A CONTENT ANALYSIS OF READING STRATEGIES IN TEACHER EDITIONS OF MATHEMATICS TEXTBOOKS

By

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To the faculty of Washington State University:

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LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS

A CONTENT ANALYSIS OF READING STRATEGIES IN TEACHER EDITIONS OF MATHEMATICS TEXTBOOKS

ABSTRACT

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Content area reading skills are critically important to students if they are to comprehend and understand subjects such as math, social studies, or science. The purpose of this study was to conduct an in-depth analysis of mathematics textbooks, specifically focused on analyzing teacher editions of mathematics textbooks with the goal of identifying, categorizing, and synthesizing content area reading strategies embedded in these textbooks. Literacy research, as well as other research in math, science, and humanities, shows that content area reading strategies support student learning across the curriculum. In particular, reading and understanding mathematics and mathematics textbooks is dependent on applying strategic reading skills. Content analysis methodology was used to examine six teacher editions of mathematics textbooks to find and explore embedded reading strategies. Results from the data analysis and synthesis reveal that very few reading strategies are integrated in the teacher editions of mathematics textbooks examined. Recommendations for specific reading strategies, as well as suggestions for strategic placement of those strategies, are provided. The results of this study could improve the teaching of mathematics and students' comprehension of mathematics concepts and principles.

CHAPTER ONE

INTRODUCTION

What happens when students cannot read their textbooks? In middle and high school, students are expected to read textbooks to build knowledge and improve skills. Although reading skills are taught at the elementary school level, in middle and high school, students are expected to read, gather information, and comprehend in many subject areas (Barton, 1997; Little, 2005). Students of all ages and ability levels are expected to use their existing knowledge to interpret and construct meaning as they are reading (Anderson & Pearson, 1984).

Many students, however, lack critical reading skills and the ability to interact with text in meaningful ways. National studies report that approximately two-thirds of eighth- and twelfth-grade students read at less than the proficient level as described by NAEP (Perie, Grigg, & Donahue, 2005). For students to be considered "proficient" as eighth graders, they must show an overall understanding of the text, including inferential as well as literal information. Eighth-grade students should also be able to make inferences, draw conclusions, and make connections to their own experiences. To be considered to be "proficient" as twelfth-grade students, they must do all that eighth grade students do, as well as make connections to other readings, make inferences even when implicit, and analyze the author's use of literary devices (http://nces.ed.gov/nationsreportcard/reading/achieveall.asp). More than 7,000 students drop out of high school in the U.S. each year because they lack the basic literacy skills needed to be successful in college or in the work place (Biancarosa & Snow, 2004; Boling & Evans, 2008). In comparison to students in other countries, American high school students show a decrease in content-specific learning, and international comparisons on reading assessments show that U. S.

11th graders perform “close to the bottom behind students from the Philippines, Indonesia, Brazil, and other third world countries” (Abadiano & Turner, 2002; Barton, 1997; RAND, 2002). While literacy rates are flat at the high school level, the world of work is requiring schools to prepare students to be competitive in the global market (Barton, 2006). The Educational Testing Service (ETS) report *High School Reform and Work: Facing Labor Market Realities* (2006) confirms previous research indicating that the 25 fastest growing jobs today have substantially higher prose/literacy requirements than do jobs that are declining, with a net effect of raising average literacy requirements.

Evidence from literacy studies of the past 30 years indicates that struggling readers need help in the higher grades (Barton, 1997; Bottoms, 1992; Brown, 2006; Coiro, 2003; Conley & Hinchman, 2004; Dillon, O'Brien, & Heilman, 2000; Fang, Schleppegrell, & Cox, 2006). Content area reading consists of literary reading or informational reading and is often different from the story formats the students were accustomed to seeing in elementary reading materials (Fang et al., 2006; Lesley, 2005). The textbooks used in higher grades are designed around content, and if they are to be understood by students in those grades, the students must possess content area reading skills.

In most contemporary classrooms today, textbooks are an integral part of instruction and the major instructional tool. It is estimated that 70-75% of instructional time involves the use of textbooks in middle and secondary schools (Eide & Heikkinen, 1998; Gordy & Pritchard, 1995). Since the teacher directs the instruction in the classroom, the textbook and the teacher become the main sources of learning. Students often find textbooks too difficult to read and to understand because of the topic-specific concepts, language, and structure (Draper, Smith, Hall, & Siebert, 2005; Nathan, Long, & Alibali, 2002; Radcliffe, Caverly, Hand, & Franke, 2008). High school and middle school teachers often focus on the content and may not provide reading assistance to their students, as teachers at the secondary levels tend to believe that the students in those grades should be able to read textbooks (Greenleaf, Schoenback, Cziko, & Mueller, 2001). The teachers may not know how to provide the reading assistance that students require to understand the content. In turn, the students who may have difficulty reading may not understand the textbook or may not be successful in any content area. As Draper noted,

> When content area teachers do not include literacy skills into their teaching they are maintaining the stratification of content knowledge and literacy skills: where content is reserved for those few and fortunate who can deal with the literacy requirements of the particular content area and where literacy skills are reserved for those few and fortunate who have gained those skills prior to entering secondary schools. (Draper, 2000, pp. 4-5)

From the research literature in literacy and content areas, it is clear that reading is an integral part of all content areas. Fisher and Ivey (2005) observed that when students rely on the textbooks or are told that the content is mandated, neither their comprehension of the content nor their literacy development is facilitated. Content area teachers need to integrate reading skills and strategies into the content and assist students with reading the subject-related textbooks (Draper et al., 2005; Gee, 2001; Lapp, Fisher, & Grant, 2008; Siegel & Fonzi, 1995). Researchers report that the lack of training and follow-up time and ownership are reasons teachers cite for not including literacy strategies in the content areas (Allington, 2001; Alvermann, O'Brien, & Dillon, 1990; Barton, 1997; Joyce & Showers, 2002; Vacca & McKeon, 2002).Often times content area reading classes for teachers is a one time, possibly one semester class. The follow-up to see if the strategies are used in the classroom does not normally occur. It is left up to the teacher to incorporate what is learned about reading strategies into instruction in the classroom.

Reading is a far more complex process than had been envisioned by early reading researchers (Anderson & Pearson, 1984; Dole, Duffy, Roehler, & Pearson, 1991). It was once believed that early literacy improvement would lead to growth in reading in later years, but in actuality, the early gains can disappear by eighth grade (Perie et al., 2005).

In mathematics, students are not necessarily taught the processes to read mathematics (Adams, 2003; Brennan & Dunlap, 1985), even though content area reading skills are critical to understanding mathematics texts and content (Allington, 2006; Draper et al., 2005). Even if literacy skills are taught in other content-area classes, the students may not automatically transfer the reading strategies to mathematics or read well in mathematics (Borasi, Siegel, & Fonzi, 1998; Bossè & Faulconer, 2008; Brennan & Dunlap, 1985; Fisher & Ivey, 2005; Freitag, 1997 Gardner, 2004; Robb, 2003). The reading demands in mathematics are different from those in other subjects. For example, most students learn to read books in elementary school from left to right. In mathematics, it is necessary to read from left to right, right to left, top to bottom, bottom to top, and diagonally. In addition, tables, graphs, charts, symbols, and illustrations are a part of mathematics reading and are critical to comprehension of mathematics concepts (Barton & Heidema, 2002; Bossè & Faulconer, 2008; Brennan & Dunlap, 1985). In addition to specialized content area reading skills (such as reading charts and graphs), student need to be able to apply generic content area reading skills (e.g., make inferences, make predictions) while reading mathematics textbooks. Because textbooks are used as a primary teaching tool in middle and high school settings (Eide & Heikkinen, 1998), and because increasing our students' performance in math is such a critical need and a national focus (Perie et al., 2005), it is important to examine mathematics textbooks for inclusion of content area reading strategies and supports.

Purpose and Research Questions

The Program for International Student Assessment (PISA) reported that in 2006 the mathematics literacy of the United States' 15-year-old students was lower than the average of all the nations examined by the Organization for Economic Cooperation and Development (OECD), an intergovernmental organization. This ranking of students puts the U.S. 15-year-olds in the same category as those in Spain, Portugal, Azerbaijan, and Croatia. Lack of ability to read may be one of the contributors to students' difficulties with mathematical problem solving (Baldi, 2007). The Nation's Report Card states that strong reading skills in early grades do not automatically transfer to the complex reading skills students need in literature, science, and mathematics (Perie et al., 2005). Shanahan and Shanahan (2008) support the need for "sound later-reading instruction…built on a solid foundation of sound early-reading instruction" (p. 43). One of the barriers for students who do not perform well in mathematics or problem solving may be their inability to read (Cummins, Kintsch, Reusser, & Weimer, 1988; Kintsch & Greeno, 1985).

There is a lack of research on content area reading strategies related to mathematics textbooks. Specifically, no research has been done on how reading strategies are embedded in mathematics textbooks (or if they are embedded). Outcomes from this type of research are critical to improving mathematics textbooks and may contribute to improving mathematics instruction, which would result, one would hope, in improving mathematics achievement. There has been no systematic examination of mathematics textbooks that includes an analysis of the usefulness, the accessibility, or the relevancy of reading strategies related to their placement in mathematics textbooks. The current research literature has little to offer those seeking answers to these questions about content area reading strategies and mathematics textbooks.

The purpose of this qualitative content analysis study is to examine the types of literacy supports and strategies that exist in teacher editions of mathematics textbooks that will help students read mathematically. Subsumed within each broad question are many related research questions, including the following:

1. What reading strategies, if any, are embedded in mathematics textbooks?

   Related research questions: Are the reading strategies explicit or implicit? How do the strategies activate background knowledge? How do they ask students to predict? How do the reading strategies give context clues? How are the strategies asking students to paraphrase?

2. How are reading strategies described in mathematics textbooks?

   Related research questions: What types of visual or graphic aids are used to describe these strategies? Are the descriptions simple or elaborate?

3. Where do reading strategies appear in mathematics textbooks?

   Related research questions: What seems to be their purpose in this location? Where are the strategies are located? Where are reading strategies placed on the page? Are they close to the mathematics problems on the page?

4. Are the reading strategies embedded, if any, placed and described in such a way as to enhance the teacher's instruction?

   Related research questions: Do the description, the placements, and the types of reading strategies lend themselves to instruction? Would a teacher, teaching mathematics, be able to integrate the reading strategies into instruction?

Since reading is an integral part of learning mathematics, teaching math teachers to use and to integrate reading strategies is an important part of mathematics instruction. But how are teachers to use the content area reading strategies during instruction if a) there are few strategies provided in the textbooks, and b) the strategies included are ineffective, cumbersome, or inappropriate? There are few resources available to mathematics teachers regarding methods of teaching students to read mathematically (Borasi et al., 1998; Draper, 2002b; Harmon, Hedrick, & Fox, 2000). The use of textbooks at varying grade levels illustrated the point that regardless of level, the same issues exist in mathematics textbooks. As math textbooks are essential to math instruction, reading strategies can and should be embedded in the mathematics textbooks.If a student is learning to read a graph, the reading strategy should then be connected to the graph on the page and assist students in learning how to read the columns and rows on the graph. The lack of data in this area speaks to the need for content analysis research that specifically targets the existence and type of reading strategies in mathematics textbooks.

A qualitative content analysis study was designed to explore these questions and concerns about reading strategies and mathematics. In qualitative studies such as this, "Research questions and answers…arise together in the course of…involvement with the given texts. The process of recontextualizing, reinterpreting, and redefining the research question continues until some kind of satisfactory interpretation is reached" (Krippendorff, 2004, p. 85). For me, this process of reinterpreting and redefining occurred continually throughout the study, enhancing the information obtained. Other questions, directions, and corresponding data/information were uncovered through the content analysis process.

Conceptual Framework

A conceptual framework based on literacy research was used for the foundation of this study. Dole et al. (1991) examined research on comprehension processes, comprehension strategies, and teaching strategies. In their study, they found that reading is a process in which readers use their background knowledge and the cues within the text to create meaning from the text. They also found that reading and teaching are active processes in which “teachers and students mediate and negotiate meaning from the instructional environment” (p. 256). The research from the Dole et al. study presents a framework that was used in my analysis of reading strategies in the teachers’ editions of mathematics textbooks.

Another layer of the conceptual framework comes from Bransford’s research on the brain and learning (Bransford, 1999). Bransford and his colleagues used research-based information to describe three broad principles of learning and their connections to education and, more specifically, classroom practice (Bransford, Brown, & Cocking, 1999). In Bransford et al.’s book *How People Learn: Brain, Mind, Experience and School*(1999), the three principles of learning they described provided a framework to guide my analysis. The three principles in that framework detailed how students learn (Bransford et al., 1999); I aligned these principles with the reading strategies included in my study.

Summary

It is important that students be able to apply content area reading strategies to the different content areas. In particular, content area reading strategies are critical to understanding mathematics textbooks. Yet there is a lack of research, specifically content analysis research, that can inform educators regarding the presence and type of reading strategies embedded in mathematics textbooks. The results of such a study could be critical to textbook developers and mathematics teachers, as well as to other content area teachers. With broader knowledge of what types of reading strategies are present in mathematics textbooks, teachers can more actively teach those strategies (if they are present), use them in instruction, and assist students in gaining a deeper understanding of math content. If reading strategies are not present, not appropriate, or not useful, or if they are not accessible to the reader, then this knowledge can influence how math teachers teach their content, and how textbook developers design future mathematics texts.

CHAPTER TWO

REVIEW OF LITERATURE

This review of literature will address three major topics that are interrelated in this study: content area reading instruction, including reading strategies; the connection of content area reading instruction to mathematics, including the difficulties of word problem solving; and the use of textbooks.

Content Area Reading

Reading is an integral part of all content areas. With the focus on reading in teacher editions of mathematics textbooks, it is important to see how research in content area reading is viewed. Content area reading "is a code name for means and methods by which to improve reading, language and thinking in every classroom" (Manzo, 1980, p. 146). The goal of content area reading is "to enable students to think and learn in content subjects by applying critical literacy skills to the study of subject manner" (Richardson, 2008, p. 122). Content becomes the focus of learning for middle and high school students because most teachers believe that students should be able to read and write by the time they enter middle school (Greenleaf et al., 2001). Unfortunately, researchers and educators find that many students come to middle and high school without the necessary skills to read and comprehend or to read and problem solve. Although most students manage to master basic and even intermediate literacy skills, many never gain proficiency with skills that would enable them to read challenging texts in science, history, literature, mathematics, or technology (Grigg, Donahue, & Dion, 2007; Shanahan & Shanahan, 2008). Content area reading strategies support teacher instruction while students use the subject-related textbooks (Draper et al., 2005; Gee, 2001; Lapp et al., 2008; Siegel & Fonzi, 1995). The teacher editions of textbooks may not provide reading assistance for teachers so that they can assist students who may need help reading and understanding the content. As Draper (2002) noted,

> Students in math classrooms may need assistance reading and creating mathematics texts because either they lack mathematical content knowledge or they lack an understanding of how to use and manipulate mathematical signs and symbols. Mathematics teachers, who are experts at reading and creating math texts, are in the best position to help their students engage in this kind of literacy. (Draper, 2002, p. 524)

Teachers do not feel comfortable teaching something they do not know well or understand (Draper, 2002a; Manzo, 1980; Yore, 1991). Their expertise is the chosen subject matter or content; therefore, they do not see themselves as teachers of reading. Teachers often view content area reading strategies as an add-on that will detract from the content, yet content area reading strategies help to facilitate learning (Richardson, 2008), and there are many content area reading strategies that teachers could use to improve the students' comprehension of the subject. Reading strategies that students apply while reading are those that will help them comprehend the material of that subject (Morrison, 1982). In order to be literate in a content area, teachers and students must be able to read beyond the words; linguistic familiarity is not enough. As Roth (2002) explained, "Knowing, therefore, means more than acquiring words and texts. Knowing requires…translating back and forth between experience and texts, and familiarity with sign conventions ….Simply exposing student to new [forms of] texts through books and lectures will not do" (Roth, 2002, p. 18). Depending on the reader's ability to comprehend the material in the textbooks, just asking students to read what is on the page may not result in readers who understand and apply what they read.

There is evidence that content area teachers need to integrate literacy skills and strategies to assist students struggling to comprehend the material (Draper et al., 2005; Gee, 2001; Lapp et al., 2008; Siegel & Fonzi, 1995). High school students who may do a reasonably good job of reading a story in an English class might not be able to make much sense of biology or algebra textbooks, and vice versa. These high-level content area reading skills are very difficult to learn, and they are rarely taught. Research indicates that at a very young age, children develop attachments to storybooks that carry through to primary grades where students are exposed to more storybooks in intermediate grades, and the reading materials are more expository (Fang et al., 2006; Mar, 2004; Xin, 2007). Fang (2008) explained that students experience difficulties making the transition from “learning-to-read” to “reading-to-learn.” Some students have more experiences with the storybook type structures, and when confronted with more expository texts in the intermediate grades they begin to struggle with reading. The skills needed to read expository texts at the intermediate grades are different from those used in reading storybooks (Fang et al., 2006). By the time adolescent students are being challenged by content area texts, literacy instruction often has evaporated altogether (Shanahan & Shanahan, 2008).

Teachers who teach reading strategies provide a scaffold for students to build comprehension of the materials being read. Vocabulary lessons, graphic organizers, strategies for reading before, during, and after reading, comprehension skills and strategies, fluency skills, and research packaged step-by-step programs provide some direction for teachers. Teaching content along with the content area reading strategies helps students improve their reading and their comprehension (Alvermann et al., 1990; Barton, 2001; Barton & Heidema, 2002; Billmeyer &

Barton, 1998; Donahue, 2003; Draper, 2002a; Gentile, 1980; Hall, 2005; Mathison, 1989; McWilliams, 1981; Moore & Readence, 1983; O'Brien, Stewart, & Moje, 1995; Siegel & Fonzi, 1995; Stieglitz, 1983; Vacca & McKeon, 2002). Many books are devoted to explaining reading strategies that assist struggling readers at all grade levels. Since there is no single program or way to teach reading strategies, the research supports building from a foundation of assisting middle and high school students in connecting what they know to what they are reading and applying that knowledge to their learning (Allington, 2001; Barton & Heidema, 2002; Billmeyer & Barton, 1998; Moore, Alvermann, & Hinchman, 2000; Zemelman, Daniels, & Hyde, 2005).

The research defines strategies as conscious and flexible plans readers apply and adapt to a variety of texts and tasks (Pressley, Johnson, Symons, McGoldrick, & Kurita, 1989). They are intentional and deliberate plans under the control of the reader. Good readers make decisions about which strategy to use, when to use it, and how to adapt it to a particular text (Afflerbach, Pearson, & Paris, 2008; Pressley et al., 1989). By making a decision as to what reading strategy will be used, readers become better able to decode the text, understand which strategy works best with a particular text, and construct meaning from the text being read. Strategies should be flexible and adaptable. Content area reading strategies assist readers by emphasizing reasoning and applying critical thinking as readers construct and reconstruct evolving meanings from the text. Readers modify strategies for different kinds of text and different purposes (Dole et al., 1991).

In order for adolescents to truly benefit from strategy instruction, research is needed to clarify how strategies operate in the content-area classrooms (Conley, 2005). Teachers who integrate the content area reading strategies with the learning process assist students in successfully moving from one phase of learning to another (Bloom, Hastings, & Madaus, 1971).

Reading strategies instruction provides a scaffold for the reading in textbooks, which in turn assists students in their comprehension of reading in mathematics (Borkowski, 1992).

Reading Strategies

The knowledge that readers bring to the task and the strategies that are used to foster and maintain understanding play an important role in distinguishing the old and new views of comprehension. Reading strategy descriptions include “intentional and deliberate plans under the control of the reader with intentional attempts to equip students with metacognitive routines for understanding text, monitoring comprehension, and fixing things up when they go awry” (Pearson, 2004, p. 221). Richardson (2008) described the work of Dole et al. in 1991 as a seminal publication in reading strategy research. Their work provided comprehension strategies that focus on “construction of meaning, prediction, generating questions, determining importance, drawing inferences and self-monitoring” (p. 93).

Content area reading strategies are tools for learning. To understand how these strategies help students “learn the content,” it is helpful to examine how these strategies correlate with general principles of learning. In their 1999 book *How People Learn*, Bransford and his colleagues described three broad principles of learning and the connections to education (Applebee, Langer, Nystrand, & Gamoran, 2003; Zemelman et al., 2005). Examining reading strategies using the lens of the three principles described by Bransford et al. illustrates how critical these principles are in supporting students’ learning.

The first principle of learning, according to Bransford et al. (1999), states that students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, students may fail to grasp the new concepts and information that are taught, or they may learn them for the purpose of a test but revert to their preconceptions outside the classroom. This means teachers must work with students to uncover, explore, and understand pre-existing understandings and learning that the students bring into classrooms. There are reading strategies that can assist with activating prior knowledge of the students before they read. Some call these “before” reading, “preactive,” or “introductory” reading strategies (Applebee et al., 2003; Barton, 2001; Barton & Heidema, 2002; Billmeyer & Barton, 1998; Fang et al., 2006). Research indicates that when background knowledge is well developed and accurate, students understand and remember more of what they read (Anthony & Raphael, 1987).

Reading with a purpose is a research-supported practice for use by content area teachers when working with students prior to any reading. When teachers provide a purpose for reading assignments, students can focus and filter the reading based on that given purpose. When they have been presented with a purpose, students have an idea of what is deemed important and what is not. This practice of giving students purpose for reading not only gives focus to their reading, but also creates a scaffold for them to use while reading (Fang et al., 2006; Wilson, 2004). Purposeful reading combined with activating prior knowledge gives students a way to grasp the text and uncover the concepts so that they understand more of what they are reading. Many readers use information from their own existing knowledge and experiences to relate to text. Background knowledge helps build a model of meaning from the text. The activation of background knowledge encourages readers to extrapolate from or elaborate on their ideas and concepts while they are reading, and this may assist them in filling in any missing information (Anderson & Pearson, 1984).

Determining importance is another reading strategy that can be used before reading or during reading. Determining importance is tied to a reader’s background knowledge and is used as a filter to decide what is most important to the reading or problem solving and what might be extraneous information (Afflerbach et al., 2008; Anderson & Pearson, 1984). While determining importance, drawing inferences and prioritizing information become crucial to comprehension of the material (Gordon & Pearson, 1983; Hansen, 1981; Hansen & Pearson, 1983). By setting a purpose, accessing a student's background knowledge, or helping students read to determine importance, teachers are better able to focus on what students know and what they need to know next in the lesson.

The second principle outlined by Bransford et al. (1999) is as follows: "To develop competence in an area of inquiry, learners must: a) have a deep foundation of factual knowledge; b) understand facts and ideas in the context of a conceptual framework; and c) organize knowledge in ways that facilitate retrieval and application" (Donovan, Bransford, & Pellergrino, 1999, p. 16). Teachers need to assist students to develop a deep understanding of the content, organize it into meaningful ways, interpret the pieces of information, analyze it to see patterns or relationships, and apply the learning to new situations. When students see or read words with multiple meanings, it is helpful to make connections to prior understandings of the words and the mathematical meaning of the work so that they can develop definitions based on their own experiences (Coulombe & Berelson, 2001). By helping students make connections, teachers are developing the student's deep factual knowledge and organizational skills to possibly be able to apply what is learned. The content of learning and reading have to be engaging and authentic. Teachers need to take cues from students, drawing on each student's deep understanding of a topic and using that as a starting point in their learning and planning (Zemelman et al., 2005).

"During" reading strategies and "after" reading strategies used in content area-instruction provide opportunities for students to take the new knowledge and develop patterns and relationships with what they already know. Using these strategies connects the old and new knowledge; thus they can be used to apply, integrate, analyze, or synthesize the information (Fang et al., 2006; Vacca & McKeon, 2002; Wepner, Strickland, & Feeley, 2002; Wilson, 2004; Zemelman et al., 2005). Having made these connections, students are then able to construct their knowledge with what they already know and apply it to the new learning.

Numerous reports from blue-ribbon panels and research and policy centers implicate poor understandings of cognitive strategies as the primary reason for adolescents' struggles with reading (Deshler, Palincsar, Biancarosa, & Nair, 2007). Adolescents need to master cognitive strategies for reading and thinking in complex situations in which texts, skills, or requisite knowledge are not always clearly understood. One way to practice and master these skills is to monitor comprehension, which is defined as a process of becoming aware of one's own understanding during reading (Dewitz, Carr, & Patberg, 1987; Shanahan & Shanahan, 2008; Taylor & Frye, 1992). While monitoring comprehension, readers ask questions of the text, whether it is to find a definition of a word, to solve a problem, or to connect to information that the reader already knows. The second principle of learning builds content knowledge and assists students to organize and integrate their learning. The "during" and "after" reading strategies provide teachers with ways to help students connect the content and learning.

The third principle Bransford and his colleagues describe reads as follows: "A metacognitive approach to instruction can help learners to take control of their own learning by defining, learning goals and monitoring their progress in achieving them" (as cited in Donovan et al., 1999, p. 17). Inquiries, dialogue, reflections, and monitoring learning all are ways to apply this principle of learning. Students show their thinking when they are reading. They can summarize or predict to help think about what is being read. They are interacting with the text, which helps them create connections to their knowledge. Teachers model their thinking while they are problem solving or reading to give students a demonstration of how to be reflective about the work that they are doing to continue to make connections and build upon their knowledge base. In mathematics, as in other disciplines, students are expected to integrate their linguistic, cognitive, and metacognitive skills to comprehend text (Mather & Chiodd, 1994).

Questioning the texts while reading, using critical thinking strategies, and problem solving are research-based instructional practices in education. These practices help students think about their own thinking and learning, which then increases their ability to comprehend. Barton (1997) explains that when readers can recognize problems in their own understanding, they can identify what may be wrong and why the problem occurred. Readers identify strategies that might remedy the problem, and then select and apply the most appropriate strategy. Once the strategy has been used, the reader then decides whether using the strategy is successful, or whether another strategy needs to be used. By using “after” reading strategies such as summarizing, students may be able to comprehend more and use what was learned to problem solve or critically think about what they read.

All three principles of learning complement the content area reading approaches and put the cognitive and the developmental needs of the students at the forefront. The usefulness of a structure for learning has to do with the ability of students to comprehend the structure and use it as an organizing factor in their learning. Providing a variety of strategies enables students to use and select the strategy that best fits the content and the material being read. The research-based best practices provide content area teachers some tools for teaching their content with reading strategies as a part of their instruction.

As the reading strategies are examined as they apply to this research, the three categories of reading strategies, “before,” “during,” and “after,” will be the foci, with specific reading strategies subsumed in each category. In the “before” reading category, the strategies examined are activating background knowledge, setting a purpose, and choosing an appropriate reading strategy. Determining importance, organizing and integrating, and using appropriate decoding are the strategies examined in the “during” reading category. Finally, in the “after” reading category, summarizing is the strategy examined.

Connection of Content Area Reading to Reading in Mathematics

Brennan and Dunlap (1985) defined reading in mathematics as “a meaningful interpretation of printed symbols/pictures and of the arrangement of symbols in expressive charts, graphs and tables” (p. 153). Barton and Heidema (2002) defined mathematics reading as “the ability to make sense of everything that is on the page…any resource that students might use to learn and apply mathematics” (p. iii). Research about reading in mathematics shows that students need to understand all that is on the page, and that knowing is not just reading what is on the page (Roth, 2002; Shanahan, 2006; Shuard & Rothery, 1993). These findings are similar to findings from the content area reading research. Draper (2004) noted that the discipline not only dictates what the content of texts should be, but also what counts as texts, reading, and writing.

School materials are often written at variable levels of reading, so they can pose a challenge to students if the level is higher than they have achieved. In addition, we know that students are often not taught the processes for effectively reading those materials; the reading processes and strategies are taught in other classes and may not transfer to mathematics (Brennan & Dunlap, 1985; Shanahan & Shanahan, 2008). Research describes the factors that make reading in mathematics difficult. Students often attempt to read mathematics texts for the gist or general idea, but do not understand that each word has a precise meaning and that each word needs to be understood specifically in service to that particular meaning (Shanahan & Shanahan, 2008). Leiva (2006) suggested that possibly students just imitate what the teacher does without fully understanding the problem and its solution.

Mathematical reading requires knowledge and skills not taught in other content areas. Abstractions, specialized symbols, concepts, and mathematical vocabulary make reading mathematics more difficult than reading other textbooks, which creates the need for strategic reading of mathematics texts even more crucial (Brennan & Dunlap, 1985). Reading in mathematics appears to be more complex because the texts are written in a succinct style in which there are more concepts per word, per sentence, and per paragraph than in any other kind of text (Brennan & Dunlap, 1985; Culyer, 1988).

Often typical words may have different meanings from those students are used to in other contexts. For instance, compare these sentences:

Sentence one: Sharon will set the table.

Sentence two: Let A be a set of all of the male children in the Grendahl family.

In the first sentence, “set” is a verb that means “to put or place.” In the second sentence, “set” is a “collection or group of objects, numbers of other items” (Bell et al., 2007). Students who have difficulties reading may have a tendency to resort to the more familiar, often less technical definition of a word (Kane, Byrne, & Hater, 1974). Using the less technical or content specific term may hinder students’ understanding about the content (Fang et al., 2006). Nasir and Hand (2006) concluded that because mathematics language has its own symbols and abstract language, as well as its complex syntax and register, it complicates the communication process. In mathematics, it is sometimes necessary to read the text of the word problems or the instructions from left to right; some number lines are read from right to left; tables are read from top to bottom; graphs are sometimes read from bottom to top; and the points on a graph may be read diagonally. However, even more complex than directionality is the reading comprehension skills required to comprehend mathematics textbooks. The longer text passages in the integrated textbooks are filled with visuals. Additionally, they have more words on the pages and in the word problems, which presents another obstacle in the struggle to read mathematically. Reading in mathematics requires the use of specialized skills and teaching techniques (Brennan & Dunlap, 1985) because “the style of mathematical writing is strikingly different from styles found in non-mathematical text; we shall see that the nature of mathematical text poses special problems for the reader and demands that he acquire special reading skills” (Shuard & Rothery, 1993, p. 42).

Readers are often asked to read text on the page, and then to read a graph or table while simultaneously remembering and comprehending what was previously read on the page, and finally to compute and solve the problem. Reading and understanding tables, graphs, charts, symbols, equations, and illustrations is critical in order to be successful in mathematics (Barton & Heidema, 2002; Bossè & Faulconer, 2008; Brennan & Dunlap, 1985). As Draper and Siebert (2004) explained, “Mathematics cannot be separated from the texts in which meanings are created, conveyed, and negotiated, just as literacy cannot be separated from the content that defines how the texts are to be read and written” (Draper & Siebert, 2004). Remembering the variety of reading skills and strategies needed while concurrently learning new vocabulary and complex algorithms is challenging in mathematics.

The difficulty of reading in mathematics may contribute to the inability of some students to read, understand, and solve mathematical problems. Although all students may not need to be taught reading strategies or problem solving strategies, students who struggle in reading may need additional assistance (Allington, 2006).

Teachers must assist in making connections for students. My knowledge of content area reading strategies and from conversations with some mathematics teachers and mathematics curriculum coordinators indicates that strategies to teach reading are not normally a part of classroom instruction. My colleagues have said that textbooks rarely provide these strategies for the teachers. One facet of reading in mathematics is word problem solving. Nationally, children perform 10 -30% worse on word problems than on those in numeric form (Xin, 2007). Researchers attribute difficulty in solving word problems to difficulty in comprehending abstract or ambiguous language (Borasi et al., 1998; Cummins et al., 1988). Cummins et al. (1988) described this added layer of complexity:

> Like narratives, word problems require skillful mapping of text input onto the reader's knowledge base if proper comprehension is to be achieved. …In the case of narratives the reader must map linguistic input onto world knowledge concerning (e.g.) actors and their motives. In the case of word problems, the solver must map linguistic input onto knowledge of the problem domain. (p. 406)

Since solving word problems requires students to read, a closer look at word problem solving is warranted. If students are asked to read the problem and then look at other parts of the page or book for more information, their problem solving abilities may be compromised. Research also indicates that students who have lower memory skills are not as able to maintain the shift that occurs when they are asked to read part of a problem and then look at a chart or graph. When reading mathematics problems, unsuccessful students use a direct translation model. They identify key words, plug the information into an algorithm, and then attempt to solve the problem. More successful students use a problem solving model to solve problems. They read the problem and first translate each statement and connect it to what they know, and then determine a process to sort out the relevant information. Successful students then create a plan to solve the problem (Hegarty, Mayer, & Monk, 1995).

The greatest difficulty in reading word problems is that students are challenged by connecting the problems to relevant contexts and that often the way in which the problems are stated can cause misunderstanding or interfere with the student's ability to solve the problem. Although more recent research indicates that even when the word problems are written to make the situation in the problem relevant, students may not see the relevance of the problem to their lives and may not take the problem seriously (Mayer, 1998).

Research has also focused on the difficulty of word problems. Weaver and Kintsch (1992) asserted that word algebra problems are challenging for most students and that teachers give well-meaning advice as such as "Read, and reread the problem until what is stated is clear" (p. 419). In fact, just re-reading a problem may not result in deeper understanding, especially if students are not using reading strategies. In a 1988 study conducted by Riley and Greeno with first graders who solved word problems, the researchers found that non-mathematical factors such as language understanding and text comprehension can influence the difficulty of word problems considerably. Based on the mathematics achievement scores across the nation, problem-solving word problems in mathematics is an area that deserves a closer look.

Mathematics textbook research often categorizes textbooks into two types: traditional or reform-based. In this paper, the term, *subject specific,* will be used instead of traditional and *integrated* will be used instead of reform-based. In the section of this chapter on textbooks, these types are fully described; here it will simply be noted that subject specific texts usually present discrete math topics, such as geometry or algebra, whereas integrated texts may present multiple math topics. Since the integrated mathematics includes many more opportunities for students to read and problem solve, it is important to connect methods of reading mathematically with problem solving in mathematics.

In mathematics, students are not necessarily taught the processes to read mathematics. If literacy skills are taught in other content area classes, students may not transfer the reading strategies to mathematics. Research shows that students need to be actively involved in the reading of textbooks to fully understand what they are learning, but sometimes knowing information and knowing how to implement skills are two different things (Donovan et al., 1999; Joyce & Showers, 2002).

What most middle and high school students who struggle to read need is explicit instruction in reading comprehension to understand the reasoning processes and strategies, as well as the knowledge of the world, texts, and disciplinary discourse that good readers employ to understand texts (Allington, 2001; Hillocks, 1995; Pearson, 1996). Students who do not develop fluency with mathematics texts will not have access to the meanings that are being developed and negotiated in the mathematics classroom. Their fluency in other kinds of texts may not serve them. As Cummins et al. (1988) concluded, “This discrepancy in performance on verbal and numeric format problems strongly suggests that factors other than mathematical skill contribute to problem solving success” (1988, p. 406). Literacy is essential to the process of developing understanding (Draper & Siebert, 2004). It is difficult to separate reading comprehension in a content area from the fundamental nature of the discipline.

Reading comprehension requires specific ways of thinking about content, depending on the domain (Goldman, 2000). In a 2008 study conducted by Shanahan and Shanahan, the researchers noted that secondary teachers recommend comprehension strategies for the specific content area or discipline in which they teach. According to this study, mathematicians and mathematics teachers were adamant that precise mathematical definitions needed to be memorized and learned. Mathematical letters and symbols also play an important role in mathematics, so being able to correctly read and understand the symbols and letters embedded in the algebraic equations was crucial to the mathematics teachers in the study. They were concerned that students could not make the distinction between the introductory material and the definitions, proofs, theorems, and explanations. The reading strategies the teachers in the study wanted to use needed to address the demands of mathematics directly. For mathematics educators in the study, the use of content area reading strategies has to go beyond the subject specific teaching of content area reading strategies such as using generic literacy strategies and asking mathematics teachers to return to their classrooms and adjust the strategy to fit into their content. Reading strategies need to be created and connected directly to mathematics (Shanahan & Shanahan, 2008).

Because the research on reading in mathematics suggests that traditional reading strategies may not be enough for struggling students in mathematics, a scaffold developed by Mayer (2004) describes a strategy for reading and solving word problems. Mayer’s four-step method includes translating, integrating, planning/monitoring, and executing (see Table 1). Mayer breaks the first two steps into problem statements and the last two steps into solution statements. He also provides the instructional ideas needed to assist students with the problem solving method.

Table 1

Mayer's Four-Step Problem Solving Method

	Steps	Instruction
1	Problem translating	Teaching students to represent sentences
2	Problem integrating	Teaching students to use problem schemas
3	Solution planning and monitoring	Teaching students to devise solution plans
4	Solution executing	Teaching students to carry out procedures

To translate a word problem, students often take the words and create a literal, phrase-by-phrase translation, which is a fragmented representation of facts. Mayer's first step focuses on factual and linguistic knowledge: distinguish between variables, operations, and numbers. Factual knowledge in a word problem might include that there are "seven days in a week." The linguistic knowledge might be in the word *estimate*, which requires students to understand that the word *estimate* is different from the word *solve*. As the aforementioned research by Mayer (2004) has indicated, mathematics text is succinct and every word carries a specific meaning. If they don't translate the text correctly, students will have difficulty with the mathematics. Teaching students how to translate word problems into sentences, especially relational sentences, has shown gains in students' ability to solve word problems (Brenner, Mayer, Moseley, Brar, & Durán, 1997; Lewis, 1989).

Mayer's second step, *integrating*, directs students to know the types of problems and the representation of the mathematical structure of the problems. Readers must be able to determine which information is important and which is not. Unsuccessful problem solvers, according to Mayer, "tend to focus on the numbers in the problem and to use keywords in the problem to determine what operation to apply" (2004, p. 731). Once readers determine the important parts of the problem, then the information is organized and any inferences are made as to the type of mathematical word problem they are facing. Hinsley (1977) describes over 18 categories of word problems, including distance-rate-time, area, probability, averages, ratios, and interest problems. Mayer (1981) described over 100 different types of word problems. According to Mayer (1981), instruction that assists students to determine relevant information in word problems and then to categorize the problems appropriately will help students be more successful in solving problems.

Mayer's third step involves *making a plan* for solving the word problems and monitoring the plan. Some students may believe that word problems are solved simply by applying the mathematical algorithms or rules, so no plan has to be made. Silver and Kenney (2000) reported that a national survey of U.S. mathematics students revealed that 54% of the fourth graders and 40% of the eighth graders thought that most of the learning in mathematics consists of memorizing rules. Usually an example for solving the word problem is placed somewhere in the text (e.g. boxes, margin notes, in the narrative, etc.). Students need instruction on how to read and plan to solve the word problem, followed by practice to help determine which algorithms to apply and when to apply them. They also need explanations for each step and instructions regarding when to use the examples (Reed, 1999). By making a plan that goes beyond putting numbers into a formula, students will have a greater understanding of the word problem and the mathematics needed to solve word problems.

Mayer's (2004) fourth step is *execute*, which involves solving the problem by carrying out the plan. Computation is required in this step; students must apply their knowledge of how to solve the problem. In this step, the lack of skill in applying the arithmetic and algorithm does not depend on reading the mathematical text; rather, it asks students to solve the problem using their mathematical skills. Mayer noted that students need both conceptual knowledge (steps one and two) and the procedural skill (steps three and four) to make mathematics meaningful.

Mayer's (2004) problem solving method illustrates the importance of students' reading mathematics with comprehension. Additionally, it points to the need for instruction and assistance in reading in content areas.

Textbooks

One of the primary instructional tools used in classrooms today is the textbook. Since teachers direct the instruction in the classroom, the textbook becomes the main source of learning, and teachers usually follow some of the plans in the textbook (Eide & Heikkinen, 1998; Gordy & Pritchard, 1995; Harmon et al., 2000; Radcliffe et al., 2008). A 2006 study found that "recent research documents that teachers in the United States rely heavily on their mathematics textbook to make decisions about what content to teach and when to teach it" (Tarr, Chávez, Reys, & Reys, 2006, p. 191). Eide (1998) found that 70 to 75% of instructional time was spent using textbooks as the primary instructional tool in most high school classrooms. Fisher and Ivey (2005) observed that when students rely on the textbooks or are told that the content is material that they have to know, neither understanding nor literacy development improves. In general, many textbooks are difficult for students to read and understand because they are written in a way that may be beyond some students' reading ability (Brennan & Dunlap, 1985; Harmon et al., 2000; Radcliffe et al., 2008). According to the Report of the National Reading Panel written by the National Institute of Child Health and Human Development (NICHD, 2000), six comprehension strategies contribute to reading achievement. The panel recommended that teachers should:

1) Teach text organization and questioning skills.

2) Provide opportunities for students to work cooperatively.
3) Provide multiple strategies for students.
4) Make visual representations of the concepts.
5) Write summaries.
6) Work cooperatively with other students.

Although number two and number six appear to be similar, the difference is that number six is looking to increase the skills as to how students work together. When these six strategies are taught by the teachers and applied by the students, achievement is higher. The panel pointed out that even though the strategies are generic, they work in all content areas.

As was mentioned earlier, mathematics textbook research has categorized textbooks into two general types of textbooks: subject specific and integrated or National Council of Teachers of Mathematics- (NCTM) oriented (Latterell, 2005). Subject specific textbooks are those that approach mathematics via discrete topics such as algebra or geometry. Subject specific textbook supporters believe that each math topic or concept should be learned in-depth by students before they move on to another topic (Latterell, 2005). Subject specific mathematics textbooks also include directions for the teacher, leading him or her to conclusions and summaries of student learning. There is an assumption underlying the premise behind these textbooks that students work as individuals. In problem solving sections of the subject specific math textbooks, one correct answer is assumed, and the exercises are routine and procedural (Latterell, 2005).

In the past, mathematics textbooks were relatively repetitive, unfocused, and undemanding. Authors of subject specific textbooks tended to place an emphasis on procedural knowledge and rote-driven computation. The pages in the subject specific texts are filled with numerical problems and little text (Reys, Reys, Lapan, Holliday, & Wasman, 2003). Reys et al.

(2003) reported that from third-grade mathematics to ninth-grade algebra, textbooks followed the same pattern, in which instructional units consisted of a few sample exercises that the teacher demonstrated, followed by a set of exercises for students to work on. The daily lesson plans included in the textbooks provided teachers with the material to cover and occasionally supplemental material was included, presumably to boost student interest in and facilitate student mastery of the topic. Subject specific textbooks often present mathematical ideas as facts to memorize rather than emphasizing the meaningful relationships of the words, numbers, graphs, and visuals on the pages (Reys et al., 2003).

The written material in the subject specific textbooks generally presents definitions, algorithms, or examples of how to perform a procedure. The exercise sections include long lists of decontextualized problems with specific numerical answers that furnish opportunities to practice the procedure (Martin, Hunt, Lannin, Leonard, Marshall, & Wares, 2001). Xin (2007) analyzed mathematics textbooks and found that the subject specific textbooks provide little support for teachers who may not have a deep understanding of the content to prepare students adequately, or to accommodate for individual differences.

In contrast, the integrated mathematics textbooks present many more reading opportunities than do subject specific textbooks (Latterell, 2005). The pages in the integrated textbooks are filled with more visual elements such as pictures, diagrams, and graphs. There are more words on the pages, which are often word problems or information that connects the mathematical information to real-life situations. The integrated textbooks emphasize problem solving and an inquiry-based approach. From a integrated perspective, the teacher's role is to facilitate students' exploration and thinking, as well as to organize students to work in groups in which they share their own solution strategies. The integrated textbooks connect mathematics with other disciplines and reasoning about problems when solutions are not obvious (Bryant, Bryant, Kethley, Kim, Pool, & Seo, 2008; Martin et al., 2001; Reys et al., 2003).

Integrated or National Council of Teachers of Mathematics (NCTM)-oriented textbooks present multiple math topics with an assumption that they will be taught every year. In theory, at the end of a three-year sequence, students have been taught three areas of mathematics, including algebra, geometry, and trigonometry (Latterell, 2005). The NCTM standards suggest that integrated courses be taught in a more natural manner and show connection to real-life situations. Integrated textbooks often support the discovery method, in which the teacher's role is to facilitate learning, as the main focus for students. In these types of textbooks, word problems are open-ended and conceptual, and use real-life data (Latterell, 2005). Each problem is unique, and different approaches may be used to solve problems.

Both integrated and subject specific teacher editions of textbooks support classroom instruction by creating step-by-step plans, definitions, and supplemental information to meet the needs of students. Some teacher editions include student pages and tips to assist diverse learners. Johnson and Cochran (1993) found that "all available investigations from the '90s indicate that teachers largely follow the teaching plans incorporated into the textbooks" (p. 287). This finding supports the research that found that textbooks are used as the primary tool used for instruction (Eide & Heikkinen, 1998; Gordy & Pritchard, 1995).

Textbooks serve as a major resource for learning, but analyses of their composition and organization have been neglected in the research on how students learn from text. Learning from text depends on several interacting factors, including the nature of the learning context, the prior knowledge and processing strategies available to the learner, and the design of the learning materials (Britton & Gulgoz, 1991; McNamara, Kintsch, Songer, & Kintsch, 1996).

Summary

Research related to content area reading and reading strategies described in the review of literature support the idea that if teachers use the reading strategies, struggling students may make strides in reading in all content areas. The seminal work of Dole et al. (1991) in using reading strategies to increase comprehension informed the examination of texts in this study. The three principles of learning from Bransford et al.’s 1999 work connect to the reading strategies and comprehension needs for instruction in content areas. Mayer’s (2004) framework for problem solving describes how to interweave reading with mathematics. Finally, the review of literature describes the use of textbooks in classrooms.

We know that mathematical reading requires specialized reading, but we don’t know what reading strategies are included in the teacher editions of mathematics textbooks. We don’t know enough about the reading strategies in the subject specific or integrated textbooks to know whether students are scaffolded and supported in their efforts to understand mathematical reading. If content area reading strategies assist students’ comprehension and understanding in all subjects including mathematics, then research that examines the reading strategies embedded in teacher editions of mathematics textbooks is critical.

CHAPTER THREE

METHODOLOGY

The purpose of this study was to conduct an in-depth analysis of mathematics textbooks with a specific focus on analyzing teacher editions of mathematics textbooks to identify, categorize, and synthesize the reading strategies embedded in these textbooks. This chapter provides background and justification for using content analysis methodology, the details of textbook selections, textbook descriptions, coding of the data, and data analysis procedures.

Content Analysis

The research methodology chosen for this study was content analysis. Krippendorff (2004, p. xvii) observed, “Content analysis is an empirically grounded method, exploratory in process, and predictive or inferential in intent.” Krippendorff described content analysis as particularly useful when there is a “desire to know something currently inaccessible and the belief that a systematic reading of potentially available texts could provide answers” (p. 75). Because content analysis provides a structure to examine, analyze, and make inferences, this methodology and design was the best fit for this study.

Content analysis as a research tool has a long history in many fields, as well as in education. For example, in 1923 content analysis was used to examine treatment of “labor” in high school texts. Another example of how content analysis has been used to explore textbooks can be seen in Berelson’s 1952 study evaluating the representation of foreign countries. Using a content analysis approach, these studies were able to provide an examination of balance and accuracy and uncovered data that pointed to an inferred bias in textbooks.

Content analysis facilitated the examination of the textbooks in this study in order to evaluate the presence (or absence) and types of content area reading strategies in teacher editions of mathematics textbooks. Weber (1990) and Holsti (1969) note that inferences from content analysis are about the attributes of the messages in the texts, whether they are the sender's message, the message itself, or the audience of the message. Budd, Thorp, and Donohew (1967) added, "Content analysis is an unobtrusive, observational research method that is used to systematically evaluate the content of all forms of recorded communications including textbooks" (p. 45)." Content analysis provided me with the methodological structure for examining the textbooks , arriving at thematic patterns, and formulating conclusions for improvement of textbooks (Holsti, 1969; Krippendorff, 2004).

Krippendorff noted that quantification is not a defining criterion of content analysis. He concluded that "text is always qualitative to begin…and using numbers is a convenience, but not required for obtaining valid answers to a research question" (2004, p. 87). In this study, quantitative data were used only as a means of recording frequency of units; qualitative analysis was used to examine and code data to further explore the research questions.

Content analysis provided a best fit for this study for two reasons. First, the purpose of this study was to examine text in a purposeful way—one that allowed for identifying and describing reading strategies. Second, information from the data provided opportunities to develop conclusions (e.g., recommendations, ideas for future research).

Process of the Selection of Textbooks

Krippendorff suggests that a sampling plan be used to ensure that "the textual units sampled do not bias the answers to the research question" (2004, p. 113). Relevance sampling was selected for this study to systematically reduce the number of units that needed to be considered for the analysis. My research plan used relevance sampling for the selection of textbooks by beginning with all teacher editions of mathematics textbooks and narrowing the sample to six textbooks that fit my criteria.

I began by considering the sample that included all of the teacher editions of mathematics textbooks used in the United States. Since the exploration of reading strategies in the textbooks was the focus of this research, the teacher editions of the mathematics textbooks were selected with the assumption that there might be a greater opportunity to examine reading strategies, and it was assumed that reading strategy instruction would be included. Another assumption was that if the reading strategies were included in teacher editions, with directions for their use, then mathematics teachers had a resource they could use to teach content area reading strategies.

Related to the goals of this study, it was critical that the broadest representation (sample) be explored in order to develop conclusions and make recommendations. Based on statistical information from mathematics textbooks publisher websites, the selection of textbooks was narrowed to the most frequently purchased textbooks in the states that purchase the largest number of textbooks: California, New York, and Texas. Each state's website provided information about the mathematics textbooks used within that state. To provide consistency in the textbook selection, only textbooks that were adopted by the state were included in the study. California and Texas adopted a number of textbooks statewide; New York left the decision to the individual schools or districts. The textbooks recommended by Washington State were added to the textbook selection process because of relevance to the researcher.

The next level of sampling reduced the number of textbooks for this study by categorizing the textbooks into the two major descriptive mathematics categories of subject specific and integrated textbooks. As was mentioned in chapter two, subject specific textbooks are those that focus on one particular branch of mathematics, such as geometry or algebra. These texts focus on the teacher leading the students to conclusions and summaries. The National Council of Teachers of Mathematics suggested that the integrated courses are taught in a more natural manner and show connection to real-life situations. In the integrated textbooks, the discovery method is the main focus for students, and teachers facilitate learning.

Since there are several textbooks from the same publisher, when the selection of the integrated textbooks was made only one integrated textbook was selected to represent the integrated texts at that grade level. The intent was that different publishers would be represented in this study. Only two textbook series fit the definition of *subject specific* as defined in this study. Any textbook that did not have a teacher edition was eliminated. Three textbooks were selected from the subject specific category of teacher editions of mathematic textbooks; three were selected from the integrated category with representation from different publishers (see Table 2). Of the six textbooks, two each were chosen to represent the fourth grade, middle school, and high school. Two of the subject specific texts selected were from the same publisher since there were no others to choose from after systematically narrowing the textbook selection. One textbook was obtained by borrowing from a local school district; two were received as complimentary copies from the publisher; and three were purchased. The textbook information categorizes the textbooks by grade level, publisher, and whether they were integrated or subject specific, which provided a cross-section of textbooks used in this study. The final selection of the textbooks used included representation from fourth grade, middle school, and high school textbooks, as well as the two major descriptive categories of mathematics textbooks, subject specific and integrated.

Table 2

List of Teacher Edition of Mathematics Textbook Used in Study

Title	Grade	Publisher	Integrated or Subject specific
Everyday Mathematics (EDM)	4	The University of Chicago School Mathematics Project Wright Group/McGraw Hill	Integrated
Singapore Primary Mathematics 4A (PM4A)	4	Singapore Math	Subject specific
Singapore New Elementary Mathematics (NEM)	7	Singapore Math	Subject specific
Connected Mathematics Project (CMP)	7	Michigan State University Pearson Prentice Hall	Integrated
Contemporary Mathematics in Context: Core Plus Course 2 part A (CP)	10	Glencoe	Integrated
Saxon Advanced Mathematics (SAM)	10	Saxon/Harcourt Achieve	Subject specific

Publisher Descriptions of Textbooks

Textbook descriptions and information were taken from the publishers' websites. This information provided background data about the textbooks and added to the selection criteria especially for the grade level decisions. For example, Singapore Mathematics labeled their textbooks as "Primary" and "New Elementary." The publisher information clarified the grade levels in which these textbooks could be used. The textbook descriptions below were categorized by grade level and given in alphabetic order according to grade level.

Fourth Grade: Everyday Mathematics (EDM)

The *Everyday Mathematics* (*EDM*) website stated that this curriculum, which included the textbooks, is currently being used in over 185,000 classrooms by almost 3,000,000 students. *EDM* publishers state that this series "received the highest rating by the federal government for any commercially published elementary mathematics curriculum" (http://everydaymath.uchicago.edu/, ¶ 2-3). The goals of the curriculum/textbook include nine strands of knowledge: algebra, data and chance, geometry, measurement, numeration and order, patterns, functions and sequences, operations, and reference frames (Bell et al., 2009, p. vii). In *Everyday Mathematics* (EDM), each unit began with a "getting started" section, followed by "teaching the lesson" with ongoing assessment, learning and practice, and differentiation options. There were progress checks and written assessments. This textbook was included in the study because it fit the criteria of an elementary textbook, fourth grade, and it was categorized as a integrated textbook.

Fourth Grade: Singapore Primary Mathematics 4A (PM4A)

The publisher's introduction states that this series of textbooks is meant to be a part of a system of learning in which adult supervision and independent practice go hand in hand. The main components of the textbooks used the concrete, pictorial, and abstract approach, which encourages active thinking processes, communication of mathematical ideas, and problem solving. The lessons are adaptable for detailed objectives and learning tasks(http://www.singaporemath.com/Pri_Math_Teacher_s_Guide_4A_p/pmtg4a.htm). This subject specific textbook is used in the intermediate grades (including fourth grade), which meant it fit the criteria for inclusion in this study.

Seventh Grade: Connected Mathematics Project (CMP)

This math series received funding from the National Science Foundation (NSF) and is called by NSF a complete mathematics curriculum for middle school teachers and students. The *Connected Mathematics Project* (CMP) is research-based and was field tested with approximately 45,000 students and teachers from diverse sites, according to the publisher. The website also states that the students using *CMP* outperform non-*CMP* students on tests of problem solving ability, and equal or outperform non-*CMP* students on skills tests and in terms of long-term retention (http://connectedmath.msu.edu/, ¶ 1). In *Connected Mathematics Project* (CMP), the organizational structure was launch, explore, and summarize. This middle-school textbook was included in this study because it is described as integrated and suitable for seventh-grade students.

Seventh Grade: Singapore New Elementary Mathematics (NEM)

According to the publishers, this textbook is a part of a four-year series of secondary texts. The word *elementary* in the title of this textbook referred to the basics of math–algebra, geometry, and trigonometry—rather than the grade level. The publishers claim that this textbook teaches students a better understanding of mathematical concepts and the application of the concepts, as well as achieving proficiencies in problem solving, mathematical reasoning, and higher order thinking

(http://www.singaporemath.com/New_Elem_Math_Textbk_4A_p/nemt4a.htm, ¶1). At the beginning of the two Singapore math textbooks, there were problem solving tips for the student. The first page of each chapter had a visual representation of the lesson followed by highlights. The lessons had class activities and examples that showed solutions. The preface explained, "This book uses an incremental development to permit long-term practice of concepts. One facet or increment, of a concept is introduced and practiced for a time until the next increment of the concept is presented" (p. xii). Each of the textbooks provided teachers with activities, exercises, alternative lessons, and assessments that organized the delivery of instruction. This textbook is one of the subject specific textbooks for middle school, and it matched the criteria for this study.

Tenth Grade: Contemporary Math in Context: Core Plus (CP)

The publisher's website called this curriculum/textbook an innovative program that engages students in investigation-based, multi-day lessons that are organized around big ideas. It was developed with funding from the National Science Foundation (NSF) and is a product of a four-year research, development, and evaluation process involving thousands of students in schools across the country. The publisher also noted that the concepts and methods are set within real-world contexts with an emphasis on mathematical modeling and data analysis. Every lesson had a four-phase cycle of launch, explore, share and summarize, and apply (http://glencoe.mcgraw-hill.com/sites/dl/free/0078772580/444608/CP_Implementation_Guide_2009.pdf, p. 9, ¶19). *Contemporary Mathematics in Context* (CP) organizes the text into the following categories: modeling, organizing, reflecting, and extending. This integrated high school textbook was included in the study based on the established selection criteria.

Tenth Grade: Saxon Advanced Mathematics (SAM)

The Saxon Advanced Mathematics (SAM) textbook is described by the publisher as a fully integrated mathematics textbook that combines topics from algebra, geometry, trigonometry, discrete mathematics, and mathematical analysis. In *Saxon Advanced Math* (SAM), there were five paragraphs that told how to use this guide, followed by suggested materials, optional resources, and a description of the materials that could be used by the teacher as supplements. The units had objectives, materials, homework, and notes for the teacher. The lessons had numbered activities. Word problems are developed through problem sets and become progressively more elaborate. Conceptually oriented problems help prepare students for college entrance exams such as the ACT and SAT (http://saxonpublishers.harcourtachieve.com/en-US/Products/default.htm?CatalogNavigationBreadCrumbs=HMH%20Supplemental%20Catalog;SaxonMath;Saxon_S03_AdvancedMath&ShowTop=true&Catalog=HMH%20Supplemental%20Catalog/&Category=Saxon_S03_AdvancedMath, ¶ 1).

Data Collection and Analysis

As is very often the case in content analysis studies, the data collection and analysis for this study took place through an iterative process. As I discovered the nuances of the data, analysis occurred that involved coding, examination of themes and patterns, recoding, more examination of themes, and so on through four phases of collection/analysis. Krippendorff (2004) discusses this iterative process and described the “logic” of the content analysis process: “A content analysis design may include iterative loops—the repetition of particular processes until a certain quality is achieved” (p. 85). He also points out that the components of content analysis do not always occur in a linear fashion, as one might have to loop back to re-examine the data, or do further comparisons, contrasts, or refinement. The content analysis process as it relates to data collection and analysis is described below (see Table 3), highlighting the four phases of this process.

Table 3

Summary of Phases of Data Collection and Analysis

Phases and Matrices	Reading	Mathematics	Other coding criteria
Phase one: Matrix A	Before, during and after reading strategies	Subject areas: • numbers • operations • geometry • algebra • data analysis • statistics • probability • processes	Identify textbooks: integrated or subject specific
Phase two: Matrix B	Before, during and after reading strategies	Bloom's taxonomy	Qualitative notes

Phase three: Matrix C	Before, during and after reading strategies	Placement of: • directions • graphs • charts • equations • numbers • text	Qualitative notes
Phase four: Matrix D	Before, during and after reading strategies	Identified word problems	Qualitative notes

Development of Data Collection and Analyses Matrices

Phase One: Matrix A: Reading Strategies, Math Subject Areas, and Types of Textbooks

Based on my research questions, the first coding matrix (see Table 3) incorporated the following elements: the textbooks identified as either subject specific or integrated, mathematical subject areas, reading strategies aligned with the Bransford (2000) research, and grade level. Each grade level was divided into three parts: “before,” “during,” and “after” reading categories, with specific reading strategies subsumed under each category (e.g., determining importance, organizing and integrating information). Even though content area research has shown that often these categories and strategies overlap, for the purpose of this research, the strategies were included in only one category. The strategies, categorized as “before,” “during,” and “after” reading strategies, are listed in Table 4.

Table 4

Categories and Reading Strategies

Category	Reading Strategy
Before reading	Activate background knowledge
	Choose an appropriate reading strategy
	Connect the knowledge to new learning
	Find the purpose for reading
During reading	Ask questions
	Anticipate or predict meaning
	Make inferences
	Make predictions
	Organize and integrate information by searching for main ideas, inferring, synthesizing
	Paraphrase
	Use appropriate decoding or word attack skills
	Use context clues
After reading	Create visual and sensory images from the text
	Draw conclusions
	Recall supporting details
	Reflect on what is read and add new information
	Seek additional information from outside sources

The reading strategies descriptors and mathematical subject areas were used to gather data in the textbooks. As coding began, it became evident that the matrix was not a useful tool for coding the text on the pages. The math subject areas were difficult to identify by the words, problems, or visuals on the pages, and the descriptor in the matrix did not match anything on the pages. There was not a match with the reading strategies either. These deficits meant that no usable data were produced. The reading strategies descriptions were retained for the next matrix and the mathematics categories were abandoned. Identification of the integrated and subject specific textbooks was retained by creating a separate matrix for each textbook.

Phase Two: Matrix B: Reading Categories and Bloom's Revised Taxonomy

Matrix A was revised and became Phase Two, Matrix B, which still used the three broad reading categories and the reading strategies in Table 4. Instead of the math subject areas, the six major categories from Bloom's taxonomy and the alternative names subsumed under the six categories were added (Anderson, Krathwohl, Airasian, Crucikshank,Mayer, Pintrich, Raths, Wittrock, 2001). A suggestion from two committee members was that the reading strategies be tied to an existing framework that might provide more in-depth categorization and analysis of the data. On the revised matrix, alternative names for each of the six categories were listed as subcategories of Bloom's taxonomy. For example, Bloom's category of *comprehend (or understand* in the revised Bloom's taxonomy) included seven alternative names: *interpret, exemplify, classify, summarize, infer, compare,* and *explain*. These expanded concepts provided clarity and more specificity to the coding process.

Using Matrix B, coding began again with the *Everyday Mathematics* (EDM) textbook. The coding criteria were to match the reading strategies descriptions (see Table 4) with Bloom's categories. No reading strategies were identified using the revised coding criteria after examining three units in the *EDM* textbook. The qualitative notes column gave me a place to describe and clarify items as they might relate to reading strategies, as well as to note placement in the text and on the page. Text stating "see diagram" or "read" was recorded in the qualitative notes column to indicate that a reading strategy might have been inferred. Teacher instructions were coded as qualitative notes to see whether the instructions provided assistance for students in reading what was on the page, or for other possible reading strategies. Although I did not uncover exact matches in the text with the reading strategies, I noted and described on the matrix the reading strategies that could have been placed on the specific pages to assist a teacher.

I continued to use Matrix B to code and analyze the remaining textbooks. Two of the textbooks, the *Connected Math* (CMP) series and *Contemporary Math in Context* (CP), included student pages as a part of the teacher editions. *Everyday Mathematics* (EDM) included student pages side-by-side with the teacher pages. Initially the student pages were coded using the same Matrix. After coding the remaining textbooks, a decision to leave out the student pages was made because three of the textbooks did not include student pages. Additionally, student textbooks were not included in the textbook selection process. The research questions focused on what teachers editions might include in terms of reading strategies, not on the presence (or absence) of the reading strategies in the student textbooks.

After the first three math textbooks were coded, introductory information for the chapters or the books was not included in the data collection. The information in the introduction was repetitive in the subsequent lessons and units, so the data were being coded twice for the same information. For example, a lesson objective appeared in the introductory information and then again at the beginning of the lesson. In coding, there was repetition of the concepts, the goals, and the overviews of the lessons. In the EDM textbook, the introductory material listed key concepts and skills related to the goals of the lessons in the unit. In each lesson, the goals and skills were repeated prior to the lesson description.

Since no reading strategies were found using this matrix, the information from the qualitative notes column and the lack of specific reading information provided from the reading strategies or the Bloom's categories was examined to determine what was on the pages of the textbooks and what the information was directing teachers to do. Examining the mathematics texts for teacher directions, placement of the directions, and various text features provided further categorization of the data that were collected from Matrix B.

Phase 3: Matrix C: Organizational Structure of Textbook, Pages, and Text Features

The qualitative notes from Matrix B provided perhaps the richest data and the most insight into which reading strategies were included, or not, as well as the context of what was on the pages. The pages of the textbooks were filled with the numbers, equations, text, pictures, graphs, and diagrams that are all a part of what mathematics teachers use to teach students mathematics. Matrix C examined the organization of the items on the pages, including teacher directions, graphs, charts, numbers, equations, and text. In addition to coding the organization of the pages, words or phrases that indicated where teachers directed students to look at graphs, then read the text, and then solve the problem were identified. Because the graphs, drawings, tables, and pictures were in close proximity to the text, the larger text unit of the page as a whole was examined to identify precisely what the teacher is asking the student to do and how the text supports the task or tasks.

Each teacher edition was organized differently in terms of its instructions and information to guide the teacher through the unit or series of lessons. The organization provided the instructional basis for the particular textbooks. The organizational scheme also gave the teachers instructional guidance, including time frames, individual or group activities, homework, and extensions. Matrix C did not produce any matches of reading strategies, but it did provide data on the organizational structure of each textbook and various text features. Again, the information in the notes column provided rich information as to where reading strategies could be included. Because no reading strategies data occurred using this Matrix, the data collected in the qualitative notes column were examined for patterns and themes. Analyses of the data in the qualitative notes column led to the creation of Matrix D.

Phase Four: Matrix D: Word Problems

As each level of analysis lead to a revised version of the matrices, more questions emerged. Questions emerged about the amount of support existing in teacher editions of mathematics textbooks to help teachers connect mathematics to reading strategies or to problem solving and concerning how the textbooks can support teachers in terms of helping students learn mathematics in a textual format.

Data collection consisted of going back through the previously collected data from Matrix C and looking for word problems to examine further. This final matrix used the same format as Matrix C, but the data collected were the word problems along with the qualitative notes from the data, rather than the teacher directions or placement. The word problems were selected based on the greatest number of occurrences classified as “before,” “during,” and “after” reading categories, as shown in Table 5.

Table 5

Reading Categories and Strategies with Greatest Number of Occurrences

Category	Strategy	Occurrences in qualitative notes column
Before Reading	Activate background knowledge	20
Before Reading	Find the purpose for reading	14
During Reading	Organize and integrate information by searching for main ideas, inferring, synthesizing	92
During Reading	Use appropriate decoding or word attack skills	47
After Reading	Summarize ideas	16

As each word problem was examined, the qualitative notes were used to confirm the need to include a reading strategy to assist students in connecting the text to the graphs, charts, and equations to be able to solve math problems. From this examination of data, themes emerged regarding the particular reading strategies, and their placement, that would be most useful for struggling students.

In this study, the analysis was guided by the data gathered from the examination of the textbooks which were connected to the principles of learning (Bransford et al., 1999). Krippendorff (2004) suggests that analysis connect coded text to the research questions. The data were gathered in numerical form only to quantify what appeared in the textbooks and to provide areas of deeper examination of the coding units. Determining which strategies occurred most frequently allowed for qualitative analysis of the coding units. Extrapolations from the coded data were examined for recursive trends, patterns, and differences. As Krippendorff (2004) explains, “An analytical construct operationalizes what the content analyst knows, suspects, or assumes about the context of the text and procedurally accounts for the drawing of inferences from that text” (p. 34).

Examining the words, numbers, graphs, and tables (along with their placement on the page) provided one look at the content. A reader of the textbooks would have to translate and understand the meaning of the words, numbers, graphs, and tables on each page. If the reader did not have assistance to read and connect what was on a page, then some teacher support for the struggling reader would be appropriate. The iterative nature of qualitative research provided many opportunities to examine the data repeatedly. The final coding examined word problems. By using the questions listed above, I was able to group the data into the broad reading categories and the related strategies.

Role of the Researcher

Judgments as to whether the text/data were indeed reading strategies were made by the researcher, who has a stronger background in reading and literacy than in mathematics. With this reading and literacy focus, consideration as to how a math teacher might teach a lesson was not a paramount concern. Mathematics teachers in middle and high schools are trained in the content of mathematics. They are not normally trained in literacy instruction. The focus became one of looking for ways that teachers might potentially help students understand and comprehend what is on the pages of the mathematics textbooks, knowing that the mathematics instruction should be the specialized expertise of the mathematics teachers.

Ethics

Because no human subjects were used in this research, the Washington State University Institutional Review Board did not have to approve this study.

CHAPTER FOUR

RESULTS

The purpose of this study was to conduct an in-depth analysis of mathematics textbooks. Specifically, the research study was designed to focus on analyzing teacher editions of mathematics textbooks to identify, categorize, and synthesize the reading strategies embedded in these textbooks. This chapter provides a description of the results, including results from the four phases of the study, as well as overarching themes that emerged from the data analysis.

Initial Findings: Four Phases Results

The data collection in each phase led to developing a new matrix for data collection and analysis. The development of each matrix was an iterative and a recursive process that led to more questions and further examination regarding what was on the page, where the information was placed, and what supports and strategies existed to assist teachers in giving help to students as they read mathematically. In Phase One textbooks were identified as either integrated or subject specific. The data were then collected by identifying the text, graphs, equations, directions, or numbers; categorizing the data into “before,” “during,” and “after” reading strategies; and then categorizing data by subject areas in mathematics: operations, numbers, geometry, algebra, data analysis, statistics, probability, or process. Phase Two continued with the same reading strategies as in Phase One, and added Bloom’s taxonomy for further categorization and analysis of the data. Qualitative notes were added to record inferences and possible placement of reading strategies in the textbooks. Phase Three continued with documentation and categorization of the same reading strategies with qualitative notes, and included also the analysis of the placement of teacher directions, graphs, charts, equations, numbers, and text. Phase Four focused on the same reading strategies from the previous phases, but also included identifying and coding word problems using qualitative notes and frequency of occurrences for each reading strategy.

The iterative nature of this research provided findings that might prove helpful for textbook publishers and teacher instruction, and ultimately could benefit students who are struggling with reading mathematically. These two research processes (i.e., data collection/analysis and generation of results and findings) became integrated and intermingled, as is often the case in qualitative research. I analyzed the text for what was present as well as what was not evident, simultaneously developing a schematic understanding of the mathematics textbooks. After each of the collection and analysis phases, either I designed a new way of coding the data, or I began to look for different data in the textbooks. The details related to the four phases of data collection and analyses were described previously and will be integrated into the discussion of the five thematic findings. Overall the data collection and analysis showed that few reading strategies existed in textbooks that could assist teachers in helping students read mathematically.

Five Thematic Findings

The six teacher editions did not provide evidence of reading strategies as originally defined in this study. Although there were a few instances of a direction to teachers to have students read beyond what the publishers directed teachers to ask students to read, there was no consistent evidence of directions to teachers to help students read the mathematics textbooks. The textbook publishers and most mathematics teachers might hope that students entering any math classes past the third grade would know how to read at their particular grade level.

However, as research shows, many students struggle when reading mathematical texts (Allington, 2006; Borasi et al., 1998; Cummins et al., 1988).

After compiling, analyzing and synthesizing the results from the four phases of the study, integrating both quantitative and qualitative data, five themes emerged:

1. The vocabulary that is important to understand in the mathematics content was not clarified in a way that would help teachers assist students with reading mathematically.
2. Text features existed in mathematics textbooks that could assist with reading, but the directions for teachers were not explicit.
3. Visual representations of text are text features that have potential to assist with reading mathematics.
4. Directions for teachers to help students with the process of reading mathematics were not described.
5. Directions for teachers to help students with scaffolding and organization were not explicit.

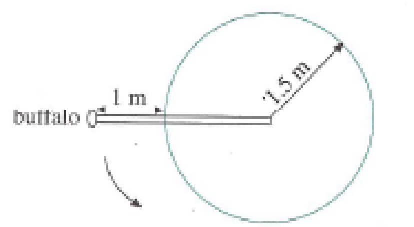
Important Vocabulary Was Not Clarified in a Way That Helps Teachers to Assist Students

Although reading mathematically requires students understand the definitions of the mathematical terms, these mathematical terms were not clarified in the texts examined, even though we know that uncommon or misunderstood vocabulary can pose a problem when students are reading mathematically (Barton & Heidema, 2002; Bossè & Falconer, 2008; Brennan & Dunlap, 1985; Weaver & Kintsch, 1992). One example of vocabulary possibly posing a problem for students was evident in Singapore's *New Elementary Mathematics* (NEM) for seventh-grade students. Figure 1 shows an example the problem from the text and highlights the need for understanding the vocabulary in order to solve the problem. Checking to see whether students understand the vocabulary may be one way for the teacher to find out whether students possess the background knowledge of what *locus* means prior to solving the word problem. In this example, there are other words that students may not understand, but mathematically, the word *locus* is important for students to comprehend in order to be successful with the mathematics of this problem. Checking to see if students understand the vocabulary is one strategy teachers can use to assess students' understanding of and background knowledge regarding what *locus* means. This could be a strategy that teachers use prior to having students solve the word problem. In this example, there was no guidance or vocabulary reading strategy provided for the teacher.

Figure 1. Visual representation of word problem

Word Problem

A buffalo is attached to a circular mill of radius 1.5 m by a wooden shaft. It turns the mill by walking around it at a distance of 1 m from the mill. What is the locus in which the buffalo walks? (*PM4D*, p. 2).



From Singapore *New Elementary Mathematics* (NEM) by Yoong, Copyright 2005, Pan Pacific Publication, p. 2.

As it is written, the problem assumes that students understand the vocabulary (which they would need to understand in order to demonstrate their knowledge of the mathematical concepts taught in this lesson). The visual representation includes the word *buffalo* with no other words connecting to the word problem. Depending on students' prior knowledge, they may or may not be able to understand the words in the problem, and therefore may not be able to solve the problem. Teacher editions of mathematics textbooks may be enhanced with additional reading strategies to employ with students to help them understand vocabulary and to assess students' background knowledge.

Another barrier to reading mathematics successfully arises if the student bases his or her understanding of the text on vocabulary or key words alone. If key words are used to read or decode mathematically, then the understanding of the problem or text may be misinterpreted. Key words may be highlighted through italics or bold type, but if the focus is only on the key word, the concept may not be understood or applied mathematically. Table 7 shows a textbox in *Everyday Mathematics* (EDM) focusing on developing the definition of parallel lines, line segments, and rays. The word *parallel* is italicized and connects the double letter *l* in the word to the concept. If *parallel* only is remembered, it is possible that the actual concept of parallel lines may be missed or misinterpreted. Another part of the same textbox shows students another way to represent a word sentence. In Table 6, students need to read mathematically, know the vocabulary, and be able to decode the specialized symbols.

Table 6

Definition of the Word - Parallel

To help students remember the definition of *parallel*, point out that the three *l*'s in the word parallel are, in fact, parallel. Some students may be interested in the mathematical symbols used to indicate parallel lines or line segments. For example instead of writing "Line segment AB is parallel to line segment CD," students can write $\overline{AB} \parallel \overline{CD}$
From *Everyday Mathematics*, Bell, Bretzland, Dillard, Hartfield, Isaacs, McBride, Pitvorec, & Saecker, Copyright 2007, Wright Group/McGraw Hill, p. 37.

There was no teacher assistance other than what was in the textbox directing students to read the written sentence as they would read the mathematical symbols. Interestingly, Table 7 was directed at English Language Learners (ELL) students; the textbox was labeled with the title, *Adjusting the Activity*. Again, there was no indication that the teacher information directed students to connect the symbol || with the word *parallel*.

As previously mentioned, research also showed that reading mathematically is difficult because of the specialized symbols, the vocabulary, and the abstractions (Brennan & Dunlap, 1985; Nasir & Hand, 2006). To interpret what is written on the page, whether it is a word, a symbol, or a number, a student needs to have clarity and direction from the teacher. In Table 7 the explanation shows how critical it was to decode the equal sign (=) correctly. The goals for this lesson were to understand the relationship between addition and subtraction and how to simplify computation, to use an algorithm for adding and subtracting, and to solve problems using addition and subtractions of integers. Table 7 was part of the *Explore* section, or introductory section, of the lesson, with directions for the teacher.

Table 7

Decoding Skills

Some students may think of the equal sign (=) as "it tells me to do something," not as "it says two things are equivalent"

From *Connected Mathematics 2: Accentuate the Negative*, Lappan, Fey, Fitzgerald, Friel, & Phillips, Copyright 2009, p. 45.

The statement in Table 7 informed the teacher that students might be confused by the equal sign symbol (=). Even though this example directs a teacher to explain to students to differentiate between "telling me to do something" and "it says two things are equivalent" by skipping this explanation may not assist students who have misconceptions about the equal sign. Teachers need to be aware of the confusion that this type of statement may cause so they can be assured that the meaning of the equal sign is clear to students.

Text Features Existed in Mathematics Textbooks, But Were Not Explicit for Teachers

The data collected and analyzed revealed how much textbooks were organized around text features. Text features provided a familiarity of patterns in texts and enhanced comprehension and learning. Understanding what text features represent and mean in any textbook increases comprehension and provides a tool for focusing on important information (Barton & Heidema, 2002). There was no clear teacher directions in the texts examined that called attention to the text features that would help students read the mathematics. The text features in the textbooks examined probably provided an organizational structure. Without directions to the teacher on how to emphasize the text features or how to teach students to use them, they are a wasted resource. Text features examined included such elements as icons, headings, captions, text boxes, illustrations, and information along the edges of the pages. The text features also provided organization in the layouts of the pages and the chapters in the textbooks. For example, in *Contemporary Mathematics in Context: Core Plus Course 2 Part A (CP)*, the pages were divided into the sections of modeling, organizing, reflecting and extending. This structure gave teachers a path for delivering the lesson. The organizational structure assisted with the mathematical content instruction, but none of the textbooks provided any reading strategy instruction within their organizational structure. Again, this seems like an opportunity lost in terms of strengthening students' comprehension of the texts and therefore the mathematical concepts.

Two text features stood out in the data. First, textual emphasis, such as formatting the text as bold, colored, or in text boxes, appeared in all textbooks. Second, text boxes of information, highlighted words, and notes in the margins of the teacher editions of the textbooks, as well as the overall organizational structure of the mathematics textbooks, were considered in the analysis of text features. Reading strategies or scaffolding for teachers that are included in the text features could be beneficial for struggling readers (National Reading Panel, 2000). However, these data were not evident in the teacher editions. The textbooks included the textboxes only to call attention to important concepts. Several text boxes offered suggestions and highlighted key points, but these were not directed toward how to read the mathematics on the page. The textbooks had various text features that reading strategy research indicates are useful to assist with reading. Again, no consistency or directions were found that called attention to the text features in any of the textbooks; therefore, the use of text features was vague and not as helpful as it could have been. In *Everyday Mathematics* (EDM), a recurring example of an organizational structure included the textboxes that referred to assisting English Language Learners (ELL), and directed the teacher, for example, “to support English language learners, clarify the meaning of *mall* in this context” (EDM, p. 86). This text feature did not specifically address reading strategies; nor did it suggest that the teacher use this feature as a support for struggling readers.

Every textbook in this study used some text features to draw attention to parts of the lessons, vocabulary, or a visual representation of a problem. Text features such as bold-faced or italicized words, phrases, or sentences, and adding color to words, highlighted vocabulary words, emphasized concepts or principles, or stressed solutions to problems. In Table 8, an example from *Everyday Mathematics* (EDM) shows the use of bold-faced words to emphasize vocabulary. The lesson reviewed points, line segments, lines, and rays, and the teacher was directed to the information in the table.

Table 8

Example of Problem with Bolded Words

Draw two dots on the board and label them A and B. Tell the students that the dots represent **points**. Remind the class that this figure is called a **line segment** and that letters are often used to name line segments.
From *Everyday Mathematics*, Bell, Bretzland, Dillard, Hartfield, Isaacs, McBride, Pitvorec, & Saecker, Copyright 2007, Wright Group/McGraw Hill, p. 25.

The bold-face technique indicates that the authors wanted to highlight the importance of the words; however, the bold-face did not emphasize the importance of the words as part of a reading strategy for students. The text feature of bold-face type directed the teacher to emphasize the vocabulary for the students, but that direction was not explicit in the teacher information.

In an example from the *New Elementary Mathematics 4A* (NEM), the lesson was on the fundamental principle of counting. Figure 2 showed how, in this example, the publisher used another text feature with bold text in a blue box.

Figure 2. Example of colored boxes as text features.

> If one task can be done in *p* different ways and following this, a second task can be done in *q* different ways and following this, a third task can be done in r different ways and so on, then all the tasks can be done in *p x q x* r…different ways.

From *New Elementary Mathematics 4A*, Yoong, Copyright 2005, p. 96.

Using the text feature of a colored box highlighted the importance of reading what was inside the box. It also included a focus on the important mathematical principles in this particular example. Again, the use of a text feature as a component of comprehension or to assist with reading was not made explicit; nor was the actual text feature expanded upon and used as a reading strategy.

The use of bold-faced type was also employed for subheadings, letters in an outline format, and notes or cautions to the teacher. In the example in Table 9, the caution might help teachers to assist students to interpret what was on the page and how equivalent expressions were written. The teacher's directions provided guidance about the distributive property. Although the text cautioned the teachers, it did not supply a reading strategy for the teacher to use with students, even though the clarification of the distributive property and the replacement of an equivalent expression was a part of the example. Even though this is an example of a text feature for the teacher, if passed over, students would not benefit from the teacher's delivery of this information.

Table 9

Example of a Caution Using Content

"**Caution**: Students may have some confusion about applying the Distributive Property. We do not apply the Distributive Property to both sides of the equation. It is used to replace an expression with an equivalent expression—thus making the resulting equation easier to solve."

From *Connected Mathematics 2: Accentuate the Negative*, Lappan, Fey, Fitzgerald, Friel, and Phillips, Copyright 2009, p. 82.

Text Features Included Visual Representations but Directions Were Not Explicit

Visual representations of the data in the teacher editions also included tables, graphs, or diagrams. The tables, graphs, and diagrams represented visually what was written in the text. Since there were few photographs in the teacher editions, they were not analyzed in this study.

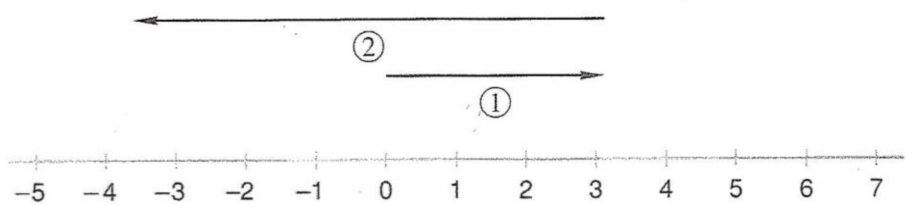
Graphs and diagrams accompanied word problems in five of the six teacher editions of the textbooks. The exception was the *Connected Mathematics* (CMP) series, in which graphs and diagrams for the lessons and word problems most often appeared on the student pages. Most of the CMP teacher edition consisted of text, but when the graphs or charts were included, they were presented as a part of the answers and teacher directions.

Research shows that students who create visual images make connections to the mathematics and their own learning (Reys et al., 2003). Teacher directions to assist students to use diagrams and visuals to plan, monitor, and execute the problem can help struggling students to read and understand mathematics (Barton, 2002), but these types of directions were not evident in the texts examined. In an example from *Saxon Mathematics* in Figure 3, the solution provided a strategy that indicated that drawing a diagram could help the students avoid mistakes.

Figure 3. Encouraging students to use visuals to solve problems.

example 35.5 Find the number that is $\frac{5}{11}$ of the way from $3\frac{1}{8}$ to $-3\frac{5}{8}$.

solution A diagram helps prevent errors.



We will add the directed length of arrow ① to $\frac{5}{11}$ of the directed length of arrow ②.

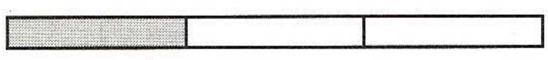
$$\begin{aligned}
\text{Number} &= 3\frac{1}{8} + \frac{5}{11}(\Delta C) && \text{equation} \\
&= 3\frac{1}{8} + \frac{5}{11}(C_F - C_I) && \text{substituted in } \Delta C = C_F - C_I \\
&= 3\frac{1}{8} + \frac{5}{11}\left(-3\frac{5}{8} - 3\frac{1}{8}\right) && \text{substituted} \\
&= 3\frac{1}{8} + \frac{5}{11}\left(-\frac{54}{8}\right) && \text{simplified} \\
&= \frac{275}{88} - \frac{270}{88} && \text{simplified} \\
&= \frac{5}{88} && \text{solved}
\end{aligned}$$

From *Saxon Mathematics*, Saxon, Copyright 2003, Saxon Publishers, p. 251.

A student may read about what is in Figure 3, “A diagram helps prevent errors,” and look at the solutions, but never read the statement about the diagram. Even though the text was on the page and the teacher might point out the diagram and provide the statement “A diagram helps prevent errors” (SAM, p. 251), this direction might not assist a student in using the diagram as a way to understand the problem or the solution.

The diagrams in *Primary Mathematics* (PM) accompanied explanations of the concepts to be learned and were most often on the same page as the numerical problems or word problems. Figure 4 shows an example from *Primary Mathematics* in which there is a visual of a bar that represents the whole and it is describes as representing something “such as a cake or a whole tray of brownies” (p. 54). The diagram in Figure 4 was followed by a reminder of the definition of a numerator and denominator. A numerical equation in Figure 4 was also presented, followed by another bar graph representing the equation. Finally, as part of the review, Figure 5 shows the visual representation of Figure 4, providing another graphic to assist in showing how to make fractions equal.

Figure 4. A bar divided into three sections with an equation.



$$\frac{1}{3}+\frac{2}{3}=\frac{3}{3}$$

From *Primary Mathematics*, Copyright 2004, SingaporeMath.com Inc., p. 54.

Figure 5. A review of equivalent fractions.

Teacher instructions	
Tell students that these two fractions are called equivalent fractions. Discuss how one can be derived from the other.	$\frac{1}{3} \overset{\times 2}{\underset{\times 2}{=}} \frac{2}{6}$ $\frac{2}{6} \overset{\div 2}{\underset{\div 2}{=}} \frac{1}{3}$

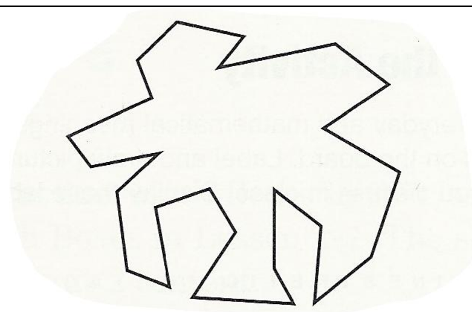
From *Primary Mathematics*, Copyright 2004, SingaporeMath.com Inc., p. 54.

Figure 4 shows a visual example connecting the bar graph to a cake or a tray of brownies, but no directions are given to connect the shaded area of the bar to the number in Figure 4. The teacher information in the text built upon the bar graph and then provided an example of a numerical equation. The last graphic was yet another way to show equivalent fractions. The graphs and visuals might assist teachers to assist students in understanding the concept, but there were no teacher directions connecting the visuals or calling attention to the textual features of the visual representations.

Figure 6 provides an example from *Everyday Mathematics* in which concepts that are abstract are represented as visuals. Figure 6 includes a nonconvex concave 25-gon. This example was from a small group lesson about polygons in which students reviewed the names of polygons. Simply reading about a nonconvex concave 25-gon might not allow some students to be able to visualize the concept. Figure 6 provides an image as a text feature to clarify understanding.

Figure 6. The text and a visual of a nonconvex 25-gon.

Teacher was then directed to ask, "Is it possible to make a polygon out of 25 straws?" yes "Out of 100 straws?" yes (EDM, p. 34).



A nonconvex (concave)25-gon

Polygons are sometimes called **n-gons**. For example, a 25-sided polygon can be called a 25-gon.

From *Everyday Mathematics*, Bell, Bretzland, Dillard, Hartfield, Isaacs, McBride, Pitvorec, & Saecker, Copyright 2007, Wright Group/McGraw Hill, p. 43.

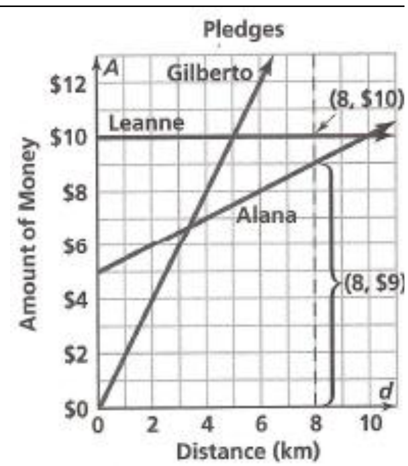
The visual representation could be confusing to students if they did not have the context or background knowledge to read the graphs and charts along with the text on the page. No teacher direction existed to guide students to connect the visual representation with the text.

A lesson from the *Connected Mathematics* (CMP) *Moving Straight Ahead* unit included three visual representations of the data and provided text that would be needed to solve the problem. These visuals could possibly assist the teacher in representing the data provided for the problem. The goal in the example in Figure 7 was to write equations from information provided in the graphs. The graphs (in Figure 7) appeared on two non-consecutive pages. The first graph in Figure 7 shows the walking rates with time and distance and student names. The walking graph in the center of Figure 7 shows the walking rates with the distance in meters and the time in seconds. The graph at the right in Figure 7 shows the number of pledges, amount of money, distances, and the plotted data. By providing a graphic representation of the text and numbers, the text translated for the students the numbers and words on the page into visual representations.

Figure 7. Three figures representing the data for problem solving.

Walking Rates

Time (seconds)	Distance (meters)		
	Alana	Gilberto	Leanne
0	0	0	0
1	1	2	2.5
2	2	4	5
3	3	6	7.5
4	4	8	10
5	5	10	12.5
6	6	12	15
7	7	14	17.5
8	8	16	20
9	9	18	22.5
10	10	20	25



From *Connected Mathematics 2: Moving Straight Ahead*, Lappan, Fey, Fitzgerald, Friel, & Phillips, Copyright 2009, pp. 24 and 26.

In the example in Figure 7, there was no direction to the teacher to assist students in reading and understanding the three visual representations in Figure 7. There were no strategies provided to help students read the tables and graphs accurately. Text features in all of the textbooks varied by problem and organization of the text. Research supports the notion that text features need to be connected and elaborated upon in textbooks to assist students with reading comprehension (Herman et al., 1987), but these connections and elaborations were not evident in the texts examined for this study.

Directions for Teachers to Help Students with the Process of Reading Mathematics Were Not Evident

The reading strategy research and Bransford's principles of learning research indicated that teaching reading strategies might result in an increase in comprehension across all content areas (Bransford, 2000; Duffy, Roehler, Sivan, Rackliffe, Book, Meloth, Vavrus, Wesselman, Putnam, Bassiri, 1987). There was little evidence of differentiation of instruction evident in the texts examined, and few examples of providing assistance in reading charts, number lines, graphs, illustrations, or the text on the pages. Teacher directions in almost all of the textbooks lacked connections or clear information that could guide student who struggle to read of mathematics. The data collected in this study showed that textbooks did not include a process for directing teachers to assist students to read mathematically. The qualitative data that I collected and analyzed indicated places in the textbooks where it would be advantageous to include tips for teaching reading strategies; however, such instruction was absent.

In the development, data collection, and analyses of Matrix A and Matrix B, reading strategies were not coded because the text did not match the established coding criteria. The result of abandoning the first two Matrices was that a qualitative notes column was created to identify possible placement of reading strategies and what might be inferred to be reading strategies in the textbooks. The qualitative notes helped to describe and clarify excerpts from the text as they might relate to reading strategies; the qualitative notes also included information on the placement of the charts, diagrams, equations, and text on the page. In my qualitative notes, I indicated designated places in the texts where reading directions or strategies could have been included. For example, text such as “see diagram” directed the teacher to look at the diagram. In my qualitative notes I wrote at this point that some teacher direction might also be included to instruct students to look at the diagram as a part of reading the problem. I also inferred from the same text that “see diagram” might be inserted when a publisher might be giving direction for teachers to assist students to read, or for a student to apply a reading strategy such as organizing the information from the diagram to apply to the rest of the problem. But these were my inferences only, as no direct instruction to the teacher (or student) was provided.

An example of teacher directions from *Connected Math 2* illustrates my results about lack of clarity (Table 10). The example directs the teacher to put the equation from the previous problem on the overhead and then ask, “What information do the variables and numbers represent in each equation?” (p. 53). Nothing in the text explained how to read or interpret the equation, and there were no teacher instructions to assist students. The next statement in the text was, “Once the class is comfortable with how to read these equations, tell the story of the cost plans offered by the two T-shirt companies” (p. 53).

Table 10

Equation Without Teacher Direction

$D_{Henri} = 45 + t$	and	$D_{Emile} = 2.5t$

From *Connected Mathematics 2: Moving Straight Ahead*, Lappan, Fey, Fitzgerald, Friel, and Phillips, Copyright 2009, p. 53.

Table 11 directed the teacher to connect the information and remind the students of the concepts and vocabulary in the lesson. Although the example in Table 11 asked students to remember specific vocabulary and concepts in Course 1, there was no other assistance offered the teacher in assessing the students' background knowledge and memory of the vocabulary and concepts. Words such as *symmetry, transformation, translation, reflection,* and *rotation* only referred students back to Course 1; no assistance was available in the text to help students remember or connect those terms to what they were learning. Again, no teacher direction or specific reading strategy instruction was included to help check the students' understanding of the vocabulary or concepts. In the following example the word *read* was included.

Table 11

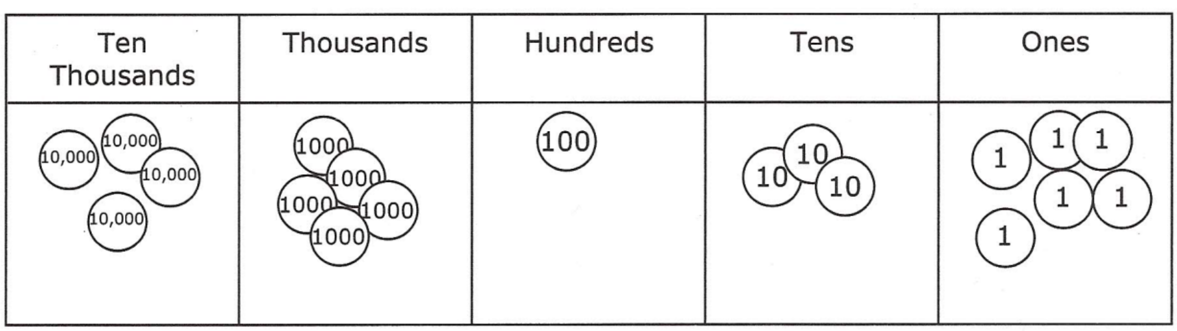
Introduction to Coordinate Models of Transformation

As an introduction to this lesson, let students know that they are going to use coordinate geometry to help them explore and learn more about transformations. Students need only prior familiarity with the concepts of coordinate representation and symmetry, and an understanding of what transformations to share. You may need to remind them of vocabulary learned in Course 1, such as translation, reflection, and rotation, and to ask them to give examples where possible.
From *Contemporary Mathematics in Context*, Coxford, Fey, Hirsch, Schoen, Burrill, Hart, Watkins, 2003, McGraw Hill, p. 110.

There are many mentions of the act of "reading," but there are no directions or reading strategies included to help the teacher guide students through a "reading" process in mathematics. During Phase Two of the data collection and using Matrix B, the word *read* was coded to determine whether it was a direction to read the text, a reading strategy, or a teacher direction that could help a student read what was on the page. These data were eliminated where *read* appeared as an instruction to read what was on the page rather than a reading strategy; or, if the word appeared in order to give direction for teacher to help students read what was on the page, I made mention of the word in my qualitative notes. Although the word *read* appeared in textbooks, it was used predominantly as a verb in order to direct students to read what was on a page.

Most often the teacher instructions that accompanied the word *read* were not accompanied by further explanation or elaboration regarding how a student could read the text on the page. In the example in Figure 8 from Singapore's *Primary Mathematics*, one can see how even the word *read* can be confusing or vague.

Figure 8. An example of the word read in Singapore Primary Mathematics.



Get students to "read" this number and write in numerals 45,136

From *Primary Mathematics*, Copyright 2004, SingaporeMath.com Inc., p. 6.

The reading strategies to use to "read" the number were assumed to be part of the students' repertoire. Although the word *read* gave some direction to teachers by merely instructing student to read, it did not provide a strategy for teachers to assist students in their mathematical understanding of what is on the page.

In the *Everyday Mathematics* (EDM) textbook, one lesson began with the teacher clarifying the use of labels by providing examples of words, numbers, and graphs. The text explained, “Most of the numbers fall into one of the five major categories” (EDM, p. 77). Table 12 shows the list of the different uses of numbers. The textbook instructed the teacher to direct the students to read the list of information about the five major categories of numbers. The focus was on the categories of numbers, and then the lesson continued with the importance of reading labels on a graph. No attention was called to the list of information or to the labels of the numbers on the list.

As this lesson continued, the teacher’s instruction noted that it is important to know how a number was used based on the label (EDM, p. 77). Figure 9 shows a bar graph with the average number of vacation days per year. Again, there was no direction or instruction about how to read the labels, nor was there information about the different labels on the graph and how they might be read differently from the list of numbers in Table 12.

Table 12

A List of Five Major Uses of Numbers

♦	counts (5 people; 10,200,000 cars
♦	measures (2.6 kilograms; 35 mph; $7\frac{3}{8}$ inches
♦	locations in reference frames (36º F; A.D. 1266; 5:41 P.M.)
♦	ratios, percents and scale numbers (95%; $\frac{2}{3}$ as many)
♦	identification numbers and codes (1-312-555-9816; ZIP code 08648

From *Everyday Mathematics*, Bell, Bretzland, Dillard, Hartfield, Isaacs, McBride, Pitvorec, and Saecker, Copyright 2007, Wright Group/McGraw Hill, p. 77.

Figure 9. An example of reading the labels on the graph.

From *Everyday Mathematics*, Bell, Bretzland, Dillard, Hartfield, Isaacs, McBride, Pitvorec, & Saecker, Copyright 2007, Wright Group, McGraw Hill, p. 77.

Although the teacher instructions directed the students' attention to the importance of the labels on the graphs, nothing was said regarding *how* to read the graph. The graph, however, could not be read from left to right, as Table 12 was read, but instead needed to be approached with a different reading strategy if it was to be understood. The list in Table 12 was read from left to right, whereas the graph in Figure 9 was read by reading the title, the labels, and numbers for information. No direction regarding how to read the table or what was important was evident in the text to support teachers who were assisting students to read mathematically.

Directions for Teachers to Help With Scaffolding and Organization Were Not Described

The research for reading mathematically supports scaffolding as a generally effective approach to teaching. Unfortunately, explicit reading instruction and scaffolding or organizational structures embedded into the mathematics instruction were missing from the teacher editions of the texts examined in this study. Most of the word problems directed the teacher to ask students to do several things at one time before solving the problems. There were no instances in which reading strategies were incorporated to guide the teacher.

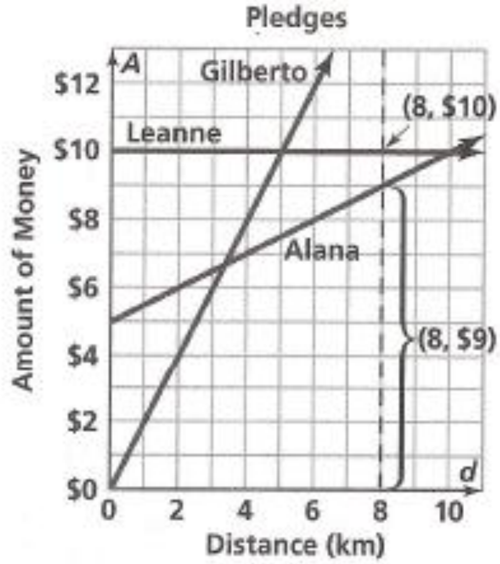
The problem in Table 13 was one portion of a larger unit on graphs and tables in *Connected Mathematics 2* (CMP). The prior lesson started with identifying walking rates in distance and time for each of the participants. Then the teacher directed students to add information about collecting pledges for the distances that each participant walked. Students needed to remember what they read in the prior part of the problem and add the information about pledges. They needed to determine what facts and numbers were important in this problem, and then organize the information from the graphs, text, and numbers to solve the problem. The questions and answers for the teacher in Table 14 and the graph, Figure 10, shows the amount of pledges and the distance the participants walked.

Table 13

Word Problem

Pick some points on the graph and tables
What information does this point represent? Which graph does (4,8) lie on? Explain. (Gilberto's graph – when Gilberto walks 4 km, a sponsor owes $8) How is this point related to a corresponding table and equation for this graph? What are the coordinates of the point where each graph intersects the y axis? What information does this point represent? (Leann's intersects at (0, 10), Gilberto's at (0,0) and Alana's at (0, 5). These points represent how much each student collects when they begin or when they have walked 0 kilometers. Graph below. (CMP, p. 26).

Figure 10. Amount of pledges and the distance walked.



From *Connected Mathematics 2: Moving Straight Ahead*, Lappan, Fey, Fitzgerald, Friel, & Phillips, Copyright 2009, p. 26.

Students needed to remember the details of the previous problem and refer back to the table and graph in the previous lesson in order to answer the questions in Table 13. Next, students needed to identify the coordinates on the graph, and then determine what point was represented on the graph. Finally, students needed to look at the graph again to determine the amount of money collected.

In this example, it might not be clear to the teacher that students might need some assistance to identify the critical parts of the problem in order to find a solution. To reach the solution, students read the text, interpreted the graph, remembered the information from the previous problem, and answered the questions so that a solution was determined. To identify what was important, students read the problem first and then examined the accompanying graph. They then needed to read the labels and the corresponding numbers on the graph. There were two different variables/types of numbers on the graph: the kilometers representing the distance walked, and the monetary amounts of the pledges. In this lesson, nothing indicated what was important and what was not, or how a student could determine that information. There was no teacher instruction to assist students to organize the information. The directions for the teacher were to ask a series of question, but specific strategies to help determine what was important were not included in the text. This problem had several parts, which may have represented an attempt to integrate the information, but no specific language was built into the lesson to guide the students regarding the information that needed to be integrated.

Another example (see Table 14) of asking students to read and the use a process without teacher direction appeared in the margin in *Contemporary Mathematics in Context* (CP). The direction suggested that students summarize the process of representing a system of linear equations as a matrix equation, solve the equations, and check the solution, which was then to be recorded in their math tool kits (their math journals).

Table 14

Read and Process Information Without Teacher Direction

CONSTRUCTION A MATH TOOLKIT: Students should summarize the process of representing a system of linear equations as a matrix equation, solving the equation, and checking the solution. Summaries can be recorded under either the discrete mathematics or algebra and functions strand in their Math Toolkits. An example could be included

From *Contemporary Mathematics in Context*, Coxford, Fey, Hirsch, Schoen, Burrill, Hart, Watkins, 2003, McGraw Hill, p. 62

Nothing in the textbook directed the teacher regarding what a summary might look like or how to assist students to read and then summarize the concept of representing the linear equations as a matrix equation.

Summary

The results of this study support research findings related to student difficulty in "reading mathematics" in that very few reading strategies were found to be embedded in the teacher editions of mathematics textbooks examined. Students may be struggling to read and understand mathematics because, if as little reading instruction is in all mathematics textbooks as was found in these texts, then there is little support for, almost no scaffolding of, and few teacher directions for improving content area reading and comprehension. The complex language of mathematics, which includes vocabulary, text features, and visual representations of the text, was not enhanced by content area reading strategies, either placed on the page for the students to access, or within the directions to teachers.

CHAPTER FIVE

DISCUSSION AND CONCLUSIONS

Reading in mathematics is a process that asks the reader to make sense of everything on the page—in other words, any resource that students might use to learn and apply mathematics

(Barton & Heidema, 2002, p. iii).

The purpose of this study was to conduct an in-depth analysis of mathematics textbooks. Specifically, the research study was designed to focus on analyzing teacher editions of mathematics textbooks with a focus on identifying, categorizing, and synthesizing the reading strategies embedded in these textbooks. Content analysis was used as the methodological tool to examine these research questions: What reading strategies, if any, are embedded in mathematics textbooks? How are reading strategies described in mathematics textbooks? Where do reading strategies appear in mathematics textbooks? Are the reading strategies embedded, if any, placed and described in such a way as to enhance the teacher's instruction? The major finding was that the teacher editions of the mathematics textbooks examined in this study did not include reading strategies to assist the students' comprehension of the concepts. The vague language, the absence of teacher direction, and the lack of scaffolding all contributed to the lack of support for students. As a result of the study findings, several recommendations are offered.

Include Reading Strategies as a Part of the Mathematical Reading

The language of mathematics in the textbooks is precise when it comes to addressing the mathematics of the text, but the language noted in the textbooks examined lacked specificity and clarity in terms of teaching students to read mathematically. The preciseness of the language for mathematics points to how very important that language is, yet not a single reading strategy was present with sufficient detail as to provide assistance either to the teacher or student. The research supports the use of reading strategies in mathematics if the strategies are content-specific (Shanahan & Shanahan, 2008). These content-specific strategies were not found in the textbooks. Additionally, it was apparent to this researcher that there were many places in the texts in which including reading strategies using mathematical language would have been very useful.

For example, the results showed that most of the reading strategy entries that were categorized under the "during" reading category when aligned with Bloom's taxonomy (from the four phases of data collection and analysis) fell within Bloom's categories of "understand" and "apply." The textbook publishers could focus on expanding reading strategies in the areas where teachers direct students to read. I grouped the reading strategies into the categories of "before," "during," and "after" because the reading strategies research and the matrices developed during the study were most suited to these categories. If reading strategies were added to key parts of mathematics textbooks, it might be helpful to include students' current status in terms of the understanding or application stages of learning.

Research points to many effective reading strategies and content area reading approaches. Table 15 includes three reading categories with accompanying research-based and reading strategies that could be integrated into mathematics textbooks to support reading in mathematics.

Table 15

Reading Categories and Research-Based Reading Strategies

Reading category	Reading Strategy
Before	Activate background knowledge
	Setting a purpose
	Choosing an appropriate reading strategy
During	Determine importance
	Organize and integrate
	Use appropriate decoding/word attack
After	Summarize

The reading strategies that could be used in mathematics textbooks have been divided into the "before," "during," and "after" reading strategies for this discussion. The descriptions suggest how each strategy can be used as a part of the mathematics reading.

"Before" Reading Strategies

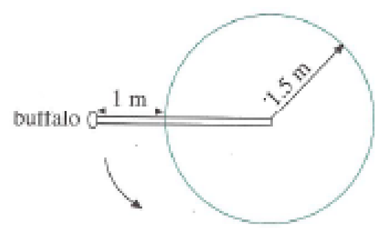
"Before" reading strategies set the stage for readers. Included in "before" reading strategies are such approaches as giving readers a purpose for reading, discussing new vocabulary, or activating background knowledge. "Before" reading strategies assist learners to connect their knowledge and experiences to the reading. Activating background knowledge, setting a purpose for reading, and choosing an appropriate reading strategy are specific strategies to prepare students to read what is on the page. To integrate these reading strategies into a math textbook, questions for the teacher could be included, such as, "What does the label tell us about the chart?" , "What information might be important as you look at the chart?", or "What does this symbol mean to you?" These questions prepare students to look for something that would be helpful in understanding the word problems that come next in the reading.

When activating background knowledge, the purpose may be to see what students already know and understand about what they are about to read. For example, the problem in Figure 11 about the water buffalo attached to a circular mill might pose a problem for some students. To activate the background knowledge a teacher might ask, "What is a water buffalo?" or "What do you think of when I say the word *mill*?"

Figure 11. Activating background knowledge with a word problem.

Word Problem

A buffalo is attached to a circular mill of radius 1.5 m by a wooden shaft. It turns the mill by walking around it at a distance of 1 m from the mill. What is the locus in which the buffalo walks? (*PM4D*, p. 2).



From Singapore *New Elementary Mathematics* (NEM) by Yoong, Copyright 2005, Pan Pacific Publication, p. 2.

In this way the teacher will come to know what information students need to know before being able to solve the rest of the problem. In this example, the vocabulary might have been a barrier hindering students from continuing to read and show their mathematical ability. But with a vocabulary discussion, students might be able to focus on the mathematical problem, as opposed to wondering what a "mill" is. To know what the students understand about the words, radius and locus, will assist the teacher in knowing where the students are in their knowledge of the mathematics in this problem. To activate background knowledge of students provides information for teachers as to where students are in their learning and may create different entry points for instruction.

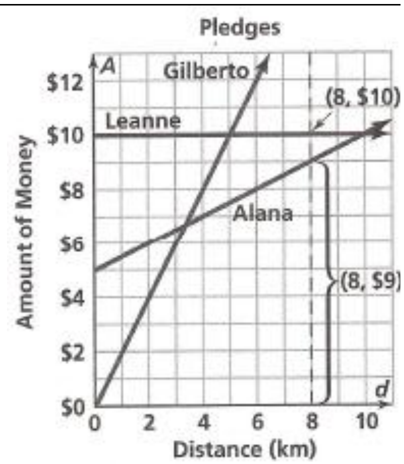
Another “before” reading strategy, setting a purpose, allows the teacher to direct students to read the words on the page and connect the equations, numbers, graphs, or diagrams with intentionality. By giving a purpose to the lesson and the reading that students need to do, the important parts of the lesson or the page could be highlighted for the student. In terms of mathematical reading, Barton and Heidema (2002) state that the purpose of the problem is often not evident until the end of the problem (p. 30), so setting the purpose alerts students to important information and provides more background knowledge for students.

Figure 12 provides three visual representations of data needed to solve problems in the *Connected Mathematics* (CMP) *Moving Straight Ahead* lesson. The goal of this lesson was to write equations from the information provided in the graphs.

Figure 12. Setting a purpose for reading.

Walking Rates

Time (seconds)	Distance (meters)		
	Alana	Gilberto	Leanne
0	0	0	0
1	1	2	2.5
2	2	4	5
3	3	6	7.5
4	4	8	10
5	5	10	12.5
6	6	12	15
7	7	14	17.5
8	8	16	20
9	9	18	22.5
10	10	20	25

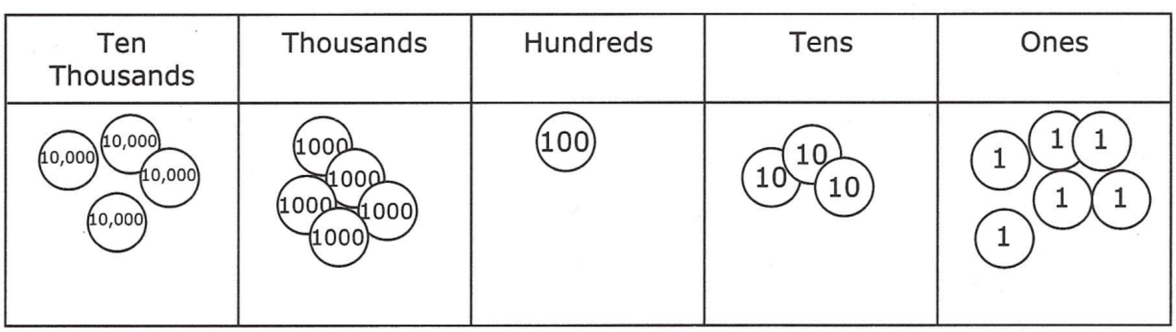


From *Connected Mathematics 2: Moving Straight Ahead*, Lappan, Fey, Fitzgerald, Friel, & Phillips, Copyright 2009, pp. 24 and 26.

To set an overall purpose for students to read these graphs gives students a direction to know what is expected. Statements such as “This set of problems will be asking you to write equations from the information you see on these graphs”, or “Here are three graphs that have different information on them, you might use all of the graphs or one of the graphs to write equations”. By setting the purpose and guiding students to what is expected from the lesson will assist struggling students with reading mathematically.

Choosing an appropriate reading strategy is another reading strategy that can be used in the “before” and “during” reading categories. In Figure 12 and Figure 13 different reading strategies could be used to read and interpret the graphs and figures. In mathematics, the charts and graphs are read differently from a number line. It is crucial for teachers to point out the differences in methods of reading the different kinds of text in mathematics textbooks. To understand the different uses of numbers, charts, graphs, equations, or anything considered to be text, students must be able to select the best strategy to read so that they can understand what the chart of the number lines mean.

Figure 13. Choose an appropriate reading strategy to read this figure.



Get students to “read” this number and write in numerals 45,136

From *Primary Mathematics*, Copyright 2004, SingaporeMath.com Inc., p. 6.

Teachers could point out on Figure 12 that the first chart is a table with information and the students could gather data by reading across the rows or by reading each column. The chart in the middle and the chart on the right of Figure 12 are read by looking at the labels and reading the points on the graphs. Figure 13 asks students to read the number and write it in numerals. Again to read Figure 13 teachers could point out that the students should begin by reading from left to right or right to left, which is a different way to read the data than Figure 12. Also teachers could point out to struggling students that the numbers in the circles and the headings above the circles are important pieces to read. Teachers can point out that may students read visuals, charts, and graphs in mathematics differently than when they are reading novels or other textbooks.

The three "before" reading strategies—accessing prior knowledge, setting a purpose for reading, and choosing an appropriate reading strategy—set students up to access what they know and inform teachers regarding what other instruction needs to occur to supplement the students' knowledge before the mathematics can be comprehended. Setting the purpose gives students a focus for the lesson, while choosing an appropriate reading strategy allowed students to read and understand the complex mathematical language.

"During" Reading Strategies

Where "before" reading strategies set the stage for reading, the "during" reading strategies assisted students in comprehending and understanding what is being read. The strategies give the reader tools to use in questioning the text, finding a way to organize the information, determining what is important and what is not, or decoding what is on the page. My qualitative data that was focused on noting what reading strategies could have been integrated into the texts consisted primarily of "during" read category strategies.

It is not surprising that the largest number of suggested reading strategies fell into this category. The students need to have some clear direction to help sort and organize the information on the pages because of the complexity of reading mathematically and the problem solving that is asked of them. The three reading strategies I noted that might work best in the "during" reading are: determining importance, organizing and integrating, and using appropriate decoding/word attack skills.

Determining importance helps students prioritize the information while organizing and integrating provide a framework for what is on the page. By using appropriate decoding/word attack skills interpretation of the symbols, words, equations, and numbers, students are able to choose a way to read about and differentiate among different tables, graphs, and words, and to understand the mathematical meanings.

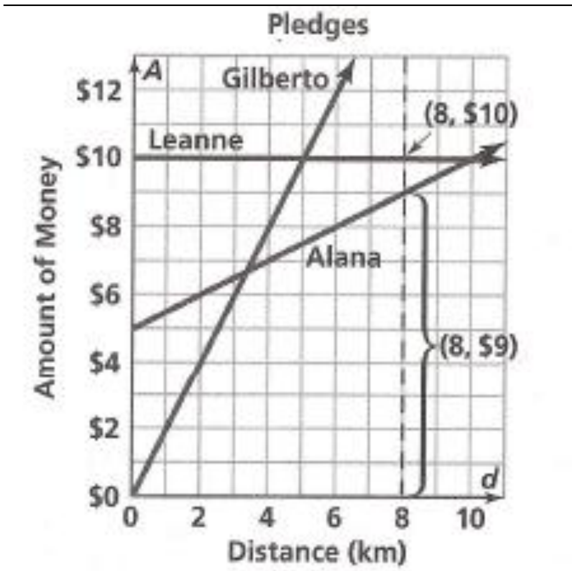
Table 16 and Figure 14 show a word problem where the teacher is asking students for many answers within a single problem. The teacher answers to the problems are in parentheses and I've emphasized them by italicizing the answers. The teacher asks students to first pick out some points on the graphs and tables and then what information does this point represent. As the teacher continues with the questions, students are having to thinks about several parts of the problem without knowing what part of the problem is most important. To assist students who might have difficulty juggling many parts of the problem, the teacher could say "In this problem the most important part of the problem is to understand what information the points represent?" Then the teacher could explain that the rest of the information in the problem shows how far someone walked or how much money the student collected.

Table 16

Determine Importance in a Word Problem

Pick some points on the graph and tables
What information does this point represent? Which graph does (4,8) lie on? Explain. *(Gilberto's graph – when Gilberto walks 4 km, a sponsor owes $8)* How is this point related to a corresponding table and equation for this graph? What are the coordinates of the point where each graph intersects the y axis? What information does this point represent? *(Leann's intersects at (0, 10), Gilberto's at (0,0) and Alana's at (0, 5).* These points represent how much each student collects when they begin or when they have walked 0 kilometers. Graph below. (CMP, p. 26).

Figure 14. Connecting the graph to the text of the word problem.



From *Connected Mathematics 2: Moving Straight Ahead*, Lappan, Fey, Fitzgerald, Friel, & Phillips, Copyright 2009, p. 26.

Figure 14 is a part of the problem in Table 16; teachers could also guide the student to know that the text of the problem connects to Figure 14 and point out that this is a visual representation of some of the text. This way a student who might not associate the graph to the text could see that the chart is an important component to the word problem. To assist students by breaking down the problems and help with finding what is most important in the different parts of the word problems will also scaffold the problem for reading mathematically.

Another "during" reading strategy is to organize and integrate. Teachers can assist students to organize the information and integrate the different parts of their learning or of the problem. Table 17 and Figure 15 are from the same lesson. The goal of the lesson is to understand the labels on numbers. The teacher is to show the list of numbers on Table 18 and to connect Figure 15 to the idea of labels.

Table 17

Organize and Integrate Information about Labels

♦	counts (5 people; 10,200,000 cars
♦	measures (2.6 kilograms; 35 mph; $7\frac{3}{8}$ inches
♦	locations in reference frames (36º F; A.D. 1266; 5:41 P.M.)
♦	ratios, percents and scale numbers (95%; $\frac{2}{3}$ as many)
♦	identification numbers and codes (1-312-555-9816; ZIP code 08648

From *Everyday Mathematics*, Bell, Bretzland, Dillard, Hartfield, Isaacs, McBride, Pitvorec, and Saecker, Copyright 2007, Wright Group/McGraw Hill, p. 77.

Figure 15. Organize and integrate this chart with the table above.

From *Everyday Mathematics*, Bell, Bretzland, Dillard, Hartfield, Isaacs, McBride, Pitvorec, & Saecker, Copyright 2007, Wright Group, McGraw Hill, p. 77.

As teachers asked students to look at this list, to help organize this information teachers could use a “before” reading strategy to set the purpose of this activity and then help students organize the information into a list similar to Table 17. Then when the teacher shows the students the graph about the average number of vacation days, then to help integrate the idea of labels, the teacher could ask “What labels do you see on this graph?” By asking this question, students are focused on the labels and not the data that is presented on the graph.

Decoding/Word Attack are important strategies for students to read mathematically. Every word and symbol is important in mathematics. Teachers can help students by providing strategies to interpret symbols or text features, such as bolded words on the pages of the mathematics texts. Table 18 is a tip for teachers to help students remember the definition of parallel. By showing students the three l’s in the word and to connect the definition to the use of symbols is important in understanding the mathematical language. To help students during reading by offering information such as this helps to connect their reading to the mathematics.

Table 18

Decoding/Word Attack

To help students remember the definition of *parallel,* point out that the three *l*'s in the word parallel are, in fact, parallel. Some students may be interested in the mathematical symbols used to indicate parallel lines or line segments. For example instead of writing "Line segment AB is parallel to line segment CD," students can write $\overline{AB} \parallel \overline{CD}$

From *Everyday Mathematics*, Bell, Bretzland, Dillard, Hartfield, Isaacs, McBride, Pitvorec, & Saecker, Copyright 2007, Wright Group/McGraw Hill, p. 37.

"After" Reading Strategies

"After" reading strategies give students and teachers opportunities to assess understanding. These strategies help to connect prior knowledge with the new knowledge and assist in the application of knowledge to new situations or problems. My qualitative data included very few mentions of the "after" reading category of reading strategies. One of the prominent "after" reading strategies I noted could be integrated into the textbooks was that of "summarizing." What summarizing has been shown in reading research to do is to assist students in understanding the concepts being taught. In one of the texts I examined, the *Connected Mathematics* (CMP) series, summarizing was a part of each lesson.

Research also supports summarization as a strategy that can be used to assess students' understanding of the ideas and concepts. It can also be used to help students identify the most important parts of the text that they are reading (Brown, 2006). Summary as an "after" reading strategy requires students to demonstrate what they understand and again provide teachers with instructional information regarding where to go next with students.

Reading strategies specific to mathematics and in mathematical language could be created so that teachers of mathematics would not see the reading strategies as “add-ons” to what is already being taught. Research supports this notion but my study findings revealed that even in the integrated textbooks, these reading research results have not been implemented in ways that help mathematics teachers or benefit students. If these “before,” “during,” and “after” reading strategies are integrated throughout mathematics textbooks, they would not only provide skills, students could use while reading mathematically, but they could also be reinforced in the actual mathematics instruction for a more powerful effect.

Include Teacher Directions to Guide Students to Read Mathematically

It would be impossible for all textbook publishers to use precisely the same language when describing reading strategies; however, clear descriptions to teachers would be helpful. Most secondary teachers do not see themselves as reading teachers, but most want their students to be successful in mathematics. To provide guidance to these non-reading teachers (e.g., math teachers, science teachers, etc.), clear directions and well described reading strategies would be a valuable took to integrate into content area textbooks.

Table 19 shows an equation without teacher directions to help students read this equation. This is part of the introduction of the lesson on connecting linear equations and patterns in the tables and graphs. The teacher directions suggest to put this equation on the overhead. Hopefully by when this type of equation is shown, students may be able to read it mathematically. Teachers could assist students by asking “How many of you are familiar with reading this equation?” “How would you read it?” Or the teacher could point to the parts of the equation and ask what does this represent.

Table 19

Equation Without Teacher Directions to Read Mathematically

$D_{Henri} = 45 + t$	and	$D_{Emile} = 2.5t$

From *Connected Mathematics 2: Moving Straight Ahead*, Lappan, Fey, Fitzgerald, Friel, and Phillips, Copyright 2009, p. 53.

Table 20 is a textbox on a page. The explanation in the textbox gives teachers information about how students might misinterpret the equal sign. There is no direction for teachers to explain or instruct what is in the textboxes. If these were skipped, then teachers may not know what students know or don't know about the equal sign. By directing teachers explicitly to address what is in the textbox may help teachers uncover misconceptions or what students know or don't know about the equal sign.

Table 20

Lack of Instruction for Teachers to Address Information in Textboxes

Some students may think of the equal sign (=) as "it tells me to do something," not as "it says two things are equivalent"

From *Connected Mathematics 2: Accentuate the Negative*, Lappan, Fey, Fitzgerald, Friel, & Phillips, Copyright 2009, p. 45.

In Chapter 4, this example described textboxes that referred to assisting English Language Learners (ELL) by stating "to support English language learners, clarify the meaning of *mall* in this context" (EDM, p. 86). For teachers to assist with reading mathematically, the content of the textboxes can be pointed out to any student who may be struggling with reading mathematically. By calling attention to the vocabulary in the textboxes, students may find ways to connect the vocabulary of mathematics to their lives. No teacher directions pointed out that these textboxes could be used for other struggling students or how to use the textboxes as a teaching tool for the students.

Good readers look at bold or italicized words and know that there is significance to them in the context of their reading. In Table 21, the word, caution, is in bold. The information in the textbox explains that students might have some confusion about the Distributive Property. No directions in the textbooks that were are part of the mathematics lessons focused on bold words or other text features. A textbook publisher might include teacher directions stating that textboxes with the word, caution, provide information that may be confusing to students, and also include that by leaving out this information may disadvantage some students in their ability to read mathematically.

Table 21

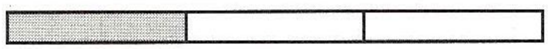
Use of Bold Word Without Teacher Direction

"**Caution**: Students may have some confusion about applying the Distributive Property. We do not apply the Distributive Property to both sides of the equation. It is used to replace an expression with an equivalent expression—thus making the resulting equation easier to solve."

From *Connected Mathematics 2: Accentuate the Negative*, Lappan, Fey, Fitzgerald, Friel, and Phillips, Copyright 2009, p. 82.

Figures 16 and 17 appear on the same pages of the teacher text. No directions were given to guide the teacher to connect the two figures. To clarify for teachers, the directions could state that examples could help students understand the concept of equivalent fractions, but to help students understand that these figures are connected, deliberately connect the equation and the examples to the mathematics and explain the connections even though the operations of the equivalent fractions are different.

Figure 16. Lack of teacher directions to connect the two figures – part one.



$$\frac{1}{3}+\frac{2}{3}=\frac{3}{3}$$

From *Primary Mathematics*, Copyright 2004, SingaporeMath.com Inc., p. 54.

Figure 17. A review of equivalent fractions. A lack of teacher directions to connect the two figures - part two.

Teacher instructions	
Tell students that these two fractions are called equivalent fractions. Discuss how one can be derived from the other.	$\overset{\times 2}{\underset{\times 2}{\frac{1}{3} = \frac{2}{6}}}$ $\overset{\div 2}{\underset{\div 2}{\frac{2}{6} = \frac{1}{3}}}$

From *Primary Mathematics,* Copyright 2004, SingaporeMath.com Inc., p. 54.

Teachers and textbook publishers need to call attention to different ways to interpret what is on the pages of the textbooks. Stating only what is written for the teacher may not be enough for students, who need to decode the mathematical language and symbols in order to be successful mathematically. Without clear teacher direction or focus on how to read mathematically, students may still be unsuccessful when asked to solve word problems.

Providing instruction using text features and visual representations helps students connect concepts and improve comprehension. These features could assist students by providing alternatives to text. More reading strategies explained to the teacher and provided for the student could take the form of directions for reading a diagram or representing the diagram in numerical form. In directing the student only to read, an opportunity is missed to assist the student in interpreting information and building understanding of mathematical reading.

If teacher directions were specific to a mathematical reading strategy instruction, students might understand that not all mathematical reading was done in the same way.

Without some direction to read the list of categories or to read the graph differently, some students may miss the mathematics part of the lesson. For students to be able to read the table and graphs accurately, they needed to have access, via the teacher, to effective reading strategies on how to read the labels, organize information, read each table or graph to interpret the information, and then come to a solution to the initial question ("How does the constant walking rate show up in the table, graph and equation?") (Lappan et al., p. 23).

Use the Principles of Learning, Reading Strategies, and a Problem Solving Method to Scaffold Reading in Mathematics

Integrating reading strategies into mathematics textbooks and providing teacher support and direction for instruction would help with mathematical reading, but combining a problem solving method and connecting the principles of learning may provide a higher level of support for students. Table 16 shows the connections between Mayer's problem solving method, Bransford's principles of learning, and reading strategies.

Table 22

Combining Reading Strategies, Principles of Learning, and Mayer's Word Problem Solving Method

Mayer's problem solving method	Principles of Learning	Reading Strategies
Translate	Principle 1	Using "Before"
	Activate background knowledge	Accessing background knowledge
	Uncover, explore, and	Identifying purpose for reading
	understand pre-existing	Determining importance
	understanding that students	Asking questions
	bring to the classroom	Using word attack skills (decoding)
Integrate	Principle 1 & 2	Using "Before" and "During"
		Accessing background knowledge
		Determining importance
		Asking questions
Plan and Monitor	Principle 1 & 2	Using "Before" and "During"
		Accessing background knowledge
		Determining importance
		Asking questions
		Inferring
		Synthesizing
Executing	Principle 2	Using "Before" and "During"
	Develop deep foundation of	Accessing background knowledge

Mayer's problem solving method	Principles of Learning	Reading Strategies
	factual knowledge	Determining importance
	Understand fact and ideas in context	Asking questions Inferring
	Organize knowledge	Synthesizing
	Apply knowledge	
	Principle 3	Using "After"
	Develop a metacognitive approach	Inferring Synthesizing
	Monitor learning	Summarizing

If the reading strategies examined in this study were tailored to mathematics, then it is possible that students would benefit by being able to read mathematically. Reading strategies from teachers would then be a part of the mathematics instruction—a component of a systematic approach to teaching mathematics. Another connection to students' success in learning is to have an organizational scaffold such as a problem solving method (i.e., Mayer's four-step method). A scaffold connects the problem solving to Bransford's principle two.

To apply the three components on the table, using Mayer's Translate step of his problem solving method teachers might consider using Bransford's first principle of activating background knowledge throughout their instruction. Then they could use a before reading strategy to find out what students already knew about the lesson or the problem. Then the teacher could ask students to focus on what the problem is asking them to do or what factual knowledge they need to have in order to solve the problem. Continuing with Mayer's problems solving method, the second step, Integrate, directs teachers to ask students to determine what information is important or not, and organize the information. This step connects to the "during" reading strategies of organize and integrate. In this step, Bransford's first and second principle overlap. The teacher is still activating the background knowledge of students and working with deepening their understanding of the content, which is principle two.

Mayer's four-step problem solving model (2004) addresses the first two steps of problem translating and problem integrating. Steps three and four, planning and monitoring and executing, describe the actual problem solving. Even though Mayer uses the word *monitoring*, he describes this as "monitoring the plan" (p. 87), which is done just prior to the computation of the word problem. If the principles of learning are used as a framework for student learning, the third principle, *metacognition*, is not a part of Mayer's model.

According to Bransford (1999), "Metacognition is important because it gives students a way to take control of their learning" (p. 68). Students can then monitor their progress or lack of progress while they are learning. By reflecting on their own learning, students may be able to take what they learn, apply it to other situations, and continue to build their knowledge not only in mathematics, but also in other content areas. Without a separate step of metacognition, teachers and students may not reflect on the mathematics reading or the mathematical process. The importance of including metacognition allows a student to think deeply about a process or text, an internal dialogue needs to occur so that connections are made and students can begin to learn independently (Bransford, 1999). Bransford and his colleagues (1999) also suggest that including metacognition in any discipline-based learning can enhance students' achievement, but it must be explicitly emphasized. Connecting the reading strategies, the principles of learning, and Mayer’s problem solving method and adding the metacognitive component to the problem solving method could increase students’ success.

I would also recommend three areas where further research. First, examine classrooms where teachers use mathematical reading strategies or are using the principles of learning and a problem solving method. Studies such as the one Shanahan and Shanahan described (2008) could be duplicated in a mathematics setting with direct instruction and support for the teacher in the classroom. Next, examine the effectiveness of reading strategies, if they are embedded into the textbooks and see if teachers use the strategies, look for better mathematical understanding if the strategies are used, and to look at math achievement. Finally, study the effectiveness of explicit directions to teachers regarding reading strategies embedded in math textbooks. How are the strategies implemented and are they effective?

Limitations

The limitations of this study include the sample size. Not all teacher editions of mathematics textbooks were examined. The results of this study may not extend to other teacher editions of mathematics textbooks. Additionally, in those textbooks that were examined, not all of the chapters were examined for reading strategies (but rather a sample of chapters). Because not all chapters were examined, some reading strategies may have been missed. Finally, because I examined these textbooks with a literacy/reading lens, I may not have detected strategies that mathematics teachers may feel are “reading strategies” from their perspective.

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