I then briefly discuss Jackie's learning in the curriculum mapping arena. Because this arena is the broader structure into which the

other two fit, there is considerable overlap between her learning in this third arena and the other two. Catherine's curriculum mapping was not a site for her learning. Finally, I consider what this analysis suggests about the role of the textbook in teacher development.

Teacher Development in the Design Arena

In the task selection arena both teachers designed mathematical tasks to present to their students. As I describe below, the different ways they read the textbook resulted in different approaches to selecting tasks and, consequently, different types of learning opportunities. The teachers' learnings are summarized in Table 6.3.

Appropriation and Invention as Sites for Learning

The teachers' contrasting reading of the text created sites for learning that were virtually opposites of one another. Each enabled a type of reflection that the other limited. Both types of reflection, nevertheless, had significant impacts on the teachers' mathematical knowledge that, in turn, impacted their future reading of the text, of students, and of the tasks in action.

A broader view of the nature of math through appropriation. Catherine appropriated tasks from the text into her teaching. As described earlier, her primary motivation was to add particular topics associated with the reforms to her teaching. Thus, many of the tasks she appropriated seemed unfamiliar or even questionable. Using these tasks allowed her to examine them while in action in her classroom rather than as written on the page. As she found herself guiding students through these tasks, she began to appreciate their value. The most striking example was the change in her view of problem solving. Catherine's initial reaction to the problems of the day in the text was that they were too challenging for her fourth-grade students. Through examining these problems and observing their work, she began to see that the problems required students to think in ways that they had not previously learned. Even though she had always believed that mastering the basic operations was key to learning

Table 6.3

Catherine's and Jackie's Learning in the Design Arena

| JE | Teacher | Nature of learning | Examples from cases | Impact on curriculum development |
|---------------------------|-----------|-----------------------------|---|--|
| ָּבָּ ב | Cathorino | Broader view of what | • Problem of the Day | Effected reading of tast Toacher house |
| į | ווכוזווכ | DIOGREE VIEW OF WINGE | TIONICIII OI MIC Day | דווברובת ובמחוווף חו ובעו: ובמרוובו תבפמוו |
| | | mathematical knowledge | Calculator activities | to try more exploratory and conceptual |
| making sense of students' | | includes | Exploratory tasks and | activities from text. |
| | | | manipulative suggestions | |
| | | | | Effected curriculum mapping: Teacher |
| <u>~</u> | Jackie | Deeper understanding of the | Place value unit | resequenced chapters, spending more |
| | | mathematics she was | Fraction unit | time on topics she felt were important. |
| Learning from curriculum | | teaching | | |
| invention (the process of | | | | Effected what reading of text: Teacher |
| | | | | looked for opportunities to develop |
| | | | | place-value concepts in multiplication |
| | | | | |
| | | | | Effected goals for students: Teacher |
| | | | | developed goals that emphasized |
| | | | | understanding, which influenced her |
| | | | | reading of students and their encounters |

math, this experience led her to realize that knowing how to proceed when given a complex problem also was crucial; she called this the "thinking part" of the problem. "The more they're working on the problem solving," she enthusiastically told me in April, "the more important it's becoming to me" (Interview, 4/3/93).

A deeper understanding of math through invention. Jackie did not try to appropriate tasks from the text. Rather, she used the ideas in the text to guide her invention of tasks. Still, her thinking changed from using the text in this way. Her learning was stimulated by the process of thinking through the mathematics in order to invent tasks. Designing tasks and then redesigning them in response to her students' encounters with them were a central components in her teaching and one of the most profitable sites for her learning. In order to invent tasks to present to her students, Jackie explored mathematical ideas embedded in the topic in new ways. This type of exploration was particularly evident during the class work on place value at the beginning of the school year. Reading the text for underlying mathematical ideas, designing tasks to engage the students in these ideas, and considering the types of representations to use all enriched her exploration of the structure of numerals in the base-10 system. Designing tasks and questions that allowed her students to confront the role that place value played in column addition pushed Jackie to examine place value in other operations. The result was a deeper understanding of place value as the foundation of the number system, which was evident when she began to prepare to teach multiplication by exploring the role of place value in it.

Learning From Task Selection

A key distinction between the two teachers' task selection was in their reading of the text. This distinction also figured in the impact that their task selection had on them. In each case, the teacher's orientation to reading the text enabled specific types of learning related to mathematics but inhibited others. Below I discuss the relationship

between each teacher's reading and the opportunities for learning it provided, as well as those it limited.

Learning about the substance of mathematics. Jackie's inclination to read the ideas in the text and create to her own tasks created multiple opportunities to explore these ideas. As a result, her approach to selecting tasks deepened her understanding of what Schwab (1978) called the substantive structures of the mathematics taught. This type of learning mathematics--deepening one's understandings through exploring the content in preparation to teach it—is similar to one form of learning that Russell et al. (1995) observed in teachers. They found that such preparatory exploration caused teachers to consider and see explicitly what they knew implicitly. Jackie's learning was similar. Midway through teaching fractions, she exclaimed: "Things are dawning on me. ... I never thought that one half was the same as five tenths. I mean I did equivalent fractions because I had to, but I don't think it really dawned on my mind what that meant" (Interview, 4/7/93). Jackie's understanding of the implications of equivalent fractions seemed to have reached a new level of depth. Russell et al. argued that learning mathematics that involves a gradual deepening, allowing new connections to emerge, is a crucial type of subject-matter learning teachers need to experience in order to improve their mathematics teaching.

Jackie's deeper understanding of math influenced her reading in all three arenas of curriculum development. In the mapping arena, it contributed to how she sequenced the mathematical topics, as well as her pace through them. Her jump from the place-value chapter to column addition and her decisions to spend more time than the textbook suggested on place value and fractions were influenced by deeper understandings of the mathematics involved. In the design arena, her mathematical understandings also impacted the ideas she looked for when reading the text. As described above, the insights she gained through exploring place value in the context of addition and subtraction led her to look for these idea in the multiplication chapter.

When enacting tasks, her deepening understanding of particular mathematical ideas shaped the goals she established for her students and influenced her reading of students as they worked on the tasks.

Learning about the nature of mathematics. Catherine did not pursue this type of mathematical exploration. Her tendency to appropriate tasks into teaching afforded opportunities to examine different aspects of mathematics. Experiencing new activities in her teaching prompted her to reexamine many of her views about the nature of mathematics and mathematical understanding. Her learning was about what Schwab (1978) called the syntactic structures of the discipline. As described in her case, Catherine began the year convinced that computational mastery and being able to produce the correct answer were of primary importance. However, as she watched students struggle with complex problems or use manipulatives to model algorithms, she came to believe that understanding and being able to think through problems also were important. In fact, near the end of the year, she speculated that "people that really are able to do problem solving and the higher mathematics are the ones that understand the connections" (Interview, 4/8/93), which is how she accounted for the difficulty she had in math: "I really didn't understand a lot of the reasons why certain things worked."

Catherine's learning suggests the possibility that change in one's ideas and conceptions can follow changes in one's practice. This type of change seems to lessons taught by recent research on teaching and teacher change. Researchers have found that a teacher's past experiences and current beliefs powerfully influence how she makes sense of new pedagogical ideas (Brown & Borko, 1992; Cohen, 1990; Moje, 1996; Putnam, 1992; Remillard, 1992; Stephens, 1982). Many have speculated that lasting change can come only through greater attention to the ideas and understandings that underlie teachers' actions rather than to the actions themselves (Cohen & Ball, 1990; Duckworth, 1987; Feiman-Nemser & Featherstone, 1992; Kennedy, 1991). For example, some have viewed textbooks, curriculum guides, and workshops that provide teachers activities to

insert into their practice with skepticism because they do not address ideas at the heart of teaching.

Catherine, however, illustrates that teacher's guides might have the capacity to stimulate change in teachers' thinking through prompting changes in their practice. While reconfirming the close link between beliefs and practice on which the above arguments are predicated, Catherine illustrates that change also can flow in the other direction. As others have observed (McLaughlin, 1990; Remillard, 1992; Wiemers-Jennings, 1990), the act of incorporating new steps into one's own practice can provide a site for reflection and learning, particularly given the nature of current reforms. Because these calls for change ask teachers to teach in ways that they have never experienced (Cohen & Ball, 1990) and that run counter to commonly held views of knowledge and learning (Cohen, 1989), teachers like Catherine often have few images of what this teaching might look like in their classrooms. They may find the message of the reforms appealing, but their visions may be incomplete or grounded in their own "personal sense of what works" (Richardson, 1994, p. 6). These teachers are likely to benefit from actual tasks to pose to students.

Catherine's broader view of math also influenced her future activity in two of the three arenas of curriculum development. Because she began to value mathematical understanding, she paid more attention to the tasks in the teacher's guide designed to nurture students' understandings. For example, in February, she tried the suggestion in the textbook to use base-10 blocks to teach division. Similarly, during the fraction unit, she selected many of the exploratory tasks in the text that emphasized underlying meanings, which affected the goals she had for the tasks she gave students. She began to look for more signs of understanding when assessing their encounters with the tasks.

Each teacher's approach to selecting tasks also restricted her opportunities to learn from the process. Because Catherine used tasks in the text, she did not need to invent new ones; nor did she need to delve into the mathematical ideas because they

were embedded in the tasks she used. Jackie, on the other hand, did not use the tasks in the text; she invented her own. But she did not have opportunities to learn from using new tasks that she would not have invented herself. In essence, their particular readings created missed opportunities to learn from task selection.

Missed opportunities. For both teachers, the fact that what and how they read was shaped by their views of mathematics and the mathematical foci of the reforms restricted their opportunities to examine new mathematical ideas. In order to learn from using tasks, Catherine had to be willing to try them. Similarly, if Jackie was to learn about a particular mathematical idea, she needed to see the idea in the text and then be convinced that it was valuable; this did not always happen.

Catherine's views about mathematics and the reforms led her to dismiss certain chapters in the text. She held well-formulated views about the importance of computation and how it should be taught, and she believed that the reforms were not about computation. As a result, Catherine did not read those chapters. Thus, she did not appropriate tasks from them or permit alternative ideas about teaching them to enter her practice for the first 5 months of the school year. As I discuss below, the changes she made in her views of mathematical understanding eventually led her to try a suggestion for using base-10 blocks to teach division. This was the first time that I observed her using the text to guide her teaching of computation.

Jackie's missed opportunities were also a function of what she read in the text. Even though she focused her readings of the text on ideas and concepts, her views of the mathematics content shaped the meanings she made of them. Because she believed it was important, she examined the structure of the base-10 place value system more deeply and invented tasks to help her students do the same. She saw these ideas as central to understanding column addition and subtraction, and focusing on them when designing tasks. She did not read ideas such as number sense or the meaning of addition into the estimation suggestions in the text, nor did she see them as important to

understanding column addition. Rather she saw estimation as an application of the understanding she was building through the work on place value. Thus, she did not construct tasks that focused students on it.

Learning in the Construction Arena

The construction arena of curriculum development was the place in which the teachers' reading was most pronounced. Moreover, it was also the arena that had the greatest impact on the teachers, primarily when they engaged in adapting unfamiliar tasks. In the midst of enacting tasks, both teachers focused on reading students and reading the tasks in action in order to direct their responses. These activities prompted learning in both teachers. Below I describe how their reading created opportunities for their learning and consequently impacted their curriculum development processes. (See Table 6.4)

Task Adaptation as a Site for Learning

Learning through reading students' encounters with new tasks. One activity of task adaptation was reading tasks in action, which involved assessing the tasks with respect to what they enabled students to do or understand. The changes they had undergone in their teaching made students' approaches more apparent. Thus, this type of reading allowed Catherine and Jackie to examine students' understandings and approaches. Both found that their students visualized mathematical ideas and used strategies to solve problems that they had not considered. These insights caused them to look at the mathematics and their students' abilities differently.

This type of learning mathematics is similar to one form of learning that Russell and her colleagues (1995) witnessed in many teachers. They described the process as engaging in mathematical thought with students. "In assessing the reasoning of students' responses, especially when they are unfamiliar and unexpected," they explained, "teachers think through the mathematics again for themselves in new ways, seeing new aspects of familiar content" (p. 3). This was the case for both Catherine and

Table 6.4

Catherine's and Jackie's Learning in the Construction Arena

| | ובשרוובו | Nature of Jearning | Examples from cases | impact on curriculum development |
|---|------------------|--|---|---|
| | 440 | Dang down the distance of | Ducklam of the day | • Effected reading of the text: Teacher |
| reading students encounters with tasks | Camerine | broader understanding of what mathematics includes | rroblem of the day | read and used more conceptual tasks over year |
| | | í | | Effected reading of students: Teacher |
| | | Insights into student thinking | | focused on students' solution strategies; |
| | | | | improvised during problem solving |
| Learning from | | Greater awareness of | | lessons by asking students to articulate |
| examining students' | | students' abilities | | their strategies |
| understandings and | | | | • Effected curriculum map: Teacher |
| approaches to | Jackie | Deeper understanding of the | Randy's observation | resequenced chapters and altered pacing |
| unfamiliar tasks | | mathematical content | during place value lesson | to focus on central place-value idea |
| | | | about the relationship | Effected improvisation: Teacher |
| | | Insights into students' | between 10,000 and ten | invented tasks based on reading of |
| | | thinking | thousand. | students rather than text |
| | | | | Effected reading of students: Teacher |
| | | | | refined goals for tasks |
| Reading students | | Broader understanding of | Problem of the Day | • Effected reading of the text: Teacher |
| | Catherine | what math includes | Fraction lessons | used more exploratory activities during |
| | | | | fraction unit and fewer rote exercises |
| | | Greater awareness of | | Effected reading of students: Teacher |
| Learning from | | students' abilities | | focused on students' understanding |
| examining student | | | • | Effected goals for task and |
| confusion | Jackie | Deeper understanding of the | Dart problem | consequently teachers' improvised |
| | | mathematical content | Fractions | response |
| | | | | Effected improvisation: Teacher |
| | | Greater awareness of | | invented tasks based on reading of |
| | | students' abilities | | students rather than text |
| | | and their learning | | Effected reading of students: Teacher |
| | | | | focused on students' understanding |

Jackie. They found that listening to and assessing students' responses to tasks helped them see mathematics differently. This happened for Catherine through using the problems of the day. She was surprised to find that some students solved problems differently than she had. Listening to their alternative approaches broadened her ideas about what mathematics included. She realized that the ability to develop and use strategies to solve problems was an important part of mathematics. Even though Jackie expected her students to come up with alternative solutions and perspectives, assessing them sometimes stretched her understanding of the concept. For example, her assessment of the observation made by Randy during the place value unit led her to a deeper understanding of the relative sizes of large numbers.

Jackie's and Catherine's experiences from these episodes also involved learning about students and their ways of thinking. However, the evidence suggests that listening to her students contributed to Catherine's learning in an area familiar to Jackie. Jackie began the year believing that students could and should invent their own solutions. This, however, was a new idea for Catherine. She became more aware of her students' abilities to construct their own solution strategies, unlike her approach.6

Learning through reading students. Adapting tasks also involved reading students when they were struggling. Both teachers confronted instances in which their students had difficulty with the concepts or tasks central to their lessons. Thus, they found themselves paying close attention to their students' thinking in order to help them. As a result, they began to examine more closely the mathematical ideas involved in the concepts or tasks and, consequently, reconsidered their own views of the mathematics and of their students' abilities.

⁶Catherine's learning about her students' abilities to construct their own solutions and its consequent impact on her teaching is similar to the changes observed in teachers involved in the Cognitively Guided Instruction (CGI) study (Carpenter et al., 1988). These researchers introduced teachers to the types of addition and subtraction problems, as well as the strategies that students typically use to solve them. They found that teachers with this knowledge were more inclined to attend to their students' solution strategies than those without it.

Russell et al. (1995) also found that episodes involving student confusion or problematic thinking caused teachers to look at related mathematical structures underneath their students' reasoning. In essence, students' difficulties become a catalyst for further exploration of the topic. Similarly, Catherine's efforts to look beneath her students' troubles led her to develop a sense of what they needed to understand or be able to do, along with a greater appreciation of these abilities. When her students had difficulty using counters to solve problems such as $\frac{3}{4}$ of 12, she carefully examined the process and their errors with it, realizing that they needed a firmer understanding of the meaning of the numerator and denominator. Jackie had similar experiences with fractions and the dart board problem. Helping students through their struggles with nonunit fractions led her to explore her own understanding more carefully and to see connections she had not considered. During her students' work on the combination problem with the dart board, Jackie noted, analyzed, and responded to her students' difficulties which pushed her to examine the nature of the problem, as well as the mathematical thinking it represented. This process influenced her decision to push her students beyond their random approaches to the problem.

In addition to prompting growth in their understanding of math, examining student confusion also prompted both teachers to reconsider the evidence that they had assumed indicated student understanding. Jackie's analysis of her students' confusion with nonunit fractions suggested that their correct answers for fractions in which the numerator was 1 was often the result of their abilities to follow a pattern. They knew that $\frac{1}{3}$ of 12 was 4 only because they realized that they could get the answer by dividing 12 by 3. They got stuck when she asked them to show $\frac{2}{3}$ of 12. Similarly, finding that her students did not know where to begin to solve many of the problems of the day, even when she allowed them to use calculators, increased Catherine's awareness of her students' abilities and inabilities. Even those students who were good at computation were not necessarily able to think through the problems.

Learning from Task Adaptation

The effect of Catherine's and Jackie's learning in this arena was similar in that its primary impact was on the ideas and conceptions that contributed to task enactment activities. These encounters with their students' understandings and struggles caused both teachers to refine their task goals and to revise their ideas about students' learning and knowing math. These changes influenced the meanings they made of students, the tasks they were working on, and their improvising.

Their learning also influenced some of the ideas that shaped task selection. Broadening her view of what mathematics included had an effect on Catherine's reading of the text. She used more conceptual and exploratory tasks as the year progressed. The impact on Jackie's task selection was not related to her reading of the text. Her mathematical learning increased her confidence in her ability to invent tasks and to construct a mathematical path responsive to students. She changed from feeling unsure about skipping ideas in the text to feeling secure in her ability to guide students through each topic.

Only Jackie's learning impacted her curriculum mapping. As she developed a deeper understanding of place value, she made adjustments in the sequence of the chapters by jumping to a new chapter. She also pursued the items within the text's chapters in a different order, adding ideas she believed were important and omitting others. Jackie's mathematical learning also influenced her choice to spend more time on particular topics.

Teacher Development in the Mapping Arena

The teachers' decisions in the curriculum mapping arena shaped the big pictures of their curriculum such as its organization, contents, sequencing, and pacing. As a result, many design and construction decisions the teachers made ostensibly affected their curriculum maps. For example, the teachers made daily choices about what to do the next day. Even though this choice was a task-selection decision, its outcome also

affected their curriculum maps. Jackie's decisions to invent a related task on the same topic and Catherine's choices to continue with the next lesson in the text belong in both the selection and mapping arenas.

As a result of this overlap, the mapping decisions that provided the most fruitful sites for their learning were closely intertwined with task selection decisions that led them to adapt the map in the text, which Catherine rarely did. She either matched her curriculum map to that in the text or, when planning to teach computation, discarded the map in the text. Thus, her reading of this aspect of the text was literal. As a result, this arena was not a site for her learning.

Jackie, on the other hand, often adapted the map of the text. Thus, the mapping arena was a site for her learning. Even though she started each unit with the ideas in the textbook, her mapping involved reading the students with respect to her mathematical goals for them in order to determine whether to continue with the task or topic at hand or to try something new. She allowed her design and construction decisions to redesign the contents of the chapters, to resequence them, and adjust their pacing. This reflective process was what prompted her learning in this arena. Through analyzing the activities of her teaching and her students' understandings, she deepened her understanding of the mathematics and gained insights into her students' thinking.

Many of the mapping choices that Jackie made during the place-value unit provide examples of decision-making processes that prompted her growth. Each time I interviewed her in the fall, she seemed to be in the midst of deciding whether or how to adjust the curriculum map in the text in order to be responsive to her students' developing understandings of place value. Central to her reflection was her developing understanding of the power of place value and her sense of what the students did and did not understand about it. As she thought through the various consequences of jumping to the next chapter, or plodding through the place-value chapter at a turtle's pace, she looked more closely at the relationships between place value and addition and

subtraction. The mathematical learning that grew out of this careful analysis influenced her mapping decisions, and increased her confidence in her ability to construct a valid and worthwhile curriculum map.

Teacher Development and the Textbook

What role did the textbook play in the teachers' learning? Looking at the above analyses of the teachers' curriculum development processes, as well as the learning and change it fostered, two points emerge: First, the most fruitful sites for learning occurred when the teachers had to read the text, their students, or situations in their teaching with an eye toward designing or constructing curriculum. This process of reading and decision making caused the teachers to reexamine their beliefs and understandings that, in turn, influenced the curriculum they enacted. Second, the teachers engaged in this type of active curriculum development when the text's role was most flexible or its contribution was indirect, allowing, or even calling for, their involvement in the curriculum process. The most learning, for example, occurred for both teachers in the construction arena. In this arena the text's role was the least direct, albeit unintentionally. Tasks or ideas from the text sometimes initiated classroom activities, but it was the teachers who were actively involved in reading and acting on these events. The instances that prompted little teacher development were those in which one of the teachers used suggestions in the text verbatim, without adapting them, or when they completely dismissed parts, replacing them with their own.

A possible interpretation of these two points is that the text had little to offer the teachers' professional development since they seemed to learn when the text did less and they did more. This was not exactly the case. The text contributed indirectly to their learning. Topics or tasks in the text, that the teachers accepted or inserted into their teaching did not, by themselves, provoke reflection or change, but they often created places for this to occur. Catherine, in particular, appropriated unfamiliar suggestions from the text that alone did not motivate her to rethink existing ideas. The

appropriations, however, created situations in her teaching that engaged her in active reading and improvising. Similarly, both teachers accepted the mathematical topics offered by the text. This process did not involve learning. These topics, however, provided the terrain in which later mathematical learning occurred. Indirect as it was, this role in teachers' learning must not be discounted. In fact, as I describe below, it has the potential to be crucial.

The Role of the Textbook in Developing Curriculum and Teachers

I close this chapter by returning to the three-way relationship that framed this study--the teacher, the textbook, and the curriculum. What do the cases of Catherine and Jackie suggest about how textbooks might contribute to curriculum development that is also teacher development? Whether it was intentional or not, the textbook provided two types of resources that the teachers used in developing curriculum: It proposed the mathematical terrain within which, or from which, the teachers enacted curriculum, and it provided materials for them to build with. The materials the teachers read and selected from included raw concepts, tools, and prefabricated tasks. They used these materials along with their personal resources to design and build curriculum. Growth occurred when teachers engaged in the process of curriculum building, that is, actively reading students, the text, and the tasks, and continually inventing or improvising in response to what they read. On the other hand, when either teacher used guidance from the text without engaging in this decision-making process, her thinking was not stretched.

Ironically, as I alluded to earlier, engaging teachers in a curriculum development process was not necessarily the intent of the HBJ publishers; in fact, it appeared to be the contrary. The text developers offered a set of prepared activities, within a specific structure, for teachers to use. Even though it seemed evident that teachers would need to make selections among the plethora of suggested tasks, there was no mention throughout the text about the selection process. Given my finding that the process of

curriculum development can be a source of teacher development, it seems that texts might facilitate the teacher's role in it rather than doing it for them.

Naturally, this claim has limits and questions. Jackie's and Catherine's cases suggest that there is much that textbooks cannot do alone or at all. Together, these two teachers illustrate a range of personal and contextual factors that impacted their curriculum-development choices. In some instances, these factors were central to the decisions they made. Yet, text developers must assume that a range of teachers will be using their materials in differing situations. Can a single text accommodate such variety? Furthermore, both cases capture the responsive and unpredictable nature of teaching. Jackie's case, in particular, illustrates how teachers' efforts to develop curriculum in response to students are likely to lead them down uncharted and unanticipated paths. How might a text help teachers follow such paths and support them through their unplanned travels? Must teachers eventually choose between following the text or the students? I pursue these questions in the following and final chapter.

CHAPTER SEVEN

CONCLUSION: A NEW ROLE FOR TEXTBOOKS

This chapter considers what the previous analyses of Catherine and Jackie suggest about the role that textbooks might play in reform in mathematics education. My inquiries focused on the relationship among two teacher, the curriculum, and a specific reform-oriented text. My findings, however, raise questions about the role of any text in reform-related teaching. A key outcome of my analyses, for example, was the model of teachers' curriculum development, which illustrated the multiple layers of the curriculum development process. This model highlights the various places that a text might contribute to the enacted curriculum. It also reveals places where a text's impact is likely to be limited. Another outcome of my analysis that takes us beyond the specifics of the HBJ text was the characterization of the activities that prompted teacher learning. Even though their use of the text differed, both teachers learned when actively involved in curriculum development activities. Furthermore, their learning influenced their subsequent curriculum-development decisions. These findings have implications for reform-oriented textbooks and teaching.

In this chapter, I discuss implications of my findings by considering what they illuminate about teachers' curriculum development and the role that textbooks and teacher support might play. I do so in three parts. In the first part, I explore what my analysis in Chapter 6 suggests about curriculum and teacher development and the textbook's role in each. Then, I discuss implications these perspectives and findings have for textbook development and selection and for teacher development. In the final

section I discuss likely challenges to textbook change due to market and institutional forces.

Curriculum Development, Teacher Development, and the Text
In Chapter 6 I offered a model of teachers' curriculum-development activities
that consists of three arenas. Each arena addresses substantially different components of
the curriculum process, involves different teacher actions and decisions, and is
responsive to different influential factors and resources. Thus, the potential role of the
textbook varied significantly within these three arenas. Even though the specific
influences in each of Jackie's and Catherine's arenas cannot be generalized to all teachers,
this model offers a framework for examining any teacher's curriculum-development
activities, and thus, the role that a text plays in teaching. In essence, the model of
teachers' curriculum development provides a framework for answering the overarching
question of this study: How do teachers make sense of and use a reform-oriented
mathematics textbook? The model portrays how teachers' textbook use is embedded in
a larger set of activities and illustrates how examining these activities, their roots and
influences, their interrelationships, and the outcomes in teaching helps us understand
the possible ways texts might contribute to reform in mathematics teaching.

The purpose of this section is to take stock of our current understandings of teachers' curriculum development and textbook use. Thus, I consider the contribution that the findings of this study make to research on teachers' textbook use. I begin by discussing what the model of teachers' curriculum development offers to our understandings of the activities of teaching. I then consider what this model suggests about the power and limits of texts. In so doing, I discuss what my findings suggest about how texts might facilitate teachers' curriculum development that is also teacher development.

Perspectives on Teachers' Curriculum Development

The model of teachers' curriculum-development processes contributes to our understanding of activities of teaching in several ways. As a theoretical framework, it offers a lens for examining teachers' curriculum development activities, including how they interact with and use textbooks. It illustrates the distinctions between the purposes of each arena, highlighting the multiple roles a text might play. Moreover, my examination of the details of the model for two teachers reveals patterns in their activities and in their decision-making processes. In this section I discuss three specific activities of teaching mathematics and textbook use that the previous analysis of teachers' curriculum development illuminates: (a) differentiation in what textbook use involves, (b) the unique nature of the construction arena, and (c) the role and importance of teachers' reading in shaping the enacted curriculum.

A Sharper View of Textbook Use

In Chapter One, I discussed the ambiguity in the literature about the meaning of the term "textbook use". Researchers have defined use differently and have not focused on the same aspects of practice when assessing the role the text played. For example, Bush (1986) and Floden et al. (1981) considered mathematical topics alone, identifying teachers who used the text's topics as close followers. Stephens (1982) and Donovan (1983), among others, looked at how teachers represented the subject to assess the extent to which they were following or subverting the intent of the authors. Freeman and Porter (1989), Graybeal and Stodolsky (1987), and Sosniak and Stodolsky (1993), on the other hand, examined the different aspects of textbooks that teachers used or dismissed. They all found fidelity with the text in some aspects of teaching and large discrepancies in others. Yet, there was little consistency in the aspects of the text these researchers examined, leaving few opportunities for comparison of findings across studies. In addition to assuming incongruous definitions of "use", much of the research focused on teachers' interactions with texts in isolation, rather than considering the text's place in

teaching as a whole. Sosniak and Stodolsky (1993) argued that to understand teachers' textbook use we must examine it within teachers' larger agendas.

The model of teachers' curriculum development that emerged from my analyses situates teachers' textbook use within a larger, more complex agenda. It offers a framework that articulates the varying aspects of the curriculum process, refining and clarifying the breadth and depth of the researchers' lenses. As I discuss below, the three arenas add breadth to the way the activities of teaching are discussed in the literature and they offer frames for looking more deeply at the details of the process.

Different arenas, different possibilities. One way this model contributes clarity to the literature on textbook use is by delineating three arenas of the curriculum development process, thus offering a broader picture of teaching. The research on teachers' use of texts has treated teaching as one homogeneous activity, examining how "it" was shaped by a text. My observations of Catherine and Jackie suggest that teaching comprises different kinds of activities that involve varying types of decisions. The three arenas in the model represent the multiple activities of teaching, providing a frame for examining textbook use that allows for the possibility that teachers will use a text differently in each arena.

By focusing on single aspects of teaching, such as topic determination, task selection, or task enactment, researchers have observed partial images of teachers' textbook use, resulting in a variety of conceptualizations of textbook use in the literature. Some researchers have viewed teachers as either following or subverting texts. Others have focused on how teachers selectively incorporated them into their teaching. Others, arguing that strict fidelity is not possible, have examined how teachers interpreted textbook offerings in the process of using them. By taking into account the nature of each arena, we can see that certain of these images are more plausible in particular arenas than in others. For example, questions about teachers following or subverting their textbooks are more germane to discussions of the mapping arena than the other

two because the structural nature of a text's offerings in this arena tend to limit their malleability or openness to interpretation. On the other hand, the nature of the design arena, particularly its focus on selecting and designing tasks within particular topics, allows for considerable teacher interpretation of a text's suggestions. Because decisions in the construction arena are often impromptu responses to students, researchers examining teachers' textbook use in this arena are likely to focus on the extent to which they incorporate ideas from their texts into their classroom practice. Thus the model of curriculum development illustrates that examining the role a text plays in a teacher's practice involves consideration of its role in each of these three arenas.

A view within each arena. In addition to representing the multifaceted nature of curriculum development, this model provides a template for examining the details within each arena. Even though the particular models of Catherine's and Jackie's decision-making cannot be generalized to all teachers using any textbook, they reveal the complexity of factors that figured in the choices of two notably different teachers. The models presents an image of teacher decision making that involved interactions among the teacher's ideas about teaching and learning math, characteristics of the teaching context, students, and the text. These images add to the research on teachers' textbooks use by suggesting that these influential factors act in conjunction with one another. The model offers a frame for examining how these factors interact in each teacher's decision making.

Moreover, by highlighting the influential factors within each arena, the model helps to uncover characteristics of curriculum development that have received little attention in discussions of textbook use. Below I discuss two aspects of the process that this model helps to capture and articulate: The nature of the construction arena and the activity of reading. Both offer insights to understanding teachers' curriculum development activities and the potential for change.

The Nature of the Construction Arena

The model of teachers' curriculum development contributes to studies of textbook use by its characterization of the unique challenges in the construction arena. Although many studies have focused on how teachers use texts, few examined the process of enacting curriculum plans in the classroom with respect to the textbook. Those that have (Donovan,1983; Remillard, 1991c; Stephens, 1982) hinted at the tensions teachers have confronted between "using" the materials and attending to students' immediate needs. This tension, also felt by Catherine and Jackie, frequently has been missed because researchers have focused on how teachers use texts without attending to the circumstances that surround their use. By delineating characteristics unique to each arena, this model allows us to examine these circumstances. In particular, it highlights the unique demands the construction arena places on teachers, emphasizing its responsive nature and its dependence on students.

A better understanding of this arena and the factors that shape it is crucial for considering the role texts might play in reform because it is in this arena that curriculum is actually enacted. Thus, the activity of this arena is a key target of the current reform agenda. Reform documents, in addition to outlining new curricular goals, call for change in how students encounter and learn mathematics. By capturing the improvisational nature of this arena, this model helps to explain why the text played only an indirect role during this part of both Catherine's and Jackie's teaching.

This view of the construction arena raises questions about what determines the enacted curriculum and the text's role in it. Merely identifying topics to add to the curriculum or tasks to pose to students does not determine how they will be enacted in the classroom. As I described in Chapter 6, my analyses suggested that teachers' readings of the text and classroom events were key factors in the decisions they made in the construction arena. I discuss the importance of reading below.

The Importance of Reading

The model of curriculum development highlights reading as a key activity in both teachers' curriculum decisions and in their learning. Reading involved the active process of constructing meaning of various phenomena with an eye toward action. The teachers' different readings of the text first became evident as I developed the model of the design arena; in the process of selecting tasks, they focused on different parts of the text (items on student pages versus items in the margins of the teacher's guide) and attended to different aspects of it (tasks versus mathematical ideas). My examination of the two teachers' activities in the construction arena brought to light a different type of reading. Their curriculum decisions were informed by their reading of students and tasks as they were enacted in their classrooms. Thus, the process of curriculum development involved reading students' responses, events in the classroom, and suggestions in the text in order to decide how to respond. While their reading was influenced by the personal resources the teachers brought to their teaching, it was not limited by them. In fact, it was during the process of reading that the teachers encountered new and potentially challenging ideas about teaching and learning mathematics.

Understanding the nature of the reading process is important to understanding teachers' curricular development for three related reasons. First, it is the mental process closest to teachers' curriculum decisions. Thus, change in how or what teachers read is necessary for change in the enacted curriculum to occur. Second, it is a process in which the beliefs and understandings that teachers bring to their teaching help them to make sense of new events. Thus, it illustrates the process through which teachers' personal resources figured into, without completely determining, their curriculum decisions.

Last, because reading involves an active process of sense making, it has the potential to prompt teachers to reexamine their beliefs. In other words, reading did not always involve only a process of assimilation. Even though the teachers' beliefs influenced what

they paid attention to and their interpretations of it, the activity of making sense of unfamiliar events also prompted them to consider new understandings or perspectives. Thus, teachers' reading should be a primary focus of efforts to change the enacted curriculum. Moreover, fostering it might also be one route for such change to occur.

Given the centrality of teacher reading in the curriculum-development process, textbooks or curriculum materials intending to influence the enacted curriculum might do so through contributing to how teachers read and the subsequent decisions that they make. In the following section, I consider how and to what extent textbooks might be able to influence how or what teachers read. I examine what Catherine's and Jackie's cases suggest about the textbook's power to contribute to teachers' curriculum development processes.

The Potential and Limits of Textbooks in Curriculum Development

The assumption underlying the design and selection of reform-oriented curriculum materials is that textbooks have the ability to influence the enacted curriculum, that is, the curriculum that students actually encounter. In this view, the job of curriculum developers and publishers is to provide teachers with reform-based activities that they can "implement" in their classrooms (Russell, 1994). Jackie's and Catherine's cases, however, challenge this assumption by illustrating the limited role the text played in the construction arena and how their reading mediated the textbook's contribution to their curriculum processes. Consequently, my findings suggest that textbooks are not likely to directly shape the enacted curriculum, but they have the capacity to contribute to the enacted curriculum in alternative ways or through other parts of the curriculum development process. In this section I discuss what we learn from these two teachers about how textbooks might contribute to teachers' construction of the enacted curriculum. I also consider what the cases suggest regarding the limits of the power of texts. Later, I discuss related implications for textbook developers and teacher educators.

What Textbooks Have the Potential to Do

My analysis suggests two ways that texts might have an indirect impact on the enacted curriculum: First, by focusing on the task selection and mapping arenas, they might offer resources for teachers to use in the curriculum-development process that might figure in the enacted curriculum. Second, by intentionally fostering teacher development, they are likely to impact change in teachers' reading and decision making in all three arenas. I discuss each of these approaches below.

A resource in the curriculum development process. By illustrating the different purposes of the three arenas, the model highlights places in the process that are most and least receptive to a text's offerings. The teachers' decisions in the construction arena, because of its demand for responsive and improvised action, were minimally influenced by the text's suggestions. Decisions in the mapping and design arenas, on the other hand, were more receptive to the type of guidance a text might offer. Both teachers adopted all or part of the text's curriculum map and drew topics, tasks, or mathematical ideas from it to use when constructing the curriculum. These were part of the resources with which the teachers constructed the enacted curriculum. For example, neither the HBJ text's organization of the mathematics content into 13 chapters nor the tasks suggested in each chapter directly shaped the teachers' activities in the construction arena, but these resources figured significantly in their decisions in the other two arenas and, consequently, contributed to the enacted curriculum.

The HBJ textbook's focus, on the other hand, was to shape the enacted curriculum by providing teachers with prefabricated lessons to walk students through. Even though the text attended to curriculum mapping and task selection for teachers, these were not acknowledged as consequential points in the curriculum development process. Teachers' activities and choices in these arenas were not addressed by the text developers. The only decision-making activity that was arguably expected of teachers was that of selecting among the plethora of options provided in the text. This

expectation, however, was not explicit. The fact that the textbook included considerably more activities than could possibly be covered in a year was not mentioned in the book anywhere. Moreover, the text offered no guidance in the selection process.

A textbook designed to impact the enacted curriculum through the other two arenas would need to acknowledge the relationships among the activities of each arena. It would also need to take seriously teachers' reading and decision making at each stage of the curriculum-development process. Such a textbook would place as much emphasis on how the content is represented and the aims of the suggested tasks as the HBJ text placed on step-by-step instructions through the construction arena.

Facilitating teacher change. In addition to delineating all three arenas, my findings highlight the active role that teachers play in this process. Catherine's and Jackie's cases reveal that teachers' knowledge, beliefs, and commitments and their interpretations of classroom events play a primary role in their curricular decisions. Consequently, a textbook that is able to facilitate change in these personal resources might more effectively influence the curriculum process.

Both cases offer insights into the potential for reform-oriented textbooks to facilitate teacher change by providing examples of teacher learning with respect to the curriculum development activities. Most notable was the nature of the activities that prompted growth in their thinking. When the teachers engaged in curriculum development activities such as reading the text, inventing tasks, assessing students' mathematical encounters, and deciding how to proceed, they found themselves reexamining their beliefs and understandings about students or the mathematics and making subsequent changes. This pattern in their learning has implications for how textbooks might intentionally foster teacher change even though such activity was stimulated by the text only in Catherine's case.

Catherine's case, by providing an example of text-initiated teacher learning, suggests that texts have the potential to contribute to teacher change and learning when

they require teachers to actively participate in the curriculum development process. As she used new suggestions in the text and found herself in unfamiliar terrain, the process of reading her students and the tasks in order to navigate through this new terrain caused her to reevaluate many of her views.

Of particular interest in Catherine's case is the fact that engaging teachers in this type of active curriculum development was not an intent of the HBJ textbook developers. In fact, as I described above, the text seemed designed to not engage teachers in the curriculum process, but rather to do it for them. An implication of Catherine's case, then, is that textbooks might be intentionally designed to engage and support teachers in taking an active role in curriculum development.

Jackie's case also suggests that participation in the curriculum development process can facilitate learning. In her case, however, it was Jackie herself who initiated these activities and not the text. Her case raises questions about how texts might be designed to support teachers in selecting and inventing mathematical tasks, guiding students' encounters with them, and assessing their understanding in order to decide how to proceed. Her case also illustrates that, in spite of the text's capacity to offer new topics or tasks, teachers ultimately decide which to use. Thus, their decisions are key to the text's ability to contribute to the enacted curriculum. In the section that follows I consider implications of these issues.

<u>Limits of the Power of Textbooks</u>

Because the models of Catherine's and Jackie's curriculum development place textbook use within a broader decision-making context, they highlight the multiple factors that affect teachers' curriculum decisions. As I discussed in Chapter 1, much of the research on teachers' textbook use has focused on the perceptions and understandings of teachers that figure in how they use texts. Researchers have observed that teachers' ideas about purposes of school, their knowledge and beliefs about mathematics, and their perceptions about the value and authority of the text all

influence their text-related decisions. Except for the Content Determinant Study (Floden, Porter, Schmidt, Freeman, and Schwille, 1980; Kuhs and Freeman, 1979), which found that teachers' perceptions of external pressures also influenced their decisions, these studies tend to give minimal attention to influential factors outside of the teachers.

As discussed earlier, my findings confirm the power that teachers have in mediating textbook offerings. Both Jackie's and Catherine's personal resources influenced how they read and drew on the HBJ textbook. These findings also highlight factors outside of the teachers that impacted their text-related choices. The models of their decision making in each arena reveal that support and demands from the context, the activities of students, the nature of the arena itself, and the nature of the textbook influenced their decisions. Researchers examining teachers' decision-making processes and responses to reform policy have observed the power of external factors such as these (Cohen, 1989; Cohen et al., 1990; Fullan, 1991; Talbert & McLaughlin, 1993; Sarason, 1982). Nevertheless, because of its focus on the teacher-text relationship, research on textbook use has kept these factors in the background. As I discuss below, the models of Catherine's and Jackie's curriculum development suggest that certain of these factors are central in facilitating or inhibiting teachers' choices with respect to the text. Moreover, they have important implications for the circumstances under which reform-oriented texts should be used.

The role of the context. Both cases illustrate the influence of contextual factors on teachers' interactions with textbooks. As a pair they offer different perspectives on the influence of external expectations, pressures, and support on how teachers read and use textbooks. The two elements of the context that had the most significant impact on both teachers were pressures they felt to cover particular content and encouragement they experienced to attend to certain aspects of the text.

The fact that teachers feel pressured to cover a large amount of content in one year is not new. Such expectations, usually imposed by school districts, have been

documented as being influential in teachers' text- and curriculum-related decisions (Cohen et al, 1990; Floden, Porter, Schmidt, Freeman, and Schwille, 1980; Kuhs and Freeman, 1979; McLaughlin, 1990). The extent to which these two teachers responded to district pressures to cover content appeared to be a function of organizational structures in their individual schools. Catherine's case provides an example of how the typical school structure intensifies external pressure. She had one school year to get students through the established list of topics. Her strategy for moving quickly through the four operations while concurrently covering the noncomputational chapters in the new text was a response to this pressure. Jackie's case highlights the power of external pressures from a different perspective. She illustrates one teacher's response to increased curricular flexibility when these pressures are diminished. Because she had the same students 3 years, she felt the freedom to exercise more control over the number of topics she covered in a year and the depth at which she pursued them. Even though it is likely that teachers will interpret similar circumstances in their own ways, these two cases provide an example of the power of the context to foster or inhibit change.

The other type of contextual factor that had a significant influence on both teachers' choices was personal or collegial interactions with interested others. The role and power of such support in teachers' decision making has not had a prominent place in the literature on teacher change. Nevertheless, the cases confirm findings of other researchers who have observed that collegial interactions (Beasley, Corben, Shank, & Feiman-Nemser, 1996; Lieberman, 1990; Little, 1982; Little & McLaughlan, 1993; Smith & Featherstone, 1996) and the inquiry process itself (Berkey, Curtis, Minnick, Campbell, Zietlow, & Kirschner, 1990; Featherstone & Smith, 1996; Florio-Ruane, 1986) can increase teacher reflection and experimentation.

Even though outside support took a different form and, consequently, had different impacts on each of the two teachers, the fact that both were influenced by interested others hints at the ability of such support to mitigate the isolation and

individualism inherent in most teaching contexts (Jackson, 1986; Little, 1982; Lortie, 1975; Richardson, 1994). The support that Jackie felt from her colleagues was an intentional part of her PDS school context. Through the mathematics study group she was able to explore mathematical ideas and alternatives approaches to helping students learn them. These activities provided her with alternative images of teaching math and the knowledge that she was not alone in her efforts to use them. This type of support facilitated Jackie's move away from the textbooks. Catherine's textbook use was also influenced by contextual support that was not intentional. Rather it was a result of the study. She found that my frequent presence in her classroom and the interviews that called on her to articulate rationales for her decisions prompted her to look carefully at the textbook and think deeply about the choices she made. Unlike Jackie's experience, this support increased the amount of attention she paid to the textbook. In other words, the teaching context may figure significantly in teachers' interaction with new texts.

The role of students. Another factor outside of the teachers that influenced their choices was the students' themselves. This was particularly the case in the construction arena. Both Catherine and Jackie read their students' responses to tasks they presented as gauges of their understanding and interest. What they read figured significantly in the decisions they made from moment to moment and from day to day, making the enacted curriculum impossible to predict or predetermine.

The role of students in teaching and particularly the influence that their actions have on teachers' decisions has recently surfaced as a central concern in research on teaching (Cohen, 1989; Featherstone & Smith, 1996; Fullan, 1991; McLaughlin, 1993; Moje, 1996), but has received little attention in the research on textbook use. My findings, however, suggest that how teachers read students' activities in the classroom plays a central role in shaping their textbook and curriculum-related decisions.

The nature of the arena. My examination of Jackie's and Catherine's decision making also reveals that the influence of the above factors varied according to the

particular arena. For example, the structures of their school and teaching situations figured powerfully in the mapping arena for both teachers, while personal support from others had the greatest influence in the design arena. Students, on the other hand, played a strong role in shaping their decisions in the construction arena. Even though my findings regarding these two teachers cannot be generalized to all teachers, the fact that the same factors figured more strongly in the same arenas for both teachers is a noteworthy pattern. This overlap suggests that external factors may not influence teachers' curricular choices similarly in different arenas. Rather, the influential power that any external factor has might be a function of the particular arena.

The nature of the textbook. Another factor that influenced Catherine's and Jackie's interactions with the HBJ textbook was the nature of the text itself, its contents, design, and how it was viewed by them. The fact that the text was reform-oriented and included a range topics and activities associated with the NCTM <u>Standards</u>, for example, stimulated both teachers' interests in using it. Still, certain characteristics of its design prompted different reactions from the two teachers as a result of their personal resources. In fact, particular aspects of <u>what</u> the text offered together with <u>how</u> it offered them facilitated their different responses to it.

A characteristic of the HBJ textbook that prompted almost opposite responses in each teacher was its familiarity. The HBJ text did not represent a radical shift away from the text it replaced. As I described in Chapter 3, the text responded to the reforms by adding new topics, pedagogical suggestions, and student activities that reflected changes called for by the NCTM <u>Standards</u> to its customary offerings and format. It was still divided into the standard 13 chapters and focused primarily on developing computational proficiency. In essence, the text represented a collection of reform-related ideas inserted into a very familiar body—an image not unlike Catherine's view of the reforms.

This familiarity influenced the way both teachers used the text. Even though it included many new topics, its familiar organization and format made it particularly accessible to Catherine but disappointing to Jackie. For Catherine, using the text's suggestions required a willingness to try new tasks, but not a wholesale revision in her ideas about teaching mathematics. She referred to the HBJ text as "middle of the road" (Interview, 11/9/92). Jackie, too, felt the text represented partial and tentative steps toward change, but this lessened her interest in using it. She expected her new text to reflect greater commitment to the reform agenda. She was discouraged by the large number of tasks that appeared unchanged from those in her old text, and she questioned its capacity to stimulate significant change: "If you want to be traditional with this book, you can do it just like you did with any other book" (Interview, 2/1/93).

Another characteristic of the HBJ text that intensified the different ways the teachers used it was the variety of offerings it provided with little guidance in navigating through them. The text provided a large selection of disconnected tasks or activities within a familiar structure. In the process of using the tasks, the teachers had to select among these offerings. As I described in Chapter 6, both teachers tended to read and consider tasks that fit with their ideas about good mathematics teaching. Consequently, both used tasks in the text, yet there was little overlap in those they used or how they used them.

Despite the choice of tasks offered by the text, the larger curricular map included little flexibility. The text was organized into 13 chapters, each consisting of a set of daily, sequential lessons. Furthermore, the picture of the curriculum it presented was only moderately innovative. Because of its inflexibility, a teacher who was dissatisfied with the content, sequencing, or pacing would need to replace it with her own. A reformminded teacher like Jackie, interested in increasing the emphasis in the text on student understanding, had to choose between the guidance of the text and her own goals. Thus, the limited versatility in structure and great variety of tasks increased the

likelihood that teachers would use the text in very different ways. This served to dilute its capacity to contribute to reform-related practice.

The different responses that Jackie and Catherine had to the text raise questions about findings of researchers who viewed textbooks generically and considered the extent to which teachers used components of textbooks differently. Their findings have been mixed. Freeman and Porter (1989) and Graybeal and Stodolsky (1987) analyzed and classified the main component of textbooks and examined which of these teachers tended to use. They noted that teachers paid attention to items on the student page more than the margins and suggested that publishers put more reform-related activities on the student page. Even though I examined only two teachers, my findings revealed minimal overlap between the two teachers in the text components they used. More reform-related activities on the student page may not have impacted teachers like Jackie, who tended to avoid the student pages. Similarly, new suggestions in the computation chapters may not have influenced a teacher like Catherine who relied on her own approach to teaching computational procedures.

My findings point to consistency within each teacher. In other words, Catherine and Jackie read and used different parts of the text, but there were evident patterns in those parts used by each teacher. This within-teacher consistency implies that the selections teachers make from their textbooks depend more on the individual teachers than the various components of the text. Their different ideas about mathematics and what the reforms were about, for example, accounted for differences in the aspects of the text they paid attention to.

The Potential for Change

The findings of this study both confirm and add to the limited claims in the literature regarding the power of textbooks to motivate change in teaching. Although the number of studies examining the impact of textbooks on teachers is small, most have found that teachers' beliefs and perceptions mediate the offerings of many innovative

textbooks (Donovan, 1983; Remillard 1991c, Stake & Easley, 1978; Stephens, 1982). Two studies that documented text-motivated change (Wiemers-Jennings, 1990; Remillard, 1992) were of teachers using texts that had undergone moderate, rather than fundamental, change. In another study of preservice teachers, Ball and Feiman-Nemser (1988) described a prospective elementary teacher whose mathematical knowledge was enriched through close examination of the materials in the textbook. The two cases in this study confirm the general sense in the literature that, despite the potential power a text might have to facilitate change in teaching, the teacher is the final arbitrator in determining the extent of its impact. On the other hand, my findings also provide a clearer view of two teachers' curriculum-development processes, including the various factors that influenced how they used the text. They also highlight relevant characteristics of the curriculum-development process, such as the nature of the construction arena and the importance of reading, that have not been acknowledged in previous research or in curriculum designers efforts to prompt change. In the following section, I consider implications of my findings for writers and users of reform-oriented textbooks.

Implications for Writers and Users of Reform-Oriented Textbooks

The question underlying this study was whether and how redesigned curriculum materials have the capacity to support curricular and pedagogical change in mathematics education. The findings discussed previously suggest that texts may be able to contribute to change in teaching, but through routes less frequently considered. In this section I discuss ways that curriculum developers might pursue these routes. My findings also suggest that teachers' personal resources such as their ideas about teaching, learning, and mathematics play mediating roles in teachers' interactions with texts.

Consequently, it is unlikely that reformed curriculum materials will have any significant impact on teaching if careful consideration is not given to the types and nature of support that accompany them. Thus, I also discuss implications for teacher education

and professional development. My aim is not to cast professional development as a necessary measure in the successful change of curriculum materials. Rather, it is to emphasize the need for coordinated efforts in curriculum material development and teacher development activities. In fact, a central contribution of this study is the interconnection of curriculum development and teacher development (Featherstone & Smith, 1996).

In this section, I use the terms "textbook" and "curriculum materials" interchangeably. Textbooks generally refer to the most traditional of curriculum programs that usually include a classroom set of student texts and a teacher's guide. The term "curriculum materials" has been used in recent years to refer to programs that are unlike textbooks in design and content. Many noncommercial curriculum developers have adopted the term curriculum materials to differentiate their programs from those most commonly used in schools. In the previous chapters, I used the term textbook, since it best describes the HBJ program. The following recommendations for curriculum developers and the materials they develop that are intended for all developers.

The suggestions in this section grow out of findings of my study. Many are, however, speculative and conjectural. They have not been tested by previous research because they have not yet been attempted. They are all candidates for further research. Thus, implicit in the following recommendations for reform-oriented textbooks design and teacher development is a research agenda to examine their impact.

<u>Textbooks that Foster Teachers' Curriculum Development</u>

I asserted earlier that reform-oriented textbooks designed to engage teachers in curriculum development have the potential to also facilitate their learning. This assertion was influenced, in part, by McLaughlin's (1976) discussion of mutual adaptation in instructional policy initiatives. As I described in Chapter 6, McLaughlin and her colleagues found that effective implementation occurred when teachers and

administrators adapted the project design to their particular circumstances and, in turn, adapted local conditions as well. This process of making goals and assumptions explicit fostered learning-by-doing. In other words, through the adaptation process, both the school personnel and the programs they had set out to implement underwent change. This change was not unlike the learning that both Catherine and Jackie experienced when trying to adapt their curricular plans to their students' responses. Thus, curriculum materials that are able to foster teachers' curriculum development are also likely to stimulate their learning.

An image of textbooks designed to engage teachers in the curriculum development activities assumes revision or expansion of several assumptions underlying the design of most curriculum materials.¹ These assumptions fit into three categories: (a) who curriculum materials are for, (b) what curriculum materials offer, and (c) how they communicate with teachers. In the following sections, I describe how these assumptions are currently manifested in curriculum materials and then offer recommendations for ways textbook writers might change them. Later in the chapter I discuss caveats associated with these suggestions.

As will become evident, my treatment of these three assumptions separately, for the purposes of analysis and discussion, is artificial; in reality they are part of the same larger whole. For example, implicit in how text writers talk to teachers are assumptions about what they talk about. I argue that texts need to talk to teachers about more than they traditionally have. This argument implies a change in how texts communicate as well as what they communicate. Thus, these assumptions and the suggestions that follow should be viewed as interconnected.

¹I am not suggesting that all curriculum materials are the same. My experience suggests that most commercially published teacher's guides are similar to the HBJ text with respect to these assumptions. At the same time, a number of groups are currently developing curriculum materials that challenge these assumptions.

Who Textbooks Are For

Naturally, texts or teacher's guides are written for teachers to guide their instruction. My analyses of the HBJ text suggest, however, that the text's focus was shaping students' experiences in the mathematics classroom. Its communication with teachers was wholly to this end. Thus, it was written with the activities of students, rather than teachers, in mind. The role of teachers implied by the text was to "deliver" activities to students.

My findings revealed two characteristics of teachers' curriculum development that limit the effectiveness of textbooks designed to predetermine students' experiences in the classroom. First, teachers are likely to read their own ideas and purposes into tasks in their text. Second, the process of enacting tasks in the construction arena is responsive and interactive. It was the point in their curriculum development that both teachers relied almost completely on their own personal resources to decide how to proceed.

A third factor limiting the effectiveness of texts written to speak to students through teachers is the nature of the reforms themselves. Central to the reform agenda is the idea that students' understandings of mathematics should enable them to reason and solve problems, rather than merely follow rules or memorize facts. To this end, reformers have emphasized instructional activities in which students actively solve problems and discuss their ideas with others. Such an instructional format involves a significant shift from those found in commercial textbooks, including the HBJ text, in which the teacher or textbook poses questions that the students answer. It is unlikely that textbooks can bypass the teacher in the process of orchestrating reform-oriented activities. Furthermore, helping students learn to think mathematically requires that teachers understand the mathematics themselves, as well as attend to students' developing understandings, looking to their ideas and struggles to determine what to pursue in a given lesson. Thus, implicit in reformers' goals for students are parallel

goals for teachers: thoughtful decision making that is responsive to the situation at hand (Ball, 1994). As Jackie found, this could not be done by prescriptively following predetermined steps in a text.

My position is that reform-oriented curriculum guides need to be written <u>for</u> teachers. As Bruner (1977) put it, "[Curriculum] must be first and foremost a curriculum for teachers. If it has any effect on pupils, it will have it by virtue of having had an effect on teachers" (p. xv). Curriculum developers need to view teachers, rather than students, as the primary users of their materials. Furthermore, they need to aim, through their materials, to engage teachers in active curriculum development. In the following sections on <u>what</u> reform-oriented materials should offer and <u>how</u> they should communicate their offerings to teachers, I discuss ways that textbooks might be written for teachers with the intent of fostering their curriculum-development activities.

I expect that the mathematics content and organization of these texts reflect a genuine commitment to the ideas of the reforms. Even though the analysis in Chapter 3 is critical of the HBJ text's superficial commitment to the reforms reflected in the content and organization, I will not address this issue in my suggestions. I see commitment to the reforms as a necessary characteristic of reform-oriented texts that a number of noncommercial curriculum writers have taken seriously. While necessary, it is not sufficient. Thus, my focus here is on more subtle aspects of text design that take into account the role of the teacher using them.

What Textbooks Offer

Mathematics textbooks generally guidance in two aspects of mathematics instruction: mathematics content and teaching the content. The HBJ textbook attended to both these aspects of teaching mathematics, but, as I discussed earlier, not necessarily in ways designed to engage teachers in curriculum development. The focus of the text's guidance was on the outcomes of the curriculum development process—the tasks to give students and the order in which to give them. The overall assumption implicit in HBJ

text's offerings was that texts should provide finished curriculum for teachers to enact in the construction arena.

Catherine's case illustrates how a collection of preplanned activities might contribute to changes in teachers' ideas about mathematics learning. Through providing tasks to pose, the text introduced new ideas into her practice, where she examined them, made decisions about how to act on them, and became convinced of their value. Thus, textbooks have the potential to foster teacher change through providing a collection of non-standard tasks for teachers to try (Featherstone & Smith, 1996).

Even though this type support prompted Catherine to rethink some of her views on mathematics learning, it was not an intentional aim of the writers. Furthermore, both cases illustrate that just providing tasks was not sufficient. It was not in a form that Jackie found useful and it was not enough to help Catherine consider underlying mathematical ideas or pedagogical implications. The text did not go on to help teachers actually <u>use</u> the suggestions it offered in any way other than following them in order. Its focus was entirely on the initial stage of the construction arena—presenting students with tasks. A key implication of my findings is that texts that contribute to teachers' reading and decision making, particularly in the other two arenas, are more likely to impact teaching.

Contributing to teachers' reading. In order to make a greater contribution to teachers' reading of curriculum materials, developers will need to offer more to read than tasks. Knowing that teachers looked to the text for different things, text writers will need to provide a variety of types of information for teachers that will contribute to their efforts to assess and interpret specific tasks. For example, in addition to describing a task, text authors might discuss the underlying mathematical goals, suggesting ways that the task might be made more or less complex, but still focused on the intended goal. They might also suggest a range of pedagogical options that teachers have used to address the particular mathematical idea along with sample student work or responses

to these tasks. Because teachers might attend to different parts of a text, writers will need to explain how the different parts are related to one another and to the overall goals of the lesson or chapter.

Another type of reading that was central to both teachers' curriculum development was their reading of students and tasks in action. In order to contribute to this type of reading, texts will need to prompt teachers to examine their students' thinking with respect to the goals of the mathematical tasks. This sort of reading might be encouraged through descriptions of possible student responses or work, annotated to highlight how they could be interpreted. Researchers have found that examining examples of students' invented solution strategies to problems can pique teachers' curiosity about their own students' approaches (Carpenter et al., 1988; Davenport & Sassi, 1995; Featherstone & Smith, 1996). The rapidly growing body of research on children's thinking in various mathematical domains can already contribute much to possible frameworks. For example, researchers involved in the Cognitively Guided Instruction Projects (Carpenter, Fennema, Franke, 1994) have developed frameworks for student's thinking about addition, subtraction, multiplication, division, and place value. Others have examined students' understandings and abilities with respect to ratio and proportion (cf. Behr, Harel, Post, & Lesh, 1992; Parker & Leinhardt, 1995), estimation and number sense (cf. Sowder, 1992), geometry and spatial reasoning (cf. Clements & Battista, 1992), probability and statistics (cf. Shaughnessy, 1992), and algebra (cf. Kieran, 1992). Drawing on work such as these, texts can offer teachers lenses for examining students' understandings.

Texts can also focus teachers' reading on the processes through which students develop understandings during classroom discourse by providing images of classroom interaction. Some alternative curriculum materials developed in the last several years have begun to provide samples of classroom discourse that might occur as a class pursues a particular task. These can provide "useful images of teachers engaging"

students in mathematical investigations [that] allow teachers to envision the taking on of similar actions" (Davenport & Sassi, 1995, p. 40). While they provide images of rich student discourse, there are two ways texts might go further in assisting teachers in the type or reading Jackie and Catherine found themselves doing. First, they might use annotations to provide the reader of the text access to the teachers' thinking during classroom interaction. Lortie (1975) argued that students learn by watching what teachers do, but they do not have access to the decision making processes behind teachers' actions. Similarly, sample dialogues that only provide teachers with images of rich classroom discourse run the risk of focusing teachers on the doing and not the analysis that guided it. Second, sample dialogues might also include examples in which students or teachers are genuinely perplexed about how to proceed along with commentary on how these struggles might be assessed. Again, such details would have the potential to bring to the fore the reading process, rather than focusing solely on implementation

Contributing to teachers' decision making. The other curriculum development activity that reform-oriented textbooks need to attend to is decision making. The purpose of both teachers' reading was to determine how to act on, or respond to, suggestions in the text and events in their teaching. In order to contribute to teachers' decision making text writers will need to build into their materials spaces and support for teachers to make decisions. My use of the term "space" has two connotations. Figuratively, it refers to a measure of flexibility in which teachers can move. Literally, it refers to an opening in which to work such as a work space or an empty canvas. Texts designed to guide teachers in their own decision making need to include both kinds of space; they need to be flexible and responsive to teachers' choices and incomplete without their input. Ironically, the idea that space should be added to curriculum materials runs counter to many text writers' inclinations. Every possible space in the HBJ text, for instance, was overflowing with predetermined activities to give students.

In order to provide space for teachers' decision making texts would need to be much less "finished" than published texts we are familiar with.

My position that curriculum materials might make spaces for teacher decision making is similar to Bridgham's (1971) view that good curriculum materials might be like envelopes containing multiple possible trajectories through a defined pedagogic terrain. Ben-Peretz (1990) suggests the boundaries of the "curriculum envelope" are defined by certain pedagogical characteristics, emphases, ideals, or goals established by the developers. Much like selecting among the many routes through a city, the paths that teachers and students take through the pedagogic space are not predetermined by the writers, but are the results of day-to-day and moment-to-moment decisions. These images of curriculum materials as envelopes that offer flexibility of movement are similar to Shulman's (1983) conception of educational policy. He suggests that policy should be "designed as a shell within which the kernel of professional judgment and decision making can function comfortably" (p. 501). They might outline moral and political imperatives, but not provide directions for actions. Bridgham's idea that the curriculum envelope contains trajectories or possible routes through particular terrain, however, distinguishes the role of curriculum materials from that of policies in a crucial way; in addition to offering freedom of movement within pedagogic space, curriculum materials must also assist teachers in navigating through that space in productive ways. As Heaton (1994) put it, "Curriculum developers must find ways to guide teachers' pedagogical and mathematical decisions, not make decontextualized decisions for them" (p. 376).

The combination of flexibility and guidance I am suggesting for texts contrasts with the variety of tasks the HBJ text offered teachers to choose among. The number of options in the HBJ text made it necessary for teachers to make selections, but without any help in doing so. Furthermore, selecting among the variety of tasks was the only aspect of teacher decision-making incorporated into the text. The curriculum map and

design of the tasks were not intended to be flexible. While the text offered teachers variety, it lacked versatility. It is my position that the type of variety in the HBJ text, and many textbooks like it, gives teachers choice at a superficial level, but does not provide the requisite guidance or space for meaningful decision making. In order to foster teachers' decision making, textbooks need to include versatility, rather than variety. They need to offer flexible routes through the mathematical terrain, rather than eclectic assortments of activities.

In addition to making spaces for teachers by structuring materials to include flexible routes through them, texts need to support teachers' decision making within those spaces. Several of the suggestions I have already made regarding the type of information and images texts might provide can contribute to fostering teachers' decision making. Discussion in the text about underlying mathematical goals, possible student responses, and annotated images of classroom discourse can invite teachers to assess their students and think with curriculum writers about where to go next. Texts might also provide several possible trajectories that teachers might follow, rather than one linear path. On several occasions Jackie felt she had to decide to follow the text or the students; a text that supported teachers' decision making would guide teachers to follow students.

Contributing to the design and mapping arenas. As I have already discussed, the focus of the HBJ textbook was the construction arena. The authors' mapping and design decisions were evident, but they were not open to question or adaptation. Thus, the teachers either followed the suggestions offered or abandoned them all together. In short, the lack of explicit attention to mapping and design decisions inhibited the text's flexibility in these arenas.

Central to the suggestions I have offered above is the assumption that a reformoriented textbook would contribute to teachers' reading and decision making in the design and mapping arenas as well as the construction arena. Text writers need to make the activities of these arenas more prominent and they need to engage teachers in them. For example, they might provide a map or picture of the larger mathematical terrain into which a set of ideas fits, including discussion of sequencing and pacing. Also, by discussing ideas underlying tasks and ways they might be adapted, a text can encourage teachers to make informed adaptations or invent new tasks.

Underlying the suggestions above is the assumption that textbooks should talk to teachers about more than they traditionally have. Rather that merely giving tasks for teachers to use, texts need to include discussions of the underlying mathematical ideas, how teachers can use them, and how students might respond. The aim of resources such as these would be to facilitate teacher reading and decision making in all three arenas and to foster their learning. A related assumption, that I discuss below, is that textbooks will need to communicate with teachers differently.

How Textbook Writers Communicate with Teachers

As I have already discussed, the HBJ textbook was designed to provide teachers with a collection of tasks to give to students. It communicated by speaking through the teachers and the guidance it provided for their actions. It did not speak to them about these tasks or the ideas underlying them. This choice of language is common among many curriculum guides that set out to shape the activities of the construction arena. They tend to direct teachers' actions by offering steps to follow, problems to give, actual questions to ask, and answers to expect. This approach to teaching guidance focuses entirely on the in-class activities of teaching and not on the rationales, assumptions, or agendas supporting them, discouraging teachers from engaging the ideas underlying the writers' decisions and suggestions.

Texts designed to engage teachers in helpful dialogue would need to communicate in a different language in order to attend to the activities of reading and decision making. They must be designed to speak to them, not merely through them. In addition to suggesting to teachers what they might say or do, text writers need to talk to

teachers about these suggestions, about the mathematical and pedagogical ideas underlying them, and about students' likely encounters with them. In doing so, they need to make their agendas and perspectives accessible to teachers. The suggestions in the previous section are all predicated on the assumption that textbooks might be designed to talk to teachers in this way.

Weighing the Possibilities

These suggestions for redesigned textbooks are two overarching recommendations that have grown out of my findings: texts need to offer both more and less than they traditionally have. They need to offer more in terms of conversation, description, images, examples, resources, and flexibility. But they would also need to offer less in terms of predetermined structure and design. Together, these two recommendations place untypical expectations on textbooks and text writers; they require that textbooks look considerably different from current texts, and they suggest different perspectives and aims for text writers. I explore the implications of these demands in the following section.

Implications for Reform-Oriented Textbooks and Textbook Writers

The recommendations in the previous section call for a radical shift in the design and purpose of texts, as opposed to the superficial changes evident in the HBJ textbook. Some developers of alternative curriculum materials have begun to pursue these shifts by making changes in the standard text format. Increased emphasis on classroom interaction and student activity has led many developers to reduce the amount of paper and pencil work. Some have eliminated the student's text all together, relying on black-line masters or student activity booklets when necessary. Many alternative text writers also avoid presenting the mathematics curriculum in a large number of chapters that focus on skill development. Some recently developed materials consist of fewer units that focus on conceptual ideas. Few curriculum developers, however, have attempted to engage teachers in the type of curriculum development called for by the preceding

recommendations. Doing so is likely to require changes in the orientations and understandings of those that write them.

Implications for Writers of Textbooks

Those who write textbooks or other curriculum materials are generally thought of as curriculum developers since the focus of their work is on conceptualizing and organizing the curriculum for teachers. My findings, however, highlight the significant role that teachers play in the curriculum development process and the consequent need for texts to contribute to teacher development as a means of contributing the curriculum development. Consequently, text writers need to know about more than mathematics, curriculum, and student learning. They must be able to understand teachers and the processes of learning to teach mathematics differently. They need to draw on and add to general knowledge about teachers and teacher learning, and they need to understand and attend to the diversity of teachers.

Knowledge about teachers. In order to contribute to teacher development, text writers need to understand who teachers are and what they bring to their mathematics instruction. Curriculum materials and the language used to talk to teachers need to reflect this understanding. It is imperative that the work of curriculum writers' be informed by knowledge about teachers in relation to mathematics instruction, the reforms, and the processes of teacher learning and change.² The growing body of research on teacher thinking, learning, and change can contribute to this knowledge (cf. Hargreaves, 1994; Huberman, 1993; Schifter, 1995a & 1995b). Those who write texts should be familiar with the research on the relationships between experiences, beliefs, and practices. Furthermore, field tests of curriculum materials under development

²It is likely that many curriculum developers know something about teachers with regard to these topics. It is, however, not evident that this knowledge informs the design of texts. As I will discuss later in this chapter, the most powerful factor influencing the choices of commercial publishers is the market. Their design choices are based on what will sell. At this point, we do not know whether a text that pays attention to teachers as active curriculum developers and learners will sell in the commercial market because it has never been tried.

should be designed to contribute to this knowledge and should continually inform the way text writers talk to teachers.

In addition to knowing about what teachers value or pay attention to, text writers also need to understand which topics are likely to be difficult for teachers. For example, they need to be aware that the type of mathematics instruction that the current reforms promote is vastly different from the math most Americans encountered as students or as teachers. It is therefore likely that teachers will find many tasks as unfamiliar and challenging for themselves as they are for students. In other words, curriculum developers need to realize that learning to teach mathematics for understanding is necessarily a process of unlearning and relearning (Ball, 1994; Talbert & McLaughlin, 1993). Thus, reform-oriented texts need to recognize and support this process. My analysis of the HBJ text suggests that the writers assumed that teachers were familiar with the reform agenda and the intent behind the choices in the text. They assumed, for example, that teachers understood and were already committed to the new ideas the text suggested. These assumptions did not hold true for either Catherine or lackie.

Differences among teachers. In addition to drawing on general knowledge about teachers as a group, curriculum writers need to be informed by an understanding of the ways in which teachers are likely to be different. Text writers need to know about the range of different perspectives and backgrounds teachers bring to their teaching.

Catherine and Jackie, for example, were at different points in their learning with regard to the reforms when they first encountered the HBJ text. The text, however, met both teachers at the same place; it assumed that they both would interact with it in the same way and that they both had the same knowledge and ideas about teaching mathematics and the reforms. A text that can effectively contribute to both Catherine's and Jackie's curriculum development would need to recognize and accommodate these differences.

The task for text writers, then, is to construct materials that are multifaceted in what they

offer to teachers. They need to offer straight-forward guidance or suggestions, accessible explanations of underlying ideas, images of classroom interaction, and allow for a great deal of flexibility and invention. In essence, reform-oriented texts must, at once, present a vision of thoughtful mathematics teaching and help a range of different teachers pursue it.

Rethinking the Medium of Reform-Oriented Curriculum Materials

The suggestions I have made for what reform-oriented curriculum materials need to offer teachers and how they need to communicate with teachers do not readily fit into the standard textbook format. The contents would need to be significantly thicker than most texts and they would need to be designed in a way that allows them to be flexible and responsive to teachers' decisions. These demands bring to the fore the limitations of the medium of the standard, printed textbook format, raising questions about alternative media for curriculum materials. One possible alternative is computergenerated hypertext environments. Being much more versatile, flexible, and nonlinear than printed books, hypertext may have the capacity to provide space for teachers to engage in the curriculum development process. Furthermore, because it is a medium for curriculum materials, hypertext may be free of much of the baggage that other materials carry. Below I briefly consider some ways that a hypertext environment might fit with the role I have suggested reform-oriented curriculum materials need to play. I do not see hypertext as the only possible medium for such texts, but it seems more appropriate than others I am able to imagine at this point.³ Clearly this is an area in need of further conceptualization and research. My immediate aim is to suggest an alternative that defies the boundaries established by what is familiar.

³My knowledge of the complexities of hypertext is limited. However, I have been encouraged to consider such a medium for curriculum materials that can be more interactive for teachers through conversations with Dan Chazan and Steve Smith. My understanding of the interactive and flexible possibilities of hypertext, while still minimal, has gained depth through observations of the work of Deborah Ball and Magdalene Lampert, who have developed hypertext environments to be used in teacher education.

Like most computer-generated environments, hypertext has the capacity to interact with teachers using multiple formats. Unlike a printed text that is limited to words, pictures, and drawings on the page, an electronic medium can also display video segments of classroom interaction or audio taped commentary by teachers. Because these offerings would not be arranged in a linear manner, teachers could access them in the order that made sense to them, rather than in an order selected by the writer. It can offer many possible paths through its contents that are akin to Bridgham's (1971) trajectories through pedagogic space. Electronic media also have the capacity to store a great deal of information in an organized way, making it possible for curriculum materials to contain the thickness and depth necessary in order to be accessible to and appropriate for a diverse group of teachers without being physically cumbersome.

Curriculum materials stored in hypertext also has the potential to put the user in charge of directing a path through the materials. In fact, using it would require teachers to navigate through them and interact with them. The non-linear nature of a hypertext environment could provide the flexibility necessary for teachers to act on their reading of the classroom situation. The changeable nature of an electronic medium would enable developers to provide curricular plans that are versatile, allowing the teacher to adapt and add to them.

Limits of Changed Textbooks

The type of textbook I have conceptualized prescribes a different relationship with teachers than has commonly been the case. Textbooks have most frequently been designed to shape the curriculum for teachers and guide them in carrying out these predetermined plans. My findings suggest that textbooks and curriculum materials can contribute more substantively to reform-oriented teaching if they place much of the decision making in teachers' hands. Doing so would require the degree of autonomy that Shulman (1983) envisioned for teachers with respect to policy when he suggested that policies might represent moral and political imperatives rather than directives of

teacher actions. Given the personal and contextual factors that figured in Catherine's and Jackie's choices, it is unlikely that this autonomy can be nurtured by changed curriculum materials alone. Thus, success of redesigned textbooks is necessarily dependent on opportunities and support for teachers to learn. In his discussion of policies as shells in which the kernel of professional judgment might function comfortably, Shulman (1983) raises questions about these other considerations:

If professionals are to exploit the opportunities offered by autonomy in the interests of youngsters, how must they be educated, selected, supported, and supervised? What is needed on the parts of educators if they are to render intelligent and proper judgments regarding choices among competing policies, trade-offs between alternative goals or decisions regarding fruitful methods? (p. 501)

It is these questions of teacher education and support that I take up in the ensuing sections.

<u>Implications for Teacher Education and Professional Development</u>

My findings and subsequent recommendations for revised textbooks and curriculum guides have implications for the education and development of teachers for two reasons. First, because the type of interactive relationship that I envision for teachers and texts is foreign to most teachers, they need opportunities to learn to participate with texts in curriculum development. Second, as the various factors that influenced Catherine's and Jackie's choices suggest, there is much that revised textbooks cannot accomplish alone. In other words, it is unlikely that reformed curriculum materials will have any significant impact on teaching if consideration is not given to the types and nature of support that accompany them. My aim is not to cast professional development as a necessary measure in the successful change of curriculum materials. Rather, it is to emphasize the need for coordinated and coherent efforts in curriculum material development and teacher development activities.

In the following discussion I consider how professional development activities and preservice teacher education can support teachers in becoming more active in the curriculum development process. I focus my suggestions on three related areas of

learning for teachers: (a) cultivation of reading and decision making, (b) deepening and broadening their mathematical knowledge, and (c) developing knowledge of the workings of the curriculum development industry. Development in these three areas can foster teachers' abilities to assess students and mathematical tasks and goals, and to critically examine the offerings in their textbooks in order to adapt and transform them.

Developing these abilities is likely to require time and experience (Bridgham, 1971; Ben-Peretz, 1990). According to Ball and Feiman-Nemser (1988), transforming one's curriculum materials "requires an understanding of the meaning and possible consequences of the way they are designed and what they include" (p. 420). Having minimal classroom experience, new teachers are likely to be less prepared to anticipate the consequences of curricular plans. Thus, inservice teacher development seems to be a more fruitful context for helping teachers expand their abilities to interact with and transform prepared curriculum materials. Nevertheless, preservice teacher education can be viewed, as Ben-Peretz (1990) suggests, as the place to lay "the necessary foundations for the future development and growth of the abilities needed for reflective, problem-solving-oriented, and creative curriculum use" (p. 110). With this in mind, I begin each section below by considering ways that inservice teacher development might support teachers' curriculum development activities. I then consider how preservice teacher education might lay the foundation for this later learning.

<u>Cultivating Reading and Decision Making</u>

At the beginning of this chapter, I discussed the central role that reading played in the teachers' curriculum-development decisions and in their professional development. How the teachers interpreted the offerings in the textbook and the events in their teaching figured significantly in their choices. Consequently, I argued that reform-oriented teacher's guides needed to be designed to encourage teachers' reading and subsequent decision making. Teachers' professional development (both inservice and preservice) also needs to play a significant role in fostering teachers' reading and

development opportunities and course work often focus on methods and activities to be used in the classroom (Ball, 1994; Sparks & Louks-Horsley, 1990). This approach assumes that methods or activities are self-contained and complete. My analyses of the teachers' curriculum enactment, however, suggested that these preplanned activities were only one of many resources they drew on in the process. In order to make inaction choices in response to students' activities, Catherine and Jackie drew on personal resources to consider mathematical goals, assess students, and make adaptations or improvisations. Thus, while professional development need not abandon the practice of offering methods and activities, its focus should be on fostering teachers' abilities to thoughtfully and intentionally use them in the process of curriculum development.

Practicing teachers are likely to have experience assessing students and examining and reshaping textbook suggestions to fit their classroom needs. Yet, as Catherine's case illustrated, this reasoning and decision making is often not explicit. The aim of inservice professional development activities, then, should be to help teachers become consciously aware of the curriculum development activities they engage in and to encourage them to examine the ideas underlying their choices. Catherine and Jackie provide two examples of how opportunities to reflect on their curricular decisions and to talk about them to others heightened their awareness of the choices they made. In the cases, I referred to these as opportunities for conversation and reflection. Jackie's opportunities involved conversations with other colleagues. Catherine's involved conversations with me. In both cases, the role of the other was not to provide direction or advice; it was to ask questions and examine events of their practice, their reading of the text, and their subsequent decisions with them. Professional development that provides such opportunities for teachers, together with contextual changes necessary to support them, are likely to foster teachers' engagement of the curriculum development process. These opportunities might take the form of collaborative-inquiry partnerships

and groups in which teachers act as the "other" for one another. Below I explore some related foci that such collaborative inquiry activities might include.

Reading texts. Because texts can be read in multiple ways and teachers are likely to read them differently, collaborative inquiry groups might focus on reading, interpreting, and exploring the ideas and suggestions in curriculum guides. This type of work would allow teachers to examine mathematical tasks, discuss underlying concepts and goals, consider various options for using them, and discuss their students' encounters with them. The idea that reform-oriented curriculum materials can serve as vehicles for teacher inquiry, not just instructional guides grows out of evidence that teachers' discussions about their use of a new curriculum materials fosters reflection and self examination. Much of this evidence remains anecdotal, but has emerged during pilot studies of new curriculum materials (Lappan, personal communication, March, 1994; Russell, 1994; Smith, in preparation). It is supported by my findings regarding the impact that Catherine's conversations with me had on her thinking.

Reading students and tasks in action. Central to the process of enacting curriculum was the teachers' reading of the events in the construction arena. How they made sense of their students' needs and understandings and the demands of the mathematical tasks influenced their in-action decisions. As I discussed previously, much of this reading was not deliberate. Collaborative activities designed to foster teachers' intentional reading of students and tasks in action might involve analyses of students' work or video segments of classroom discourse. The focus of such analyses would be on identifying the mathematical roots of students' activities, assessing their understandings with respect to mathematical concepts, and exploring possible curricular actions. Those facilitating teacher groups that involve examining students' thinking and classroom discourse have found that such activities can enhance teachers' mathematical

⁴In recommending a teacher-inquiry group format, I am drawing on evidence from many teacher development projects that suggest similar structures can be highly motivating contexts for teachers' exploration and learning, as well as sources of emotional support (Ball, 1994; Featherstone, Pfeifer, & Smith, 1993; Hammerman, 1995; Smith & Featherstone, 1995).

knowledge (Russell et al., 1995, Smith & Featherstone, 1996) and their ideas about pedagogy (Hammerman, 1995).

Decision making. Decision making goes hand in hand with reading in the curriculum development process. In the three arenas, teachers make decisions that are both proactive and reactive. Some are preplanned; others are improvised. They draw on their personal resources to decide how to act on the text's suggestions and respond to students' actions. These decisions are at the heart of the enacted curriculum. Yet, like much of their reading, the decision-making process is often not explicit and not a target of efforts to stimulate curricular and pedagogical change. Collaborative-inquiry activities need to be designed to make the decision-making process explicit and grounded in the results of one's reading. Teachers need to have opportunities to critique decisions they have made and explore alternative possibilities with others. They also need to engage in decision making with colleagues about future curricular choices. In essence they should be supported in their efforts to adapt curriculum ideals to their specific contexts.

Planting seeds for future reading and decision making. There are three related areas of development that preservice teacher education might pursue in order to prepare teachers to actively engage the curriculum development process with their texts. All three include helping teachers-to-be develop perspectives on the work of teaching that often run counter to common folklore. The first area concerns how preservice teachers view textbooks. Many perspectives on teacher-text relationships (cf. Russell, 1994) tend to place the teacher and the text at odds with one another, each vying for the same authority over curricular decisions. Ball and Feiman-Nemser (1988) observed this tension in the perspectives of preparing teachers who, through their teacher education course work, developed a disdain for textbooks. Instead, preservice teachers should be encouraged to develop working, rather than antagonistic, relationships with textbooks and curriculum guides. Teacher education should provide them with opportunities to

assumptions implicit in their design, and to consider how curriculum materials might be adapted. Activities in teacher education designed to give students opportunities to practice designing and teaching lessons or units need to include tasks that focus their attention on reading and adapting curriculum guides. The intent of these activities would be to help prospective teachers begin to develop stances toward materials that are interactive and collaborative.

The second area of development for preservice teacher education involves preparing prospective teachers to take on the activities involved in curriculum development. Preservice teachers most frequently view teaching as a performance. Because their visions of teaching have been developed through years of watching teachers in action (Lortie, 1975), preparing teachers focus primarily on what teachers do, not how they think and make decisions. Thus, deliberate attention should be paid to developing and making explicit preservice teachers' reading of texts, students, and mathematical tasks, and on the subsequent decisions they make. Preparing teachers need to have opportunities to analyze the preplanned and in-action decisions of teachers, including themselves, with an eye on their mathematical goals and what students are learning. They need to come to see this type of analysis as central to the work of teaching.

The third area of development involves a central component of curriculum development that is often late to develop in beginning teachers, that is the inclination to pay close attention to learners. Researchers studying prospective and beginning teachers have found that developing a sense of themselves as teachers is the foremost concern for new teachers (Kagan, 1992). As a result, they are less inclined to attend to students' developing understanding in ways that can enhance their curricular decision making. Thus, preservice teacher education needs to attend specifically to developing teacher candidates' abilities and inclinations to examine students' understandings

(Feiman-Nemser & Remillard, 1996). Course work and related activities should be designed to foster a learner-focused perspective in students prior to or along with the development of other pedagogical skills. Like the two areas discussed above, the aim of developing this perspective is to prepare beginning teachers to engage in curriculum development as teachers.

Deepening and Broadening Mathematical Knowledge

Many have argued that teaching envisioned by the reforms requires a deeper understanding of mathematics than most elementary teachers have developed (Ball; 1993; Lampert, 1990; Russell et al, 1995). Mathematical understanding is also central to the curriculum development process. It is a critical tool in reading students and suggestions in texts. As we saw in Jackie's case, her ability to examine the mathematical ideas underlying tasks in the text and her students' responses to them bolstered her involvement in the curriculum development process. Furthermore, the teachers' understandings and views of the content determined which mathematical ideas in the text they were willing to examine. As I described in Chapter 6, neither teacher explored mathematical content in the text that was new to them. Thus, teachers need opportunities to learn mathematics that will deepen their existing knowledge and introduce them to new ideas.

Unlike other aspects of curriculum development discussed above, there seem to be fewer practical opportunities for practicing teachers to learn more mathematics than there are for preservice teachers. It is typical for teacher preparation programs to include mathematics courses that engage students in exploring the mathematical ideas they will teach. Until recently, however, learning new mathematics was not a primary focus of professional development efforts for practicing teachers. This type of learning is particularly crucial to supporting reform in mathematics teaching because teachers are being asked to teach aspects of the content they have had little opportunity to explore. Furthermore, the evidence that neither Jackie nor Catherine explored new mathematics

through using the text raises questions about the potential for texts to prompt such learning.

Opportunities to learn mathematics differently might take varying forms.

Nevertheless, there is a growing body of evidence that suggests that this type of learning can be fostered through collaborative inquiry about teaching. Teachers who work on mathematical tasks together (Roberts, 1995; Russell et. al, 1995; Schifter, 1995a & 1995b; Smith & Featherstone, 1996) and who explore mathematics through examining their students' encounters with rich mathematical tasks (Hammerman, 1995; Russell et. al, 1995) have deepened and broadened their mathematical knowledge and have developed skill in examining the mathematical roots of students' work.

Even though preservice teacher education has established space to attend to teacher candidates' mathematical understandings, there are still unanswered questions about how to do so in ways that help them connect their own learning to ideas about teaching. Mathematics and teacher educators have developed mathematics content courses (LeBlanc, Lester, & Kroll, 1992; Simon, 1995) and methods courses (Ball, 1989; Remillard, 1993) designed to broaden and deepen preservice teachers' mathematical understandings. Little is known about the impact these courses have on beginning teachers. It is unclear whether the standard design of mathematics courses followed by methods courses facilitates beginning teachers' abilities to draw on their mathematical knowledge in their development as teachers. More experimentation with the content and configuration of such learning opportunities in teacher education programs is necessary.

Learning About the Curriculum Development Industry

Earlier I argued that the work of textbook writers needed to be informed by knowledge about teachers and the work of teaching. Similarly, teachers' textbook use ought to be informed by a realistic understanding of who textbook developers are, their underlying aims and intents, and the processes behind a text's development. Teachers

need to have access to information about how commercial texts are developed, edited, and marketed. They also need to learn about the various nonmainstream curriculum-development ventures, how their development is supported and undertaken. This information is likely to help teachers become aware of and develop perspective on the various resources available. Moreover, my hope is that teachers will develop healthy skepticism of the market influences on the commercial textbook industry.

This suggestion is in response to observations that often textbooks are treated as authorities (Remillard, 1991a) or as foolproof recipes. School district officials and teachers tend to believe that achieving curriculum change is primarily a matter of selecting the right textbook (Tyson-Bernstein & Woodward, 1991). It is my belief that this sense of authority and power surrounding published curriculum materials magnifies commonly-held views of teaching as application of "best" methods and casts text developers as possessors of these methods. Such a view of texts dissuades teachers from participating with texts in the curriculum-development process. Thus, knowledge about the curriculum-development industry may help to deflate the image of texts as authorities, encouraging teachers to critically examine texts and their interactions with them.

Helping teachers learn about the curriculum development industry will be difficult for two reasons. First, such knowledge seems peripheral to the work of teaching and thus adds another item to the list of things teachers need to learn. Second, this knowledge runs counter to the inclinations of the market-driven textbook industry which puts great effort into shaping consumers' perceptions of their products. In order to promote interest in their texts, commercial publishers foster an image of texts as prepackaged solutions to curricular problems that can embody practices "aligned with" the NCTM Standards. As my description in Chapter 3 indicates, the HBJ textbook offers an example of a text that employs rhetoric, hype, and the names of "experts" to promote such an image. Despite these difficulties, efforts to make the workings of the textbook

industry an explicit topic of conversation among teachers and district officials may encourage teachers and others to look at texts differently and could potentially pressure textbook publishers to respond.

Two groups of people seem to be well positioned to initiate conversations about the interworkings of the textbook industry: developers of nonmainstream (or alternative) curriculum materials and teacher educators. Both groups operate outside of the public school system, but have vehicles for contributing to it. Currently a significant number of noncommercial efforts to develop curriculum materials are underway. The development process of these materials is distinctly different from the commercial process. In most cases, it involves careful work of many mathematics educators and teachers responsible for designing, piloting, assessing, and revising (cf. Russell, 1994). These developers are in a position to make this process known to potential users and to contrast it to common commercial processes.

Teacher educators are also in a position to initiate conversations about the development of curriculum materials through their work with preservice and inservice teachers. In fact, preservice teacher education includes several avenues for drawing students' attention to the roles that curriculum materials have in mathematics instruction. Course work and experiences that address issues of teaching mathematics need to provide prospective teachers with information about the textbook industry and engage them in considering ways in which curriculum and teaching have been influenced by commercial texts. Preservice teachers should also have opportunities to learn about the development of noncommercial materials. Moreover, other course work designed to focus on the political dimensions of teaching might attend to the relationships among the textbook industry and public education. The challenge for teacher educators is to help preservice teachers develop flexible and working relationships with textbooks, rather than blanketly reject or accept them.

Implications for the Context of Teaching

The suggestions I have made in the previous sections have implications for the structures in which teaching takes place. Curriculum materials and teacher development opportunities do not operate in isolation; their impact on teaching is subject to aspects of the teaching context. Many current school structures, for example, explicitly and implicitly impose demands on teachers that influence their choices (Hargreaves, 1994; Jackson, 1986; Sarason, 1982). Jackie's and Catherine's cases illustrate how features of the teaching context can facilitate or inhibit teachers' efforts to realize change, suggesting that adoption of reform-oriented textbooks ought to be accompanied by contextual change.

One contextual pressure reported to constrain teachers' willingness to pursue mathematics topics in greater depth is the need to cover a specific amount of content in one school year (Peterson, 1990). The relationship between pressures for content coverage and structural characteristics of schools was apparent when contrasting the two cases. Like many teachers, Catherine felt pressure to "cover" a specific set of topics in order to prepare her students for 5th grade. Most teachers also feel pressure to prepare students to take end-of-level tests (Madaus, 1988). Having her students for 3 years, on the other hand, offered Jackie a measure of curricular flexibility with which she felt free to pursue fewer topics in greater depth each year. This flexibility was critical in enabling her decisions related to content coverage. It is reasonable to assume that contextual pressures similar to Catherine's might discourage teachers from pursuing change in the way they use textbooks.

The two cases also illustrate how specific types of support in the teaching context might enable teachers to experiment with new materials and reflect on their teaching.

The PDS context at Jackie's school included structural features that supported her experimentation in her mathematics teaching. Even though no reform-related structural changes had been made in Catherine's school, my frequent presence in her classroom

initiated a new type of interaction for her. The encouragement to experiment and the opportunities that both teachers had to talk to others are not common features in many school organizations (Hargreaves, 1994; Jackson, 1986; Little & McLaughlin, 1993). The significance of these features in both Catherine's and Jackie's growth, however, contributes to a growing body of research on the power of contextual and collegial support in teaching and teacher change (cf. McLaughlin, 1993). Findings such of these do not diminish the importance of textbook change, but they should also broaden the perspectives of those who look to new curriculum materials to stimulate change.

The Textbook Industry and the Challenge of Change

The suggestions I made in the previous section take an optimistic stance toward curriculum reform; they focus on the possibilities of change through redesigned curriculum materials, teacher development opportunities, and school contexts. In this final section, I explore some of the complexities of such changes by considering the cultural and institutional aspects textbooks and their use. First, I discuss two artifacts of textbooks as an institution in American schools: the influences that the textbook market has on the contents and design of texts and the cultural assumptions about the role of textbooks in teaching and educational change. These have implications for likely resistance to the types of changes I recommended for texts. I then conclude by considering how the educational community might confront these challenges in its efforts to realize curricular and pedagogical change.

The Textbook As an Institution in American Culture

Schools are not closed systems. They operate within the larger social and economic systems in which they are located and, consequently, are subject to a variety of external influences. Textbooks, perhaps more than most artifacts of schooling, reveal the relationship between schools and the values, assumptions, and structures of the larger society. The process through which they are designed, marketed, and selected illustrates the influence of market forces and cultural expectations and assumptions on curriculum.

These influences must be understood and accounted for in our efforts to use redesigned textbooks to facilitate change. Below I discuss the how change is limited by the market and by existing conceptions of their role.

Texts as Market Items

Most textbooks are designed, constructed, and sold within a commercial industry, and thus their content is influenced by market forces (see Chapter 3). Apple (1991) described the textbook as "an economic commodity, bought and sold in the United States and many other countries under the conditions of a capitalist market. Because of this, it is subject to intense competition and to the pressures of profit" (p. 7). As result, publishers, rather than educators, determine the content and format of texts according to what they believe the market will bear, not due to any particular academic or pedagogical aims. In fact, commercial texts tend toward eclecticism in order to incorporate as many educational positions as possible (Sewall & Cannon, 1991).

The extent to which the design of any commercial text is responsive to educational initiatives is a function of the degree to which these initiatives are translated into market pressures (Keith, 1991). As has been the case in mathematics, these pressures are generally manifested in the criteria for textbook adoption outlined by state or district officials. For example, as the NCTM <u>Standards</u> (1989) gained acceptance in American schools, those selecting mathematics textbooks began to look for evidence of attention to these new standards in the texts they examined. Textbook publishers had little choice but to respond with changes in their texts.⁵ These changes, however, tended to be guarded and superficial since taking any position to an extreme can be economically risky for publishers (FitzGerald, 1979; Tyson-Bernstein & Woodward, 1991). The HBJ publishers, for example, added problem solving, work with

⁵The power of the textbook industry to curtail educational change was evident in the late 1980s, when the current reform efforts were in their initial stages. In order to stimulate state-wide change, California enforced strict criteria for the adoption of mathematics texts. All submitted texts were initially rejected. In response, the textbook industry challenged in court the state of California's right to deem certain textbooks unacceptable for purchase.

manipulatives, and exploration to their standard offerings but avoided making substantial changes to their text.

The market control over the textbook industry has serious implications for efforts to change texts. Even though it is likely that publishers will continue to respond to pressures from the field, it is unlikely that their responses will reflect the level of depth hoped for by most mathematics educators. Thus, it is currently improbable that commercial textbook publishers would take a leading position in furthering reform efforts or that they would embrace a radically new role for texts in teaching. In order to accomplish the changes in texts that I suggested in previous sections, textbook publishers will need to experience immense external pressure from the educational community. Below I consider how this pressure might be created. First, however, I briefly discuss one aspect of cultural expectations for textbooks that influences the criteria by which they are selected.

Conceptions of the Role of Textbooks in Teaching

Earlier I discussed likely disjunctures between teachers' expectations for curriculum materials and texts designed to help them engage in the curriculum development process. Such texts are also likely to conflict with the expectations of others involved in educational decision making. The text selection and adoption process in most school districts works under a number of assumptions about what textbook should be that are translated into criteria for selection. Tyson-Bernstein and Woodward (1991), for example, found that those responsible for textbook selection in many states subscribed to a common set of assumptions that include: (a) faith in a text's ability to reflect the state's or district's curriculum in terms of content, instruction, and sequencing, (b) trust that properly selected texts could provide a foolproof means to ensure that students are taught successfully, (c) the expectation that a text can meet demands for accountability through standardized achievement tests, (d) the belief that

new textbooks were better than old ones, and (e) the expectation that a good text organizes its content into modules or lessons that can be taught in one class period.

These assumptions are likely to influence how redesigned textbooks will be received. Selection committees that believe that texts can and should predetermine and direct teachers' curricular decisions and, in so doing, ensure consistency across schools, will avoid texts that offer teachers too many opportunities for decision making. Furthermore, those selecting textbooks may attend to superficial features of the text, like the publication date, rather than what and how mathematical content is represented. They are also likely to reject textbooks that do not rely on a familiar structure for mathematics instruction.

These assumptions that guide text selection are also fostered by marketing representatives of commercial publishers who "sell" their product to schools or districts as ready-made packages, consequently shaping their ideas about what a text should offer teachers. Thus, in addition to pressuring commercial publishers to undergo change in their materials, educators must combat this image of curriculum materials as prepackaged programs that teachers implement. As I discuss in the following section, one possible way that educators might pursue these goals is to present the public with alternatives.

Facing the Challenge of Change: Pushing the Market Forward

It is my position that in order for curriculum materials to undergo significant changes in what they offer and how they interact with teachers, responsibility for their design must be in the hands of educators, rather than commercial publishers. To consider this possibility, I turn, once again, to those developing alternative curriculum materials. Currently, a handful of curriculum designers primarily interested in contributing to change in mathematics education are pursuing alternative routes to producing and distributing their materials. Most of these curriculum projects have been undertaken by mathematics educators at non-profit educational organizations, federal

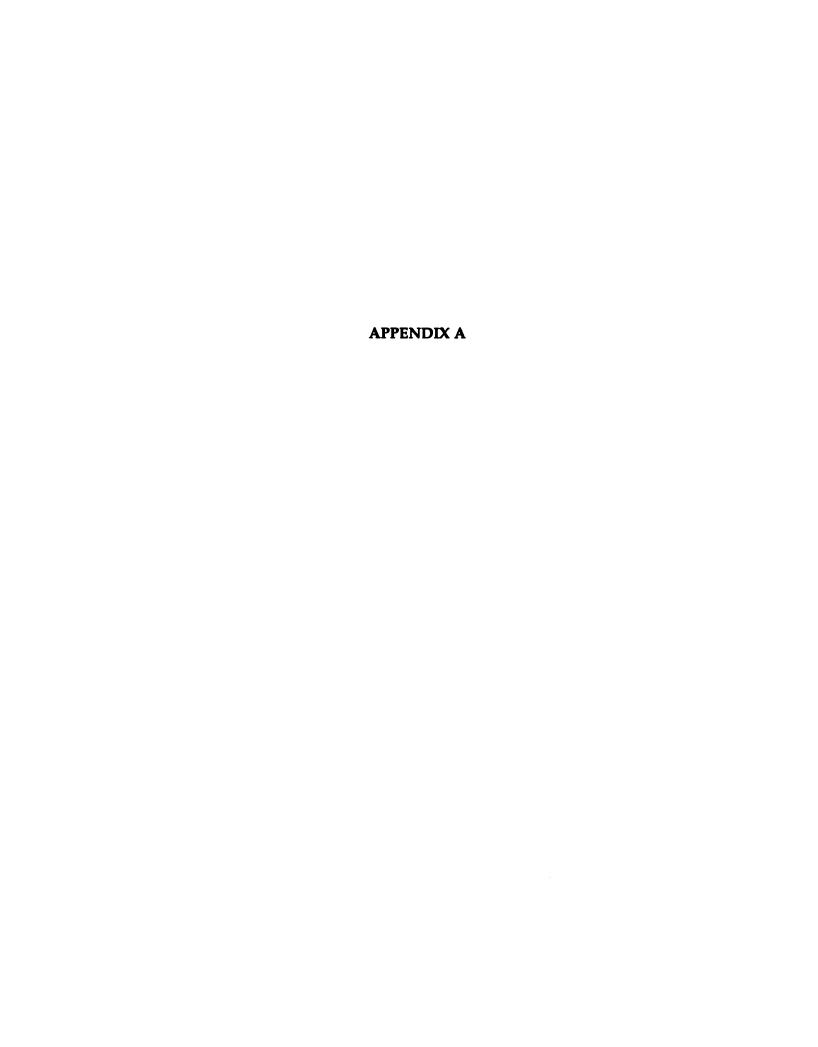
regional laboratories, or universities and are federally funded. Many of these developers are marketing their materials through companies known for marketing alternative and innovative educational materials. This arrangement allows for curriculum materials to be thoughtfully and carefully developed by educators who make decisions about content and design according to educational concerns, rather than economics. It also provides for the marketing of these materials to be in the hands of someone other than the developers.

This arrangement is similar to the way curriculum designers worked with commercial agents in the 1960s. According to Keith (1991), many federal or private funding agencies required that commercial organizations were not involved in the development of the materials, but allowed them to participate as publishers and marketers. The result was partnerships between those developing curriculum materials and corporations, such as Xerox, RCA, or IBM, interested in sponsoring an educational publication.

In response to the recent fervor created by various reform activities, these relatively small educational materials companies are beginning to flourish. It is possible that they are filling the gap in sources of alternative materials left by the smaller textbook companies during the period of market consolidation that I described in Chapter 3. This growing segment of the curriculum materials market has the potential to offer valuable resources to teachers while pressuring large textbook companies to change. As teachers, schools, and even districts aspire to change their mathematics instruction, many have begun to look beyond the offerings of commercial publishers and traditional textbooks for alternatives.⁶ Now may be an opportune time for the writers of alternative curricula to find an opening in the textbook market that allows for an

⁶The evidence for this is purely from my own interactions with teachers and school officials in California, Michigan, and Utah. Many of the teachers and school officials I have interacted with about the selection of curriculum materials have expressed dissatisfactions with the superficial attention to the reform agenda represented in commercials texts. Many have considered alternative teacher resource books that focus on student activities during instruction and have rejected the idea that students should have individual texts.

alternative conception of curriculum materials. In addition to pushing the textbook market forward, increased availability of alternative materials will provide valuable sites for greatly needed research on teachers' use of alternative curriculum materials.



APPENDIX A

SAMPLE INTERVIEWS

Baseline Interview

Part I

A. Personal History and Experience

The purpose of this section is to learn about the teacher's views on teaching and learning mathematics and recollections of previous experiences with mathematics.

Introduction

Say: As you know the purpose of my study is to learn about how teachers use and think about a New textbook. I will be asking you questions about your use and opinions other HBJ text. First, however, I would like to learn a little bit about you as a teacher and about your experiences up to this point.

Educational History

A1. How long have you been teaching?

How long in Lansing?

Where else have you taught?

What grades have you taught?

A2. Where did you get your undergraduate degree?

What did you study?

A3. Did you take a math methods class?

What do you remember about it?

How helpful was it in helping you think about teaching math?

A4. Did you take math content courses in college?

What were they?

Have any of them been helpful to you in thinking about teaching math?

A5. Have you taken any classes since your undergraduate degree?

What were they?

Why did you take them?

Have they helped you think about teaching math?

In what ways?

Mathematics History

A6. What was your favorite subject in school?

What was your least favorite subject?

A7. What do you remember about math classes you have had (in college, high school or elementary?)

Probe for the teacher's role, the student's role, her perceptions of the content, and what counts as knowing.

A8. Did you enjoy math in school?

What did you particularly enjoy about it?

What did you not enjoy about it?

A9. In what ways would you like your students' experience with math be like yours?

In what ways would you like it to be different?

B. Beliefs and knowledge about mathematics

The purpose of this section is to uncover what the teacher knows and believes about, and her attitudes toward, mathematics, and teaching and learning it.

Say: I am also interested in your general views of math as it is taught in schools today.

Purpose of school mathematics

- B1. What do you feel the goals of elementary school math should be?

 Why are these things important?
- B2. What is the most important thing you would like your students to learn from math class this year?

Teaching math

B3. Do you have a colleague or know someone who you feel is an excellent math teacher?

What about his/her teaching makes him/her a good teacher?

Feelings about math

- B4. Are there things you especially enjoy about teaching math?

 What do you enjoy about them?
- B5. Are there things you don't like about teaching math?

What do not like about them?

B6. Does the grade level you are teaching affect whether or not you enjoy teaching math?

B7. Have your feelings about math changed over the years?

In what ways?

How do you account for this?

B8. How about your math teaching. Has it changed over the years?

In what ways?

How do you account for this?

B9. Can you anything from your first experience teaching math?

What would you do differently now?

Learning and knowing math

B10. Could you name a student you have had in the past who was good at math?

Tell me a little bit about this student.

Probe for: What makes him/her good at math, what it means to be good at math, what the criteria are for being good at math.

B11. Now, who would you say was poor at math?

(Use above probes.)

Part II

C. Knowledge of HBI Text

The purpose of this section is to learn about the teacher's view of and history with the HBJ text, as well as what kinds of things she has heard about it from her colleagues. I will have the textbook available during the interview, but will follow the teacher's lead in turning to it and examining its contents. I am interested in whether and how she examines a new textbook, but would like this examination to be initiated by her?

Learning about HBI

Say: Now let's talk a little bit about HBJ.

C1. When did you first learn about HBJ?

Probe to get at her initial introduction and reaction to it?

District Adoption of HBI

C2. Why do you think the district chose it as the main mathematics curriculum?

What do you know about the adoption process?

C3. Have you had any opportunities to learn about the text?

If so, what?

Did you participate?

Were these efforts helpful to you? In what ways?

C4. Have you seen anyone else teach using HBJ?

If yes, how did this contribute to your view of the program?

View of HBJ

C5. Based on what you know, how would you describe the HBJ text to someone else?

What features stand out to you?

(Ask about her view on each feature--it's strengths and weaknesses, purpose).

C6. What do you feel the authors' goals are?

Do you agree or disagree?

- C7. As you prepare to use the text for the first time, what concerns you the most?
- C8. What are most looking forward to about it?

Use of HBI

C9 How would you characterize the way you usually use your mathematics textbook?

Do you mostly follow it or use it as a resource?

Has this changed over the years? How?

C10. How do you anticipate you will use the HBJ text?

Closing

I really appreciate you taking the time to talk with me during this busy time of year. I am looking forward to spending some time in your classroom. Is there anything else you feel I need to know about you that I haven't asked?

Do you have any questions for me before we close

End of Year Interview

Retrospective View of HBI

Say: Now that we are at the end of your first year of using the HBJ textbook, I'd like to get your impressions of the text now and you view on how your use of it changed over the year.

A1. How would you describe HBJ now?

What features stand out to you?

(Ask about her view on each feature--it's strengths and weaknesses, purpose).

A2. What do you feel the authors' goals are?

Do you agree or disagree?

- A3. What recommendations would you make for changes to the authors?
- A4.. Are there parts you find confusing or puzzling?

Which ones?

What do you find puzzling about them?

Use of HBI

- A5. How would you characterize your use of the program?
- A6. Has your use of HBJ changed at all?

In what ways?

How do you account for this?

A7. Do you think the textbook has helped lead mathematics instruction in the direction the district intended in selecting it?

A8. How well has the textbook helped you accomplish your goals for mathematics instruction?

B. Knowledge of mathematics and of HBI

Using content and representations from HBJ, I intend to get at the teacher's knowledge of mathematics and of HBJ.

Say: I would like to ask you some specific questions about the sorts of things included the HBJ program and how they help students learn mathematics.

(I will develop tasks during the year to use in this section.)

C. Overall Assessment of text characteristics

Say: I'd like to ask you some questions about how the text is organized and the mathematical content included.

- C1. For each of the following characteristics, ask what she thinks about it, why, and how it compares to other textbooks she uses:
- Content included
- Content organization and sequencing
- Level of difficulty.
- Content presentation
- Student activities
- •Guidance for teacher.
- C2. One complaint I have heard about HBJ is that it's focuses too much on problem solving and ignores the basics. Have you heard this?

What do you think?

C3. What is it about this that people are so people are so worried about?

Closing

I really appreciate you taking the time to talk with me about your teaching and how you think about mathematics. Thank you also for allowing me to come into your classroom this year.

Post-observation Interview

I will interview the teacher once a week about her teaching that week. The intention of these interviews is to find out how she was thinking about and interpreting the HBJ lesson.

Introduction

1. How do you think things went?

(The rationale for this question is to start the conversation by letting the teacher say whatever she wants to say about her teaching. If the discussion does not naturally move on to the next question then be sure to move it there.)

What was being taught

2a. (if the she based her lesson on the text. If she didn't follow 2b.)
Let's go over the lesson you taught this week in the teacher's guide. I'd like to know what
you thought about when planning for and teaching this lesson.

(From this I would like to unpack the teacher's notions about the authors' intentions or goals and her sense of what actually happened. I also am interested in her knowledge of and thinking about her students before, during and after the lesson.)

Follow up questions:

What do you feel the main idea was in this lesson?

Why is that important?

What were you hoping the kids would get from this lesson?

Did they get it? How do you know?

Are there some things about the way this lesson is designed that you really like?

Are there some things you dislike?

Would you do anything differently if you were to teach this lesson again?

2b. (If she did not use the text.)

How did you decide what to teach today?

How does the textbook handle this idea differently?

What was the main idea in this lesson?

Why is that important?

What were you hoping the kids would get from this lesson?

Did they get it? How do you know?

Would you do anything differently if you were to teach this lesson again?

How was it being taught

3. Is there anything that students typically have difficulty with with this material/activity?

If so, what? How do you deal with that?

(The intention of these questions is to get at what the teacher knows about her learners, whether or not she thinks about students when she thinks about math teaching, how her knowledge of students influences her thinking about teaching math.)

4. Is there anything else about how students react to this material—things they already know, things they're interested in, for example, that you can think of?

If so, what? Does that affect the way that you think about teaching this in any way? How?

5. As we go through the lessons, bring up specific questions about events that occurred during the lesson (e.g., the way she phrased a certain question, a students response, any omission or addition, etc.) asking her to reflect on her intention with or reaction to each. Questions on variations from textbook lesson will be phrased as:

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I noticed that... Why did you choose to....?
What did you think when (student's name) said...?
Your responded with...; What was your reasoning for this?
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- 6. Was there anything that happened during that lesson that surprised you? if so, what? Why was it surprising?
- 7. Did you have to change your plans at all today? If so, how and why?

What does she think the students got

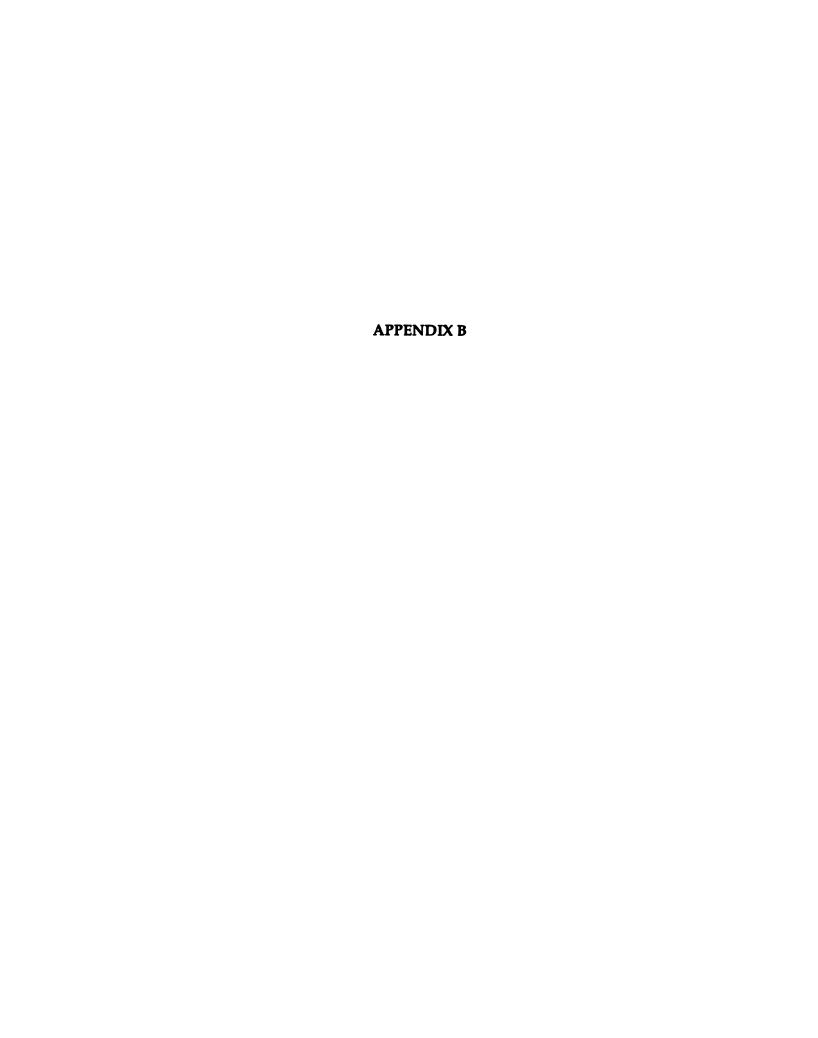
(These questions are intended to help me find out how and if the teacher assesses student engagement and learning, as well as how she thinks her kids learn math.)

- 8. How engaged in the (activity, lesson, discussion) did you think the kids were?
 How could you tell?
 Why do you think that was?
 Is this typical?
- 9. How do you think the students did?
- 10. Is there anything that they had trouble with? How can you tell?
- 11. Was there anything that they found easy? Interesting? How can you tell?
- 12. Is there anything that you want to follow up on in future classes?

 If so, why? Why is that important to follow up on?

Conclusion

13. Are there other questions I should ask you that would help me understand that lesson?



APPENDIX B

OBSERVATION INSTRUMENT

Observation Form

Date: Teacher: Observer:

| Number of students in the class: Number of students present: Names of students absent: |
|--|
| Draw a picture of the classroom here, noting major landmarks. [Note: If the grouping of desks or students changes across the day, be sure to include a map of those changes.] |
| |
| 1. Narrative description. In a narrative, describe the lesson. Include the topic being taught, the representations that were used to each it, the teacher's and students' actions, behaviors, and talk during the lesson. Describe in order the major pieces of the lesson, noting the role the textbook played in the instruction. |
| Board work: |
| 2. Instructional materials. Describe the materials in the room related to mathematics instruction. How are they stored, made accessible to students, and used during instruction? . |
| 3. Mathematics instruction. |
| 3a. Divide the lesson into the main academic tasks with which students were engaged. Briefly identify and list these tasks in chronological order. (Include a descriptive label, a brief description of the task, the number of minutes, and percentage of class time devoted to each task). An academic task is defined as an activity, the purpose of which is to focus students' attention on mathematical work of some nature. Examples of academic tasks would include (but not be limited to) a small group working on an openended problem, a teacher lecture on how to determine if two fractions are equivalent, a whole-class discussion on why we need negative numbers, individuals completing worksheets on long division alone at their seats. |

Select the two tasks that occupied the most amount of class time. Label the task that occupied the most amount of time Task A and the second task, Task B.(If the entire class was devoted to one task, please note.) For each of these tasks, answer the following questions:

- (a) From a mathematical task analytic perspective, describe the substantive content of the task. (b) Based on how the task was implemented, describe the learning goals of the task from the teacher's perspective (i.e., what did the teacher seem to want students to be learning to be able to do, to understand, etc.? (c) Based on students' classroom behaviors, describe the extent to which the teacher's learning goals were achieved or not achieved.
- 3b. Did the tasks focus students' attention on underlying mathematical meanings of the content? Give specific examples.
- 3c. Did the task focus students' attention on procedural steps and facts? If so, were the procedures connected to underlying concepts or were they mechanical? Give specific examples.
- 3d. Was "doing mathematics" emphasized (e.g., framing problems, making conjectures, looking for patterns, examining constraints, determining whether an answer is valid or reasonable, knowing when a problem is solved, justifying, explaining, challenging)? In what ways? Give specific examples.

Was getting right answers emphasized? In what ways? Give specific examples.

- 3e. What instructional representations (e.g., manipulatives, pictures, analogies, pictures, stories,) did the teacher or the students use in this lesson and on what mathematical ideas did they focus? Describe each representation, noting whether it was introduced by the teacher or by a student. Include details that will help to show how the teacher and/or students used the representation (for what purpose, with what language).
- 3f. What mathematical language (special terms used to refer to the substance of mathematics--e.g., "quotient," "parallelogram," "negative number") was used, if any? Mathematical symbols and notation? Language and skills of mathematical discourse (e.g., conjecture, example, counterexample, proof, convince)?

3g. Did you note any errors or curiosities in the mathematical content as it was represented or explained by either teacher or students? What was the source and nature of these?

How were these treated, if at all?

3h. Openness of the discourse:

If there was discussion, what were the students doing and what was the teacher's role in the discussion?

In what ways was the discourse convergent, was the press toward consensus? Give examples.

In what ways was the discourse divergent? Was there space and time to disagree, to remain unconvinced? Give examples.

Did students play an active role in initiating or leading the path or focus of the lesson? Give examples.

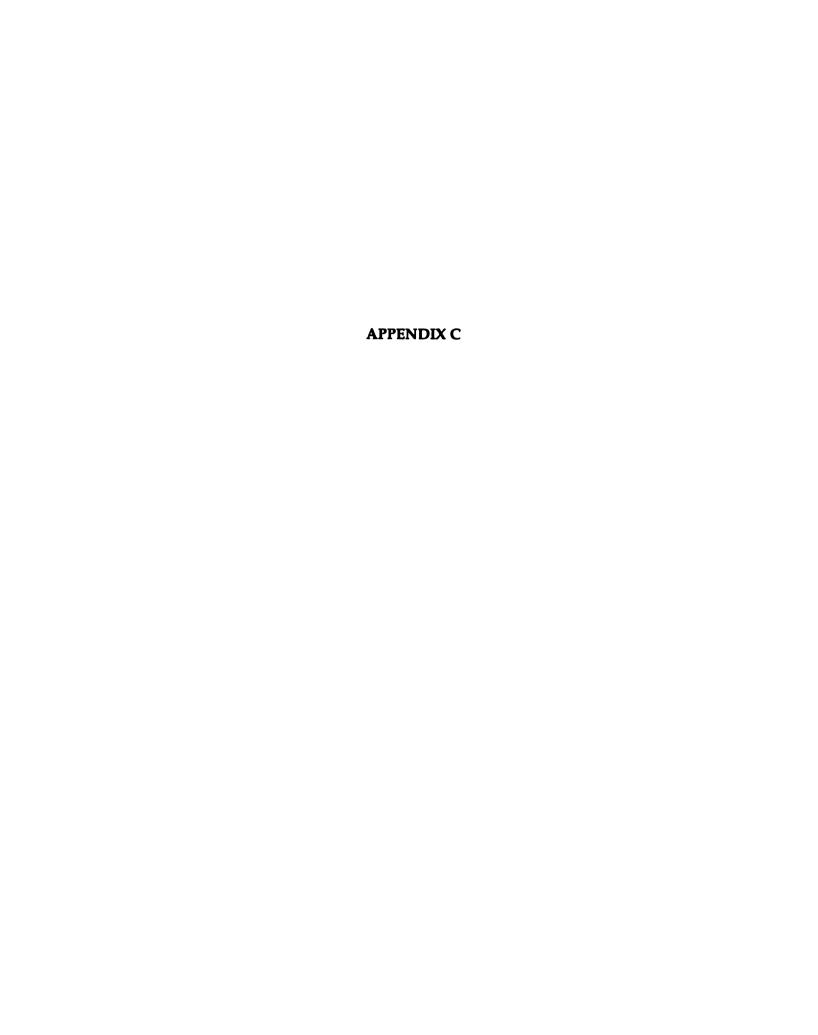
Did students seem to be confused about anything? About what? How did the teacher treat the confusion?

3i. Did the problems or tasks seem to be challenging to students? What evidence did you note of students' reaction to the problems?

Were there times during the lesson when a significant number of students seemed exceptionally engaged in the mathematics at hand? What were they engaged in?

Were there times during the lesson when a significant number of students seemed to be engaged in something other than the mathematics at hand? What were they engaged in?

- 3j. Is there anything about mathematics instruction that falls through the cracks when you describe it in this way? If so, please explain.
- 4. Textbook Use. Describe how the teacher used the textbook during the lesson. Indicate which lesson was being used and the degree to which she seemed o follow or veer from the text.
 - 4a. How were the students using the textbooks?



APPENDIX C

HBJ TEXTBOOK SAMPLE EXCEPTS

The following pages are copied from Chapter 10 of the HBJ textbook to serve as examples of the various features in the textbook. They are reprinted with permission of the publisher, Harcourt Brace Jovanovich, Incorporated.



UNDERSTANDING FRACTIONS AND MIXED NUMBERS

OVERVIEV

When children possess a sound understanding of fraction and decimal concepts they can use this knowledge to describe realworld phenomena and apply it to problems involving measurement probability and statistics.

Summary

in this chapter, students will develop and expand their understanding of fractions. The careful development from concrete to pictorial to abstract enhances students ability to master the concept of a fraction and to develop a sense of using fractions to solve problems.

This careful development includes:

exploring fractions as part of a

- exploring fractions as part of a whole or part of a group
- exploring to find a fractional part of a number
- modeling equivalent fractions
- expressing fractions in simplest form.
- comparing fractions with like and unlike denominators
- recognizing that a fraction can have a value greater than 1 and can be expressed as a mixed number

The development concludes with students' increased ability to understand the meanings of fractions. They recognize that fractions can be expressed in different forms and that the values of fractions can be compared.

In this chapter, the problem-solving lessons focus on

- using the 4-step process to solve problems
- using the act it out strategy
- choosing an appropriate strategy to solve a problem

Materials

Counters (10.4 10.8) Play money (10.5)

Scissors (10.6 10.7, 10.8) Fraction bars or TR 45 (10.6 10.9)

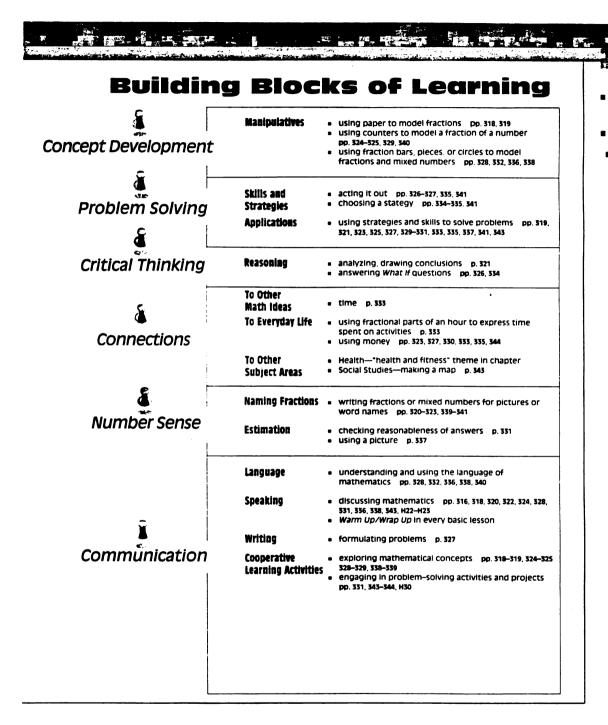
Fraction bars or TR 45 (10 6 10 9) Fraction circles or TR 46–47 (10 10)



Tested Objectives-----

The following objectives for concepts, skills, and problem-solving strategies and skills are tested. See page 316F for a complete description of both the performance and formal assessments for this chapter.

- **10-A** To identify a fractional part of a group, to identify the fractional part of a number
- 10-8 To identify equivalent fractions, to simplify fractions
- 10-C To compare fractions with like denominators
- 10-D To identify fractions as mixed numbers
- 10-E To solve problems by choosing appropriate strategies and by using the act it out strategy





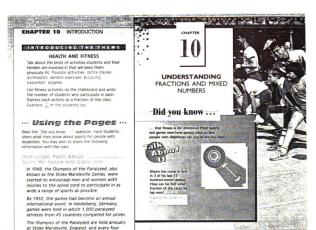
Lesson Planning Guide

*Use throughout the chapter

| | | | and the same | | | | | Practice | - | Barto |
|-------|-----------------------------------|--|---------------|---------------|---------------|---|---|----------|-------|-------|
| | 316-7 | Chapter Opener | | | |) | *Prob Solv Link p 3268 | | | |
| 10.1 | 318 -9 | To use fractions to represent part of a whole or part of a group | 1-14 | 1-14 | 1-14 | More Practice, p. H70 | | 10 1 | 10 1 | 10.1 |
| 10.2 | 320-1 | To read and write a fraction as a part of a whole | 1-26 | 1-27 | 1-27 | More Practice, p. H70 | | 10 2 | 10.2 | 10.2 |
| 10 3 | 322-3 | To read and write a fraction as part of a group | 1-25 28-32 | 1-25 28-32 | 1-25 28-32 | More Practice, p. H71 | Math Conn, Link p. 338A | 10.3 | 10.3 | 10.3 |
| 10 4 | 324-5 | To find a fractional part of a group | 1-12 | 1-12 | 1-13 | More Practice, p. H71 | Prob Solv, Link p. 326A | 10 4 | 10 4 | 10 4 |
| 10.5 | 326-7 | To solve problems by using the act it out strategy | 1-9 | 1-9 | 1-9 | . More Practice, p. H71 | | 10 5 | 105 | 10 5 |
| 10.6 | 328-9 | To explore equivalent fractions using models | 1-16 MR | 1-16 MR | 1-17. MR | More Practice, p. H72 | Manip Link p 318A | 10 6 | 10 6 | 10 6 |
| | 330 331 | Review and Maintenance Spotlight on Problem Solving | 1-20 | 1-20 1-2 | 1-20 1-2 | | | | | |
| 10 7 | 332-3 | To find an equivalent fraction in simplest form | 1-28 | 1-28 | 1-28 | More Practice, p. H72 | | 10 7 | 10.7 | 10 7 |
| 10 8 | 334-5 | To solve problems by choosing a strategy | ,1-11 | 1-11 | 1-11 | More Practice, p. H73 | | 108 | 10.8 | 10 8 |
| 10 9 | 336-7 | To compare fractions using < > or = | 1-21 | 1-21 | 1-21 | Bridge Lesson, pp. H22–H23 More Practice, p. H73 | Manip Link p 3188 Math Conn Link pp 338A-338B | 10 9 | 10.9 | 10 9 |
| 10 10 | 338 -9 | To explore mixed numbers | 1-21 | 1-21 | 1-21 | More Practice, p. H73 | Prob Solv Link p 326A | 10 10 | 10 10 | 10 1 |
| | 340-1 342 343 344 345 | Chapter Review Chapter Test Teamwork Project Extension Cumulative Review | : | | | School-Home Connection p H30 | | , | | |

A complete list of media resources for this chapter can be found in the tabbed section at the back of this manual. Resources include professional references for teachers, fiction and nonfiction books for students, films and videotapes, and computer software.

Media Resources



316

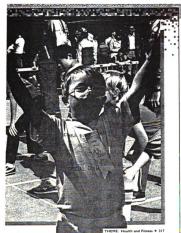
fencing.

An event called the Special Olympic Games is held to encourage mentally retarded children and adults to train and compete as athletes. Competitors are divided into categories based on age and ability. Competitions include track events, field events, grimatics, bowling, volleyball, basketball, floor nockey, swimming, diving, and ice-skating. The first international eving.

years either immediately before or after the Olympic Games, and, when possible, in the

country of the Olympics. All competitors are confined to wheelchairs, but standard equipment is used and standard dress is worn. Events include archery, swimming, basketball, table tennis, bowling, dartchery (combination of darts and archery), and field events. Men participate in bencharess weight lifting and

Special Olympics were held in the United States in 1968.



Pages 316-345

..... Think Ahead

Wran up your discussion by asking students to answer the Talk About It question. Discuss with students why a fraction can be used to explain the number of races won. Fractions show relationships. Pose this problem

Suppose Shawn won one third of the 15 hundred-meter dashes. How many races did he win? | of 15 = 5

Challenge students to explain how this problem differs from the Talk About It problem. Possible responses: Fraction is given. Solution is a whole number

You may want to discuss with students everyday situations in which they may use a fraction. Example: The bus arrives in a half hour

..... Connections

Discuss with students what they already know about fractions. Record responses on the chalkboard. Possible discussion questions:

- · Are all fractional parts always the same size? no
- What is the word name for the fraction ²/₅? two fifths
- Draw a picture to show . Pictures will vary
- . How many halves in one whole? 2 halves
- Which is greater, \(\frac{1}{2}\) or \(\frac{1}{2}\)?
- Arrange these fractions from least to greatest: 1, 2, 1

MATH JOURNAL

Vocabulary Development The following new terms will be highlighted with the Math Journal logo. Encourage students to write definitions

- for these terms in their Journals. numerator, denominator (p. 320)
 - equivalent fractions (p. 328) simplify common factor, simplest
 - form (p. 332) · like fractions, unlike fractions
 - (p. 336) mixed number (p. 338)

Language Development Students gain an understanding of

fractions by using models and writing about their discoveries.

- · Provide a picture of a fraction used to represent part of a whole and one of a fraction used to represent part of a group. Have students
- write descriptions of both pictures. Have students write a letter to a
- friend describing how to express a fraction in simplest form.
- Have students describe how to determine if two fractions are equivalent



Mathematics from Around the World
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 The following activities provide additional experiences with manipulatives and offer more variety of instruction for the concepts being taught in this chapter.

Manipulatives



ABSTRACT

LINK ACTIVITY

Equivalent Fractions Use with Lesson 10.6, pages 328-329.

The concept of equivalent fractions should begin with concrete, hands-on experiences. These manipulatives establish a visual reference for students to call upon later for further development of the concept

PURPOSE: To use geometric models to illustrate equivalent fractions

MATERIALS: pattern blocks

ACTIVITY: Have students work in pairs, starting with a yellow block as the

whole with a value of 1

· build the same shape and size using red blocks

. count how many red blocks make a whole

. determine what fraction can be used to name the red block

• repeat the process using blue and then green blocks

2 red blocks make a whole 3 blue blocks make a whole

6 green blocks make a whole

=





Each red block is the whole Each blue block is the whole Each green block is the whole



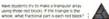


Use green blocks to build the red shape and the blue shape

EXTENSION:











LINK ACTIVITY

Comparing Fractions Use with Lesson 10.9, pages 336-337.

The comparison of fractions with unlike denominators begins with the manipulation and comparison of shapes of known fraction sizes.

To use geometric models in comparing fractions

MATERIALS: pattern blocks Have students work in pairs using the vellow block as the

ACTIVITY:

Have students

give a fraction name for the red block.

 compare it to the vellow block by placing it on top. write the comparison as a number sentence.













Students stack blocks on top of one another to answer questions about their relationships

What part of a yellow block is one red block? What part of a yellow block are two blue blocks?
What part of a yellow block are two blue blocks?
What part of a yellow block are four green blocks?







the pattern blocks

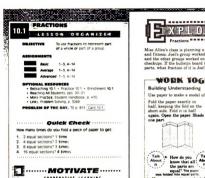
- Let nine green blocks represent a whole
- Compare the red block to the yellow.
 Compare the blue block to the red.

 <!-- The state of the red is a state . Compare the blue block to the green



Tips from Teachers
I find that putting pattern blocks in the hands of my students helps them develop a better number sense through the visual images they form. I also have my students use transparent colored pattern blocks on the overhead projector to explain various relationships for the entire class.





COOPERATIVE LEARNING Materials: for each student—unlined paper, blue

crawoo

Have students fold a sheet of paper into 2 equal parts. and color 1 part blue

 What part of the paper is shaded blue? 1 half Continue to fold sheets of paper into equal parts and color 1 part blue Complete the table

| Number of Folds | Parts Blue | Total Parts | Fraction |
|-----------------|------------|-------------|----------|
| 1 | 1 | 2 | 1 |
| 2 | 1 | 4 | 1 |
| 3 | 1 | 8 | 1 |
| 4 | 1 | 16 | 1 |



 Below the title, how many equal parts are there in Miss Allen's bulletin board? 4 equal parts

Bullding Understanding Materials: for each group of students-unlined paper,

Have students work in cooperative groups to complete the tasks on page 318. Have each group report its

findings. Conclude the discussion with these questions What fraction shows 4 out of 4 parts shaded?

Explain that if both numbers are the same, the fraction equals 1 whole

Fractions class is plann'-

Miss Allen's class is planning a bulletin board on health and fitness. Joel's group worked on the exercise part, and the other groups worked on food, sleep, and checkups. If the bulletin board is divided into equal parts, what fraction of it is Joel's group going to make?

WORK TOGETHED

Use paper to make a model of the bulletin board.

Fold the paper exactly in A fraction names one or r half, keeping the fold on the equal parts of a whole or of a group. You can read a fraction as: again. Open the paper. Shade

How many parts are shaded?

How many total parts are

· What fraction can you write

So, on what fraction of

that names the shaded part?

one louth one out of four one divided by four T. CONTRACTOR

model. Use four ces of paper. Shade one piece

How is the second model like the first model? How is it different? See Additional Answers, page 341.
 Why can you describe ½ as 1 out of 4? It is 1 of 4 objects in a group.

Why can you describe 1 as 1 divided by 4? It is 1 whole divid unto 4 equal parts.
Use paper to make two models for each fraction, one to show an equal part of a whole and one to show part

of a group. Check students models . 4 Share your models with your classmates. Have them name the fraction for the unshaded part.

the bulletin board is Joel's group working?

MEETING

FOOD FOR THOUGHT

Average Visual Materials: word cards: group, whole As each statement is read, hold up a word card to tell if what is eaten is part

- of a group or part of a whole 1 of a pizza pie whole
- 2. 1 loaf of bread whole 3. of the oranges group
- 4. of the chemes group
- of a banana whole 6. of the muffins group
- 7. 1 of the pie whole
- 8. of the plums group

Visual Thinking

DOWNERDS FRACTION ART

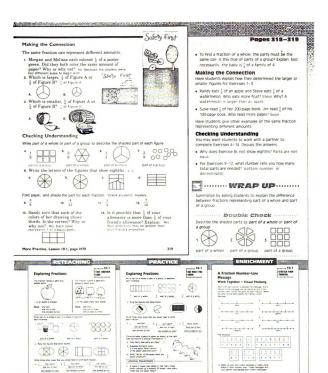
Visual Materials: drawing paper, crayons Fold the drawing paper into 4 equal parts. Draw 1 of the following pictures in each section, and write the fraction

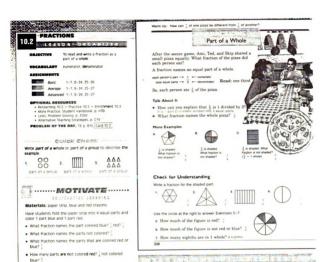
illustrated. Tell if each picture shows part of a whole or part of a group 1. Two out of five balloons are blue ?

2. One half of the cake is eaten. 1

3. One fourth of the dozen flowers are

tulips 1 or 12 group 4. Five eighths of the pizza is not eaten. 2: whole





EDACTION DRAW Vierra

Materials: graph paper (TR 25)

- · one 2-unit rectangle
- two 4-unit rectangles
- four 5-unit rectangles
- 2 Shade and label parts of the rectangles to show these fracti

Check students' figures

Problem Formulation

CIRCLE CREATIONS

parts.

Materials: for each student - paper circle. 2 colored crayons

2. Color some sections one color and

some another. Leave some not

3. Write 8 guestions about your circle

fraction. Example: How much of

4. Trade your circle and questions with

that can be answered with a

the figure is yellow or red?

another student to answer.

1. Fold a paper circle into 8 equal

- 1. Outline square units on graph paper for these figures:
 - two 3-unit rectangles
 - . four 8-unit rectangles
 - four 10-unit rectangles

Number Sense

. Are the parts colored equal to the parts not colored?

. Discuss the Warm Up question. Elicit from students

• What does the denominator tell you? number of equal

A medium-size pizza is divided into 6 equal pieces. If 3

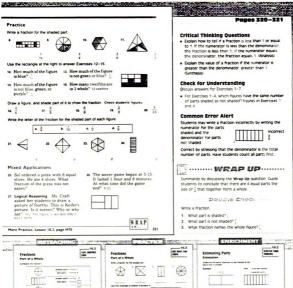
people share the pizza equally, what fraction of the pizza will each get? 2 What fraction will 2 people get?

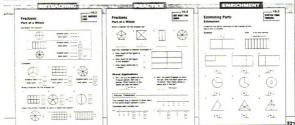
number of pieces of pizza each person eats

parts the whole pizza is divided into the numerator?

that the pizzas can be different sizes.

.....TEACH.....







Problem Solving





.....LINK ACTIVITY

Reading Math Use with Lesson 10.10, pages 338-339.

SKILL: Writing a question

Write this problem on the chalkboard.

Casey has 13 feet of ribbon.

Pat has 11 feet of ribbon. Lydia has 1 feet of ribbon.

Have students

- . identify the facts given in the problem. write a question that could be asked.
- determine if all the given facts are needed to answer the question.
- . identify the strategy or method needed to solve the problem.

solve the problem

Extension: Have students write problems for other students to

Question: Who has the longest plece All facts are needed Strategy: Draw a picture, and compare.

LINK ACTIVITY

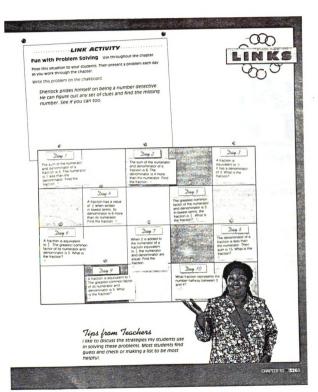
Think Along Use with Lesson 10.4, pages 324-325

MATERIALS: Think Along copying master, Teaching Resource 1

Write this problem on the chalkboard.

Denise has 6 coins. Half of her coins are quarters. One third of her coins are nickels. One sixth of her coins are pennies. How much money does she have?

Have students work in groups. Have each group record its responses. on the Think Along copying master.





it out strategy play money

1-2.5-8.9 1-2.5-8.9 Advanced 1-2, 3-8, 9

Reteaching 10.5 • Practice 10.5 • Enrichment 10.5 More Practice. Student Handbook, p. H71

Links, Problem Solving, p. \$268 PROBLEM OF THE DAY, TE p 815 Card 10.5

..... Ouick Check

How many different 3-digit numbers can you make with

the digits 8, 5, and 3? List them, 6 numbers: 853, 835 583 538 385 358

..... MOTIVATE

COOPERATIVE LEARNING

Have 4 students act out the following situation. Janet, Nick, Brian, and Megan are having a student meeting at a square table. Brian and Megan are not next to each other. Janet starts the meeting by turning to her right and asking Megan for her report.

 Can you use another strategy to find the answer? Yes draw a picture



.....TEACH..... Talk through the 4-step process.

Where is everyone sitting at the table?

Understand . Have students restate the problem in their

own words and answer the questions. Plan . Discuss the problem . Why is using play money to act it out a good strategy to use? Possible answer: easy to tell if each person

has the same amount Solve . Discuss why it is necessary to trade units of

. Suppose there was also one \$5 bill in the cash box How much extra would each person receive? \$1.25

Look Back . Have students suggest ways to check the answer. Possible answer: Use a calculator to multiply 4 x \$1.37; compare that product with the sum

Strategy • Act it Out

Janis, Val. Tom, and Calvin had a lemonade stand at the big race. At the end of the day, they shared the profit. There were 5 one-dollar bills, I quarter, es, and 3 pennies in the cash box. How much profes did each person receive

Sometimes you can solve a problem by acting it out.

► UNDERSTAND

What are you asked to find? how much profit each person received
What information is given in the problem? What information is given in the profit was 5 one-dollar bills. 1 quarter 2 and 3 per

PLAN

What strategy can you use to solve the problem? You can use play money to act out

the situation. ► SOLVE

How can you solve the problem? Count the total amount of money. Try different combinations of bills and coins. Trade 1 one-dollar bill for 3 quarters, 2 dimes, and 5 pennies. Place the money into

4 equal groups. Count one group So, each person earned \$1.37 profit.

► LOOK BACK

What other method could you use to solve the problem? Count the money, and divide it by the number of people 55 48 - 4 = \$1.37.



टम्ड टम्ड टम्ड टम्ड टम्ड

.....

OF OF OR OR

\$1.37

WHAT people to share the profit: Would each person receive more or less money

triangles

ACT IT UP

Visual Solve each problem by acting it out.

- 1. Four boys are in line for the relay race. Matt is ahead of Eric. Scott is behind Fric. Matt is behind Eddie. Who is first in line? Eddie
- Seven people ordered 4 pizzas. Each nizza is cut into 8 sections. What is the greatest number of slices each person can have? 4 slices How many are left over? 4 slices

TOOTHPICK ACTION

Materials: toothpicks for each pair of

- students 1. With a nartner arrange 9 toothpicks to make 5
- 2. Place 20 toothpicks in rows of 5 Take turns picking up 1, 2, or 3 toothoicks at a time. The student who picks up the last toothpick loses the game. Strategy: When 5 toothpicks are left, the second student to pick can control the outcome so he or she wins.

DISCUSSION SOLVING DISCUSSION SOLVING DISCUSSION SOLVING DISCUSSION SOLVES ASSEMBLED A

Reteaching 10.6 • Practice 10.8 • Enrichment 10.8

Advanced 1-11

More Practice, Student Handbook, p. H73
 Links, Problem Solving, p. 3268

PROBLEM OF THE DAY, TE p. 815, Card 10.8

..... Quick Check

Write in simplest form

2. 2 1 3. 10 1

......MOTIVATE......

COOPERATIVE LEARNING

4. 6.1

Present situations in which students can suggest several options to answer a question.

Example: Susan plans to go to California. She lives 1.200

miles away. What kind of transportation can Susan take? plane, bus, train, car

Point out that Susan has a choice of several ways to get to California.

 Do you have several choices for solving a problem in mathematics? yes

_____TEACH.....

Materials: 24 counters for each group of students
Talk through the 4-step process.

Understand • Have students restate the problem in their own words.

Plate • Discuss why make a model and draw a picture are good strategies to solve the problem. • How are the 2 methods related? Possible answer: Both

methods give a visual solution.

Remind students to make equal groups by "dealing" their counters into sets 1 counter at a time.

Solve • Discuss the solution.

 Why is it important to know more than 1 strategy to solve a problem? Possible answers. Problems vary and so do the problem-solving abilities of people; people may find 1 strategy easier to use than another.

PROBLEM SOLVING

pins. There were 24 hikers in all, and ½ of them were leaders. How many of the hikers were leaders?

Choosing a strategy is an important part of

Choosing a strategy is an important part of problem solving. Sometimes you can use different strategies to solve the same problem.

Strategy: Make a Model

Use counters to make a model of the problem. You need to find how many are in 1 group out of a total of 6 groups. Find $\frac{1}{2}$ of 24.

of a total of 6 groups. Find \(\frac{1}{6}\) of 24.

Separate the 24 counters into 6 equal groups.





Now you can count to find how many counters

So, 4 of the hikers were leaders.

Strategy: Draw a Picture
Draw stick figures to represent the 24 hikers.
Circle 6 equal groups of the figures. Count the
number of figures in 1 group. Find \(\frac{1}{2} \) of 24.

So. 4 of the hikers were leaders.

WHAT

... there were 8 leaders? What fraction in simplest form would represent the number of leaders?

MEETING INDIVIDUAL NEEDS

STRATEGIC SOLUTIONS WRITER'S CHOICE

Materials: 6 index cards, on each a problem for one of the 6 problem-solving strategies listed on page 335

- One problem is given to each group of students.
- The group solves the problem and then passes it to another group to solve.
 Play continues until each group.
- solves the 6 problems.

 4. Each group reports on the strategies it used to solve the problems and on its solutions.
- Each group chooses 4 problems on page 335 to rewrite by changing the numbers and thus making new problems.
 The group members must make sure the numbers they choose fit the
 - the numbers they choose fit the situation and the question.
- The new problems are exchanged with another group to solve.

Maxing Decisions

Problem Solvino

CHAPTER REVIEW

PURPOSE To check mastery of the vocabulary, concepts, skills, and problem-solving skills and strategies presented in this chapter

··· Using the Pages ···

The exercises in the Chapter Review may be used as a review assignment. Each item is referenced to the related page(s) on which the vocabulary term, concept, skill, or problem-solving skill or strategy is presented.

You may wish to use the pages as a classroom assignment or as a homework assignment to help students prepare for the Chapter Test. Remind students to refer to the text pages indicated to find help in the textbook.

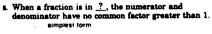
CHAPTER REVIEW

Vocabulary Check

Choose a word or words from the box to complete each sentence.

- 1. A ? names a part of a whole or a part of a group. traction
- 2. In the fraction $\frac{3}{7}$, the 3 is the $\frac{?}{}$.
- a. The total number of equal parts or objects in a fraction is the ?. denominator
 4. Fractions that name the same number are ?.





- Practions have the same denominators.
 This is a common of the same denominators.
 This is a common of the same denominators.
 A 2 number is made up of a whole number and a fraction.

Write part of a whole or part of a group to describe the shaded part of each figure.



". ||||||||

part of a whole

part of a group

Write a fraction for the shaded part.

12.

Record what you did.
See Additional Answers, page 340.

Draw a figure, and shade part of it to show the fraction. Check students drawings.

18. 7/10 17. 3

19. $\frac{2}{7}$

20. $\frac{4}{5}$ of 20 16 21. $\frac{1}{3}$ of 15 5

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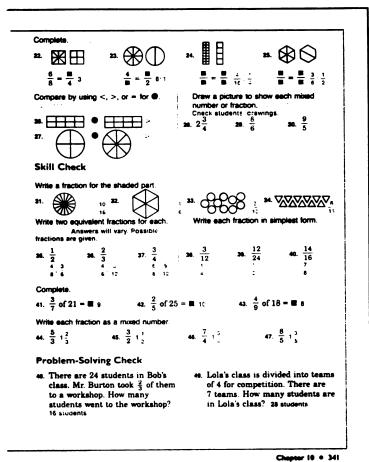
Additional Answers

Chapter Review, page 340









Pages 340-341

Additional Answers

Lesson 10 1, page 316

Talk About It

The shaded part of each can be represented by the same fraction

The shaded part of the first model shows part of a whole and the shaded part of the second model shows part of a group

Lesson 10.4 page 325

Lesson 10.6, page 328

Talk About It

Yes. They name the same part of the fourths fraction bar and the halves fraction bar.

Lesson 10.9 page 337

6. $\frac{4}{8} < \frac{3}{4}$ 7. $\frac{10}{16} = \frac{5}{8}$ 8. $\frac{3}{6} < \frac{3}{4}$



PURPOSE To test the concepts, skills, and problem-solving skills and strategies taught in this chapter

···· Using the Page ····

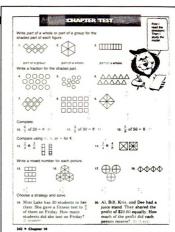
This Chapter Test can be used as a practice test or as an alternative to formal assessment. The Performance Assessment, given on page F of the Overview, can be used with the Chapter Test

The Posttest in standardized format correlates item for item with the Pretest shown on page F of the Overview A free-response test that correlates item for item with the Posttest is also provided. Copying masters for all of these tests are found in the Teacher's Guide . Testing Program.

| Objectives | Concepts | Skills | Problem Solving | Lesson Pages |
|------------|----------|--------|--------------------|---|
| 10-A | 1-6 | 7-12 | | 318-319, 320-321, 322-323, 324-325 |
| 10-8 | 13-16 | 17-20 | 1 | 328-329. 332-333 |
| 10-C | 21-22 | 23-24 | | 336-337 |
| 10-0 | 25-28 | | | 338-339 |
| 10-E | | | 29-32 | 334-535 |

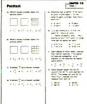
... CHAPTER 10

| Posttest | |
|----------------------------------|--|
| Chapse the letter of the correct | I What further of the transper are not shaded." |
| What part of the liquid it | ΔΔΔΔΔ |
| mir | .: .: .: .: |
| *1 *1 *1 *1 | shape? |
| t. What part of the higher it. | 9 4 4 |
| | 3 8 3 |
| | 41 +1 +1 +1 |
| * 4 * 4 * 4 * 1 | Four of the seven chedren payed becarded Which hacton shows |
| ATA. | Ti +1 +1 +1 |
| ** | t New of the lan states of bread were said. Milest tracker phone the ! |
| | 12 12 17 14 |
| . May be a se bore a un | . So of the time chappen were gate Which backer shows that |
| 0,0,0, | *: *: *: *: |
| 000 | |
| | |









TEAMWORK PROJECT

PURPOSE To work as a team to plan a biking

..... MOTIVATE

You and your students may wish to share background information such as the following.

The Appalachian Trail is the world's longest continuous hixing trail. It extends 2,050 mi (3,299 km) from Mt. Katahdin, ME, to Springer Mountain, GA. It goes

through 14 states and was finished in 1937. Several countries are said to be the place of ongin of the first bicycle: France, in the late 1700s; Germany, in 1816, and Scotland, in 1839.

Because bicycles became so popular, roads were greatly improved in Europe and America.

The best-known bicycle race is the Tour de France, it covers a course of about 2,000 miles, in 1989, the race lasted 21 days. That year, the winner came in 8 seconds ahead of the second-place finisher.

Some communities have made abandoned railroad right-of-ways into biking and hiking trails.

_____TEACH------

This project will require several hours of work, as well as research in the community, so you may want to have students work on it each day for a week or have them work on it in their free time.

Review the **Decide**, **Do**, and **Share** steps for completing the project. Answer questions before the groups begin their work. Students may need your help in providing the same

simple map of the community to all groups.

After the project is completed, discuss the questions in Talk About It.

 What characteristics did you keep in mind for the biking trail? Possible answers not too hilly avoicing heavy traffic wisk chough for I-way biking and for pairs of bikers to ride side by sign.

..... WRAP UP......

Students may wish to contact communities that have biking trails to see how those trails compare with their planned trails.

Answers for Page 343

Tair Adoust it

Possible answer Attend a town meeting
Possible answers crossing roads paint lines
Possible answer make station;
Possible answer Use as a scale

EXTENSION Con to

PURPOSE

To provide additional activities and challenges related to the chapter content

···· Using the Page ····

ACTIVITY - EQUIVALENT-FRACTION CONCENTRATION
For all students

Have students prepare the set of cards. You may wish to begin with a smaller set—perhaps 9 unit fractions and 3 equivalent fractions for each—for a total of 36.

CHALLENGE · VISUAL THINKING
Basic to Average

Exercise 1 may be done on a geoboard, with results recorded on dot paper.

In Exercise 2, students may sort by putting aside squares and rectangles and then putting aside all blues.

CHALLENGE - EVERYDAY MATH Average to Advanced

Students may use play coins to model the problems or to verify their answers.



Activity

 $\frac{1}{2} \frac{3}{4}$

Equivalent-Fraction Concentration

Prepare a set of 36 number cards. Write one of the following fractions on each of 12 cards:

 $\frac{1}{2}$, $\frac{2}{3}$, $\frac{1}{4}$, $\frac{2}{3}$, $\frac{3}{3}$, $\frac{4}{3}$, $\frac{1}{6}$, $\frac{1}{8}$, $\frac{3}{8}$, $\frac{5}{8}$, $\frac{3}{10}$, and $\frac{7}{10}$.

For each of these 12 fractions, write 2 equivalent fractions on the remaining 24 cards.

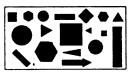
Play the game with a partner. Shuffle all the cards. Place them facedown, forming a 4 × 9 array. A player selects two cards, turns them faceup, and shows them to the other player. If the fractions are equivalent, the two cards match and the player keeps them and continues playing. If the two cards do not match, they are placed back on the table facedown, and the other player

When all the cards have been matched, the player with the most matches is the winner.

Challenge

 Find four different ways to divide this figure into 4 equal parts.
 See below for answers

2. Study the shapes in the box below.



Write a fraction that tells what part of the group is not blue, square, or rectangular.

Challenge

- There are 7 coins. ²/₇ are nickels. The rest are dimes. How much money is this altogether? \$0.60
- 2. There are 8 coins. $\frac{1}{R}$ are quarters, $\frac{3}{R}$ are dimes, and the rest are nickels. How much money is this altogether? \$0.75.

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Additional Answers

Extension, page 344 Challenge Visua: Thinking



| 4,297 rounded to its place-value position? a. 4,200 b. 5,000 the difference. 1,905 = \$\mathbb{B}\$ a. 4,000 b. 8,000 3. 12,824 5 not here |
|---|
| place-value position? a. 4,200 b. 5,000 the difference. 1,905 = a. 4,000 b. 8,000 |
| p. 5.000 the difference. 1,905 = \$\mathbb{B}\$ 8. 4,000 p. 8,000 |
| 1,905 = 8. 4,000 0. 8,000 |
| D. 8,000 |
| U,u_ |
| U,u_ |
| - |
| |
| area. |
| A. 8 aquare units (8. 16 aquare units C. 20 aquare units D. 24 aquare units |
| action is equivalent |
| 8. 4/7 Ö. 6/8 |
| ought 3 cans of tennis \$9.19 and new tennis |
| \$37.95. How much lid he receive from |
| |

CUMUL STIVE REVIEW

PURPOSE To maintain skills taught in this and previous chapters

···· Using the Page ····

The exercises are presented in a multiple-choice format similar to that used for most standardized tests. The four choices include a combination of the following types of answers, one close to the correct answer; one distractor reflecting a common error; one that is clearly incorrect; a correct answer, and "not here."

You may wish to have students write the letter of the correct answer after the number for each exercise. You may also use the answer sheet found in the Teacher's Guide • Testing Program, which provides a format similar to the answer sheets used with standardized tests. You may wish to have students find the actual answers to exercises for which the correct choice is "not



Math Connections



 Students need constant reminders of the ways in which mathematics will be useful to them. These activities will help you make these CONNECTIONS for them.

....LINK ACTIVITY

Fractions in Language Arts Use with Lesson 10.3, pages 322-323.

To express letters as fractional parts of sentences

Some letters of the alphabet occur in written language more often than others in this activity, students randomly select sentences from different books

For each sentence, have the students

- find the total number of letters in the sentence
- find the number of times each letter is used
- express each letter used as a fractional part of the sentence
- order the fractions from least to greatest
- order the corresponding letters from least to greatest use

EXAMPLE: Some animals live in an area they consider their own A C D E H I L M N O R S T V W Y
5 1 1 6 2 5 2 2 5 3 3 3 3 2 1 1 1 Total 43

Here are their uses expressed as fractional parts of the whole

HILMIT C.D.V.W.Y C. R. S ٤ A. I. N 6 43 5 43 3 43 $\frac{2}{43}$ 1 43

.....LINK ACTIVITY

Fractions in Social Studies Use with Lesson 10.9, pages 336-337.

To express sample data using fractions

MATERIALS: grid paper

ACTIVITY:

Interpretation of data in graphs, tables, and lists is an important skill in social studies. Surveys are often used to gather information about voter preferences

Have students

- randomly sample 10 students regarding their favorite color
- record the results in a table
- construct a graph of 10 connected squares.
- show the number of students that prefer each color by shading in the appropriate number of squares in the graph.
- give the fraction of the rectangle represented by each color.

EXAMPLE:





LINK ACTIVITY Fractions in Everyday Life Use with Lesson 10.9, pages 336–337.

To simulate sorting by comparing fractions

targe envelopes, index cards

A clothing store needs to sort and arrange items by size. This activity simulates sorting by size using fraction cards. ACTIVITY:

Have students • label ten cards with the fractions \$ \frac{1}{2}, \frac

 Label three envelopes 0 to \(\frac{1}{3} \) to \(\frac{1}{3} \) and \(\frac{1}{3} \) to 1. select cards from the deck and determine into which

envelope they should be placed. verify that the cards are placed in the the correct envelopes
 order the fractions from each envelope.

EXAMPLE:

0 to 1 1 to 1 1 to 1

Tips from Teachers
I use activities such as these because I want to be sure

that my students see how mathematics is used in their daily lives.

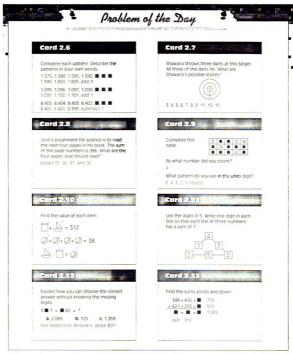




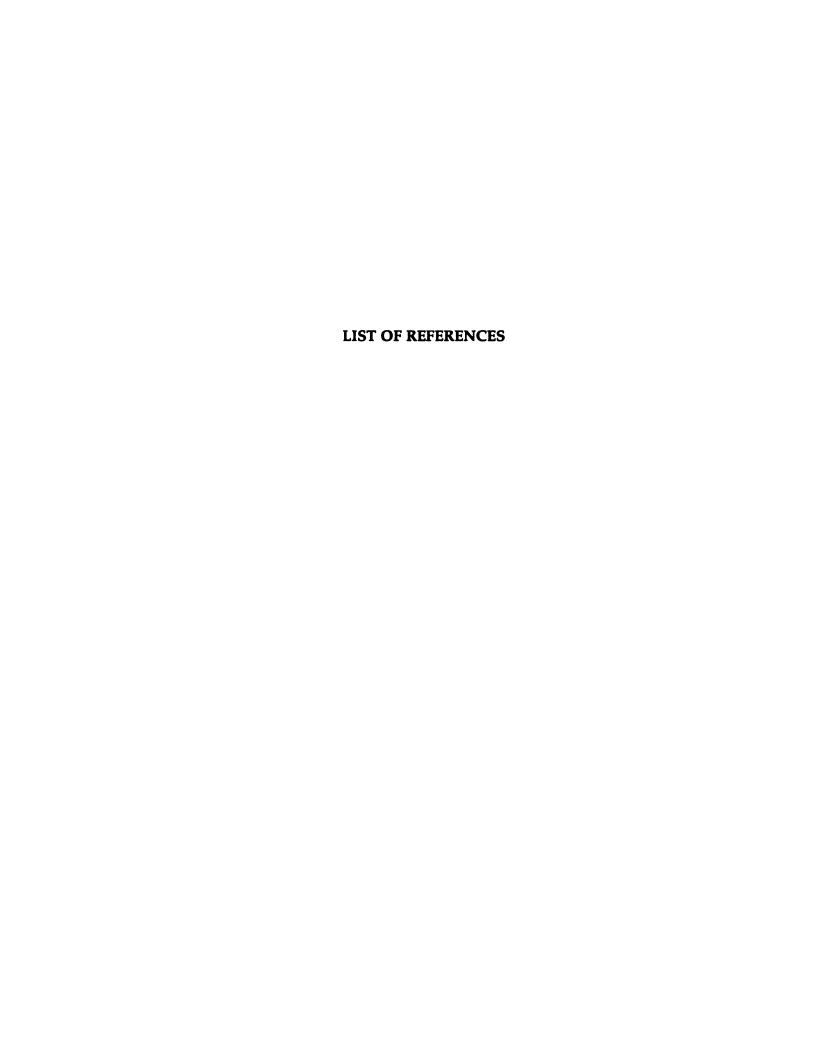


APPENDIX D

EXAMPLE PAGE FROM PROBLEM OF THE DAY SECTION



Problem of the Day • B3



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