CHAPTER 1

WHAT IS MATH–LITERACY INTEGRATION?

On the way to the gym, the class is not quiet in the hallway. They have just come from a math lesson, and are still talking about equivalent fractions. " . . . twelve-eighteenths; fourteen twenty-oneths [sic]; sixteen twenty-fourths. Do you get the pattern? Do you get it now? The numerators go up by twos. The denominators go up by threes. Wow! It's so cool!"

The way we teach math now is different from the way we were taught. Math was quite separate from reading, and in math we remember solving pages of problems. As the dispenser of knowledge, the teacher presented the math concept of the day. There was the occasional question by a student who wasn't sure what page we were on, but otherwise there was little dialogue between the teacher and the students and no math conversation among the students. The teacher explained how the problem should be solved, and that was it. There were no alternate approaches to solving the problem. The homework was assigned and the routine continued day after day, year after year.

Many teachers, like their students, still think of math as a totally separate subject from language arts. They may not see the connections to what students are learning during reading and writing instruction. Or if they do, they may not know how to make those math–literacy connections explicit or use them effectively. Helping teachers to see these links and making them work in their classrooms is the purpose of this book.

Math class can be a very exciting, vibrant part of the day. The teacher challenges students and they can challenge each other about mathematical concepts. When the teacher says, "Tell me what you think about that," or "What do you not understand?" students begin to comment and ask questions. They reflect on their thinking processes, hear each other, and build on each other's ideas. These budding mathematicians enter into passionate discussions with a point of view. Hearing other arguments, they rethink their ideas and strengthen their understandings. All of this becomes possible when current standards for school mathematics are implemented and integrated with literacy skills. As teachers, we have become more intentional about using reading, writing, and talking in math class and, as a result, we see increased understanding of math concepts and problem solving. And, by bringing math vocabulary, math trade books, and some math writing into our language arts block, we've helped students make connections across subject areas. Our students are figuring out that the thinking and learning they do in all subject areas is related.

With the recent increase in availability of math trade books, teachers have another category of informational texts to use for shared, guided, and independent reading. Teaching for understanding is easier with these additional print resources and they contribute to making the mathematics come alive. These visually appealing books illustrate a context for the mathematical concepts under study and provide models for students to use in problem solving and written explanations for solutions. Pape (2004), writing in the *Journal for Research in Mathematics Education* suggests that "problem solvers' use of context and their ability to provide explanations and justifications for their problem-solving steps are critical to constructing accurate mental models for mathematical word problems" (p. 212).

As defined in another book in this series, *Integrating Instruction: Literacy and Science*, language literacy means "the ability to use reading and writing, speaking and listening sufficiently well to engage in thinking and to communicate ideas. . . . Foundational to all language acquisition is that students develop the ability to think" (McKee & Ogle, 2005, p. 2). Hyde (2006) uses the term "braiding" to demonstrate how thinking, language, and mathematics come together to help students become better problem-solvers. The thinking strategies are the same cognitive strategies used for engaging with and understanding any new learning. Students rely on language skills to read, write, talk, and represent their mathematical thinking and problem solving. In this book, we provide many examples of how we merge, or braid, the thinking and language strategies throughout our mathematics instruction.

CURRENT STANDARDS FOR TEACHING MATHEMATICS

As elementary school teachers, we are responsible for providing students with the knowledge and strategies necessary for understanding and using mathematics. The *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics [NCTM], 2000) define the skills and strategies that students should know and be able to use effectively (see Appendix A). According to a recent article in *Education Update* (Saul, 2006, p. 1), the standards "emphasize the following practices as important to providing an effective math curriculum":

- helping young students learn to "think algebraically," leading to greater achievement in high school;
- emphasizing problem solving as early as kindergarten, so students learn to pull problems apart and identify their essence;
- developing deep and meaningful understanding of mathematics by helping students talk and write about the significance of their math learning.

Thinking Algebraically

In the book *Algebra for Everyone,* Howden (1990, p. 21) states, "Preparation for success in algebra includes much more than computational proficiency . . . These opportunities must focus on development of understandings and on relationships among concepts and between conceptual and procedural aspects of a problem." Standards-based math programs teach students to look for patterns and generalize as opposed to expecting only computational proficiency. For example, we ask students to find a pattern that describes a relationship among a series of numbers: . . . 14, 24, 34, 44. . . . Saul (2006) suggests that teachers restate problems such as "8 + 3 = . . . " to "8 + 3 is the same as. . . . " The change in language leads children to a greater mathematical understanding: the = sign means more than just a procedure. We pose leading questions and ask students to write and draw to help organize their thinking and then we ask them to share that thinking with others. In the process, we nudge students to recognize patterns and to see relationships among concepts.

Problem Solving

According to the NCTM *Standards* (2000, p. 182), "Problem solving is the cornerstone of school mathematics. . . . " Problem solving is not a distinct topic, but a process that should permeate the study of mathematics and provide a context in which concepts and skills are learned." In the process of discovering the solution to a problem, students develop a deeper understanding of the problem and can begin to justify their work.

Pape (2004) investigated middle school students' problem-solving behaviors from a reading comprehension perspective. He suggests that students require linguistic knowledge to accurately represent the problem and mathematical knowledge to execute a successful solution.

Talking and Writing about Math Learning

Talking and writing are ways that students develop a deep and meaningful understanding of mathematical concepts. According to the NCTM *Standards* (2000, p. 194), students are expected to "communicate their mathematical thinking coherently and clearly to peers, teachers, and others." They are expected to "analyze and evaluate the mathematical thinking strategies of others," and to "use the language of mathematics to express mathematical ideas precisely. They do so with the help of language arts. As Pape (2004) explains, students must use their linguistic knowledge as well as their mathematical knowledge to be successful in math. Whitin and Whitin (2000, p. 3) describe the talk and writing of children as "highlighting one of Vygotsky's (1978) main ideas: talking does not merely reflect thought but it generates new thoughts and new ways to think."

The five process standards recorded in the NCTM *Standards* (2000) include problem solving, reasoning and proof, connections, communication, and representation. To meet these and the mathematics content standards, students must develop the ability to think mathematically. Language arts provide the tools for teachers and students to read and understand problems, to write and draw their way toward understanding, and to communicate effectively.

COMPARING LITERACY AND MATH THINKING SKILLS

In our experience, teachers begin to see the power of math–literacy integration when they see the underlying similarities between the two areas. Students need to learn and use the same set of thinking strategies in reading, writing, or math workshops and throughout the day. These strategies include making connections, predicting, asking questions, being aware of their thinking (metacognition), making inferences, visualizing, summarizing, and determining importance.

In math lessons students make connections to link new information to what they already know. Connections support students' ability to *make predictions* about patterns they notice and about data presented in a variety of formats. They predict solutions to problems and check to see if they were right in much the same way they check their predictions when reading. They need to *ask questions* that can be addressed with data, check that the problem they are working on makes sense, and that their solutions are explainable and logical. This is especially true when using calculators. We constantly ask students if their answers make sense even while they are working on computation skills. We also ask if someone knows another way to solve the same problem so students get used to sharing their thinking and recognize that there is more than one way to think about and solve problems. We ask students to be *metacognitive* in the same way we want them to be aware of their thinking while reading and writing.

Students are often expected to *make inferences* about data when presented with mathematical information. We teach students to *visualize* when grappling with concepts and problem solving as a way to make the information more concrete before using abstract mathematical symbols. They learn to *summarize* and synthesize data when working to understand tables, graphs, diagrams, and maps. They must organize and consolidate their mathematical thinking just as they must organize and consolidate their thinking when interpreting the meaning of a particular text. They need to *determine what is important* when presented with a word problem and to understand how details are used to provide additional information and to clarify meaning. This thinking is similar to what readers do to determine the important points of an informational article, or to figure out characters' motives when reading fiction. In short, we pose problems, ask questions, present mathematical models, and ask students to reflect on their mathematical learning in much the same way that we ask them to reflect on their learning in reading and writing class. Table 1.1 shows these comparisons.

Students do not recognize math and literacy similarities by themselves. Teachers must help them see that what they do to understand a story can also be used to understand a math problem. They can connect, predict (estimate), question, visualize, reread, paraphrase, summarize, and check for understanding as they work through the problem. Then, students must organize their ideas to write a coherent explanation for how they solve a math problem in similar ways to how they must organize their ideas when writing an essay. All of this suggests the power of explicitly teaching how similar thinking strategies are used in all learning.

Maintaining the Integrity of the Disciplines

While math and literacy share a set of thinking strategies, there are important differences between them that must be addressed in teaching. Mathematics includes the use of numerals, symbols, and computational procedures that are domain specific. Students must learn to read these in order to understand math and to communicate effectively. Mathematics has its own language and specialized vocabulary. Students must learn the vocabulary and terms that underlie mathematical concepts. It is important for students to develop their own algorithms to comprehend the underlying operational concepts, even as they are directly taught the most commonly used algorithms. Having an array of strategies increases their repertoire for problem solving. Mathematical thinking becomes another way to view the world and solve real-world problems.

REFINING WHAT WE MEAN BY MATH–LITERACY INTEGRATION

When we first began thinking and talking about the integration of math and literacy, we discussed the similarities between them and thought this represented integrated instruction. However, some of the literature on the integration of math and literacy caused us to rethink our position.

Mathematics teacher educators have struggled with defining "integrated mathematics" and suggest that a diversity of definitions exist. House (2003, p. 5), quoting the findings of Lott and Reeves (1991), concluded the following:

TABLE 1.1. Comparison of Math and Literacy Learning

Math	Literacy
Make connections	Make connections
I can make connections to this problem by thinking about others like it that I have solved before. I can make connections between this concept and what I know from reading in science or from what I have learned about solving problems in my everyday life.	I can make connections to what I am reading by thinking of other books that I have read like this one. I can make connections to what I am reading based on experiences I have had and to what I know about the world.
Make predictions	Make predictions
I can make predictions about patterns, data, upcoming learning, problem solving, solutions, etc. I can make estimations. I need to check to see if predictions or estimations were correct or need revision.	I can predict what the story is about by looking at chapter titles. I can predict what characters will do next, or predict motives, plot, or resolution. I can predict themes or predict topics in nonfiction, etc. I need to check to see if predictions were correct or need revision.
Ask questions	Ask questions
I can ask questions about data, or for clarity, or to determine what the problem is about, and to decide if the answers and solutions make sense.	I can ask questions about story elements, characters' motives, author's purpose, to clarify meaning, and to understand the text.
Self-regulate or be metacognitive	Self-regulate or be metacognitive
Think about the problem: Does it make sense? Do I need to reread or restate the problem? Does the solution make sense? Can I solve the problem another way? Do I understand the math terms? Can I summarize the problem and explain my answer?	Think about the reading: Do I understand what I am reading? Do I need to reread or restate the reading in my own words? Do I have questions? Do I need clarification of the way the author is using certain words? Can I summarize what I am reading? Do I agree or disagree with the author?
Infer	Infer
Much like predicting, I can infer what will come next using the data presented. I can make an informed guess about additional information needed. I can infer or estimate a solution.	I can draw conclusions about the characters, setting, or solution to the main character's problem. I can infer the meaning of words using context. I can infer the author's intent or biases.
Visualizing	Visualizing
I can make pictures in my mind or I can draw what I think the problem is about. I can represent the different parts of the problem by drawing or diagramming the problem.	I can create pictures in my mind of the setting and the characters. I can picture the problem the characters are facing and think about how I would act to solve the problem. I can imagine what the characters are feeling and how they look and act.

(continued)

TABLE 1.1. *(continued)*

Summarize I can summarize the problem and explain the steps to solve the problem. I can justify the solution using logic and mathematical reasoning.	Summarize I can summarize the story, state the theme or author's intent, and can justify the interpretation of the text using examples from the text.
Determine importance When reading math problems I can separate the important information from the supporting details. I can determine which details are used to clarify and which are not important.	Determine importance When reading I can separate the main ideas from the supporting details. I can reflect on new information and can decide whether this information contributes to understanding the main points of the story or article.

An integrated mathematics program is a holistic mathematics curriculum that

- consists of topics from a wide variety of mathematical fields and blends those topics to emphasize the connections and unity among those fields;
- emphasizes the relationships among topics within mathematics as well as between mathematics and other disciplines;
- is problem centered and application based;
- emphasizes problem solving and mathematical reasoning;
- provides multiple contexts for students to learn mathematics concepts;
- provides continual reinforcement of concepts through successively expanding treatment of those concepts;
- makes appropriate use of technology.

Usiskin (2003, p. 22) suggests that connections between math and science are important, but argues that connecting math with social studies and reading is also important. However, he argues against interdisciplinary integration stating, "I believe that mathematics should not be integrated with those other areas. It is too difficult to give enough attention to the different concepts in different subjects simultaneously, yet demonstrate the differences in their importance, and also link them in some coherent way." Berlin (2003, p. 55) suggests that integration across disciplines is "embedded most often in the context of real-world applications. As such, the cross-curricular connections tend to be contextual rather than conceptual." Perhaps what is most important is to make use of the contextual opportunities to point out how students use thinking strategies, talking, reading, and writing in math class to understand, express, and record their thinking and understandings.

We are very clear about the need to provide time in the schedule for specific math instruction. We are also clear about the need for students to develop computational skills. A balance between conceptual math and traditional math with an emphasis on computation skills is necessary for students to reach the high levels of math competence expected today. Most importantly, we believe that students must find value in the study of mathematics and see how it relates to solving real-world problems.

We also know that it is necessary to teach reading and language arts in a separate block to give adequate time to developing the reading and writing competencies students need to be successful in school and beyond. Students must be directly and explicitly taught skills and strategies for decoding, vocabulary development, and comprehension. "Writing to learn" is a common phrase teachers use to explain why it is important to include writing in all of the disciplines. However, students need adequate time and explicit teaching to understand the forms and conventions of writing, to understand voice and organization, and to develop the craft of writing. Thus, we are not advocating a thematic approach to linking literacy and math, but are advocating for the explicit teaching in the math block of how to read the math text and how to write math explanations and justifications of solutions to communicate effectively. We are also advocating for the inclusion of math read-alouds and trade books in the reading block as another form of informational text reading. These texts become models for reading the math textbook and allow the teacher additional opportunities to demonstrate how to use a specific strategy or set of strategies to improve comprehension of story problems or math explanations.

Metsisto (2005, p. 11) states, "If we intend for students to understand mathematical concepts rather than to produce specific performances, we must teach them to engage meaningfully with mathematics texts." She refers to the reading demands of math classes and ends the chapter with, "Mathematics teachers should recognize that part of their job in helping their students become autonomous, self-directed learners is first to help them become strategic, facile readers of mathematics text" (p. 23).

We know that math texts present unique challenges and that students often experience difficulty understanding them. In Chapters 4 and 5 we offer strategies to help students become strategic, facile readers of mathematics text. It is, as Metsisto states, our job to help them understand the text and to help them become independent users of strategies so that they have a sense of agency for reading the text. In so doing, we are also addressing some of the English Language Arts Standards that require students to read and comprehend a variety of texts for a variety of purposes, use a variety of strategies to comprehend, interpret, and evaluate texts, employ a wide variety of strategies as they write for a variety of purposes, and adjust their use of spoken, written, and visual language to communicate effectively. Appendix B lists the complete set of English Language Arts Standards.

PLANNING FOR LITERACY AND MATH INTEGRATION

THIRD GRADER, MAGGIE: Wait . . . is this reading or is it math?

TEACHER: This is Reading Workshop! But we *are* reading about math because these scientists are using math.

THIRD GRADER, CHAD: Wow! My brain feels bigger! I use bigger words every day!

All of the teachers who worked on this book agree—the last thing we want is an extra layer of planning in our already overpacked days. The surprise is that our classroom lives actually became simpler as we focused on connecting math and literacy. The days became more cohesive because our students transferred skills and thinking from one discipline to another.

As explained above, we do not advocate teaching the day's math lesson at language arts time. What we do advocate is integration that, first, explicitly teaches students how to read the math text and effectively communicate math explanations, both verbally and in writing. Second, we advocate including math concept books in the reading block as another form of informational text. This takes planning but the planning most useful to us was brief and focused. Detailed planning for one math unit helped us identify opportunities for teaching children how to use vocabulary, talking, reading, and writing in math. Such planning also helped us identify related concept books that might be used for shared or guided reading.

Planning Math Lessons with Literacy in Mind

Classroom teachers know that math lessons present literacy challenges. Students need reading and thinking skills to comprehend word problems. They need vocabulary for math terms and for the inner dialogue students have with themselves as they solve problems. A college math student we talked with said:

> "When I am thinking about a math problem or learn something new, I do not just see a bunch of numbers in my head. I talk to myself in words. I need to sort things out. Having the right vocabulary helps me make connections. I think like this: 'Hey, I don't have a clue what is going on here.' Then someone says the word *matrix*. 'Oh! I know what kind of problem this is. This is like other matrix problems!' I use language in my head to create something real out of numbers, and to take something real and put it into numbers."

For planning math lessons with literacy in mind, we identified points in the lesson where students would need an inner dialogue to read and understand problems or to learn new concepts. We also identified opportunities for students to clarify thinking through writing and talking. The thinking strategies taught in reading such as making connections, predicting, questioning, self-regulating (metacognitive), inferring, visualizing, summarizing, and determining importance (see Table 1.1) are also important in math. By connecting with these strategies throughout our day, we help students transfer the same kinds of thinking to math. One teacher found an easy way to link these. The class had created a chart listing the reading and thinking strategies the children had learned. It was displayed in the reading "corner." The teacher shifted the poster to a prominent place in the center of the room. This allowed the class to refer to the strategies throughout the day and across the curriculum. While planning the math lesson, the teacher also put sticky notes in the margins of her teacher's manuals reminding her to prompt children to use the strategies—for example, "What other problem does this remind you of? Who has a connection?"

One of our goals for literacy in our math classes is to encourage the process of inquiry. We want to build an environment where inquiry is the norm and by including inquiry in the math class, we move closer to achieving our goal. We want our students to understand that they learn from each other as they talk together about what they know and figure out. As Johnston (2004, p. 52) writes, "The more we help children build a sense of themselves as inquirers and problem-solvers, and the less they see boundaries between domains of inquiry, the more they are likely to transfer their learning into the world beyond school." So we plan to build in opportunities like the Inquiry example in Chapter 3.

Adding Math Content during Literacy Lessons

We recommend adding mathematics content to what students are reading, writing, and talking about during literacy lessons. When we began to do this we were amazed! "My *math* lessons seem to unfold so easily," one teacher noted. Math lessons suddenly take a lot less time! This happens because we are building background knowledge in advance of the lesson. When teaching vocabulary from literature, science, and social studies we add words for upcoming math lessons. By preteaching some of the vocabulary we "frontload" a lot of mathematical information. We also use shared- reading texts with math content as we teach reading strategy lessons and, about once a week, we include a math writing prompt in our writing workshop. This activates and adds to knowledge children will use later in math lessons. Planning for integration is not cumbersome; it simply requires awareness of using math as a context for practicing language competencies. Math–literacy integration, however, needs to take the daily classroom schedule into account. Where does it fit?

Daily Schedules

Most school districts specify the number of minutes for instruction in the major content areas. Our district recommends 60 minutes daily for math instruction depending on the grade level. The district also requires that teachers set aside 90–120 minutes for reading instruction and 40 minutes for language arts instruction.

We also have daily time set aside for physical education and four days of the week students rotate through library, drama, art, and music. This leaves limited time for science and social studies. We currently use a science program that requires teachers to rotate through three to four units, each with lots of hands-on experiences coupled with text-based instruction. Therefore, to get enough minutes to adequately address the topics in science and social studies, we must integrate them with language arts instruction. We will use Carole Skalinder's fall schedule to illustrate how we find the time for this integration. Figure 1.1 shows Carole's daily schedule and represents her effort to create a coherent structure whereby the teacher and students can make connections across content.

Carole labels much of her day as "workshop," and students know there is a routine to how workshop time will be spent. The workshop format supports the notion of apprenticeship and provides comfort for students to predict how the day will progress. The routines of workshop typically include a whole-group mini-lesson followed by small-group instruction followed by independent practice or working with peers (Dorn & Soffos, 2001).

In Reading Workshop 1, Carole typically introduces a reading or vocabulary strategy by reading aloud or by enlarging the text or putting it on the overhead so all of the students can see the text while she models how to use the strategy. After the mini-lesson, Carole meets with students in small, guided reading groups to apply the same strategy on appropriately challenging text. However, Carole occasionally uses a math informational book or the math textbook for a whole-class strategy lesson before using the same type of text in guided reading. As another example, during the beginning of the year when scaffolding of solving word problems focuses on *reading* the problems, she might use Reading Workshop time to do a shared reading of a math word problem and then provide guided practice in small groups. During the time of the year when the *writing* part of problem solving is emphasized, she uses some of the Writers' Workshop time for shared writing lessons and guided practice of the skills and strategies needed for writing explanations and solutions to math problems.

During Math Workshop, Carole might introduce the whole-class math lesson by reading aloud a math-related book to create a context for the rest of the lesson. Depending on the lesson and concepts being taught, she may then guide students to use talk and writing as a way of further exploring the concept or strategy. This time slot is primarily devoted to explicit teaching of the math curriculum. Ideally, Carole would have one continuous Math Workshop. However, she must work around the schedule for physical education and resume the Math Workshop later. Carole's challenge was to set up the workshop so that the interruption would occur at the conclusion of the whole-group lesson and not interrupt students' work. The second portion of the Math Workshop includes independent practice of the concept presented earlier. During this time Carole also works with individuals who need further guidance in understanding and applying the concepts and strategies presented earlier. In the afternoon, Carole designates a 20-minute mini-block,

	Mon	Tue	Wed	Thu	Fri
9:00–9:15	**Homework connections**—students check in homework/revisit, review, ask questions **Daily geography/Word Study/Vocabulary/Poetry**				
9:15–10:30	**Reading Workshop 1** Shared reading/mini-lesson Small-group instruction: guided reading book discussions assisted writing individual or small-group conferencing Choice reading				
10:30–11:15	**Math Workshop** Whole-group lesson				
11:15–11:35	**Physical Education**				
11:35–12:00	**Math Workshop** Students pick up Math Homelinks Guided/independent practice				
12:00–12:40	**Recess/Lunch**				
12:40–1:10	**Reading Workshop 2** Read aloud/independent wide reading Small-group instruction Individual or small-group conferencing				

1:10–1:30	**Math Workshop 2**	**Math Workshop 2**	**Math Writing**	**Math Workshop 2**	**Math Workshop 2**
1:30–2:10	**Writers' Workshop** Read aloud/mini-lesson Grammar/mechanics/word study, spelling	**Writers' Workshop** Read aloud/mini-lesson Grammar/mechanics/word study, spelling	**Inquiry Workshop** Science/Social Studies research	**Science/Social Studies** Lesson	**Writers' Workshop** Read aloud/mini-lesson Grammar/mechanics/word study, spelling
	Independent writing, teacher conferencing	Independent writing, teacher conferencing	Independent reading, writing, teacher conferencing, guided inquiry	**Inquiry Workshop** Science/Social Studies research Independent reading, writing, teacher conferencing, guided inquiry	Independent writing, teacher conferencing
2:10–2:20					
2:20–2:30	**Read Aloud**	**Read Aloud**	**Read Aloud**		**Read Aloud**
2:30–3:10	**Library**	**Art**	**Music**		**Library**
3:10–3:20	**Dismissal**				

FIGURE 1.1. Mrs. Skalinder's third-grade schedule, Fall 2006.

called "Math Workshop 2," to be used four days per week for math games and problem-solving investigations. This system has allowed Carole to regularly provide time for students to work independently and in partnerships. She uses this time for math centers, which will be elaborated on later in this chapter in the section on setting up a language-rich math environment. Finally, Carole devotes the same time block one day per week for explicit and extended math talk or math writing.

Figuring out whether math literacy experiences get taught in the Math Workshop or in the Reading or Writers' Workshop requires constant monitoring and reflection about the pacing in each discipline and the current needs and readiness levels of the students. To simplify this and to help us focus on, math–literacy links, we created a Math–Literacy Planning Sheet. It was essential for us that this sheet be easy to use, flexible, and require a minimum of writing.

The Math–Literacy Planning Sheet

We start our planning for math–literacy integration by identifying the key learning standards and/or benchmarks that are part of the math lesson or unit, and then find connections with literacy standards being addressed in other parts of the day. We note the literacy demands of upcoming math lessons and enter them on the planning sheet as math–literacy objectives. A sample planning sheet for Carole's third-grade math unit on multidigit subtraction is shown in Figure 1.2. We focused on four literacy skill areas that are important to math learning: vocabulary, talking, reading, and writing. Specific activities that we have used to link math and literacy are described in Chapters 2 through 7 of this book, grouped into the four main categories on the planning sheet.

Once the math objectives are clear, we use the planning sheet to list the activities and address them in the left column. Then we list the mini-lessons and practice sessions where these activities can be integrated into daily lessons in the right column. The following list of ideas helped us as we began to organize our thinking. We wanted to incorporate a wide range of strategies and resources for differentiating instruction to address students' range of learning styles as we planned a 2- to 4-week unit.

- Think of ways students can actively enjoy exploring the concepts. Do we have varied learning resources and written material? Collect trade books, CD-ROMs, related fiction, and websites. Locate multiple levels of materials.
- Teach vocabulary: activate prior knowledge. Highlight words in the unit through stories. Have children write definitions, take notes, and make anchor charts. Add the words to the word wall and spelling list, and use them to create concept sorts.
- Identify reading, writing, and talk expectations. Use them as you ask students to think critically and to express themselves in written and oral form.

Unit Subtraction Grade 3	**Integration**
Math Vocabulary *Preteach vocabulary* Word Think Sheet	Introduce and model in word study Practice in literacy centers Reinforce in math class
Math Talk *Partner talk* Introduce "Turn-and-Talk Clock" Prompt: What would the world be like without math?" Teacher circulates, reports afterward about hearing "What do you think?" Children take turns circulating (also listen for math vocabulary)	Introduce and practice in math game mini-block
Math Reading *Visualizing: flow charts/diagrams* Visualize sequence for solving subtraction word problems Shared reading: use "water cycle" flow chart from science Children create flow charts using word problems from math lesson as texts	Introduce and model in math class Reinforce and practice in reading strategy lesson
Math Writing Writing Poetry Children write and illustrate "List Poems" (See *Teaching Children Mathematics,* Altieri, 2005, p. 21)	Reinforce and revisit in writing workshop

FIGURE 1.2. Math–literacy planning sheet—third grade.

- Use these student expressions as assessments along the way to help adjust instruction.

A Sample Math–Literacy Planning Sheet for Third-Grade Subtraction

Carole's planning sheet for a third-grade math unit on multidigit subtraction is shown in Figure 1.2. While all the boxes on this planning sheet are filled, it is not necessary to do this much planning right away! We encourage teachers to begin with just one or two entries. When we started focusing on integration in our own classrooms we selected one area at a time. For example, we might have used only the math vocabulary box for several weeks in a row, establishing a routine, and doing the same type of vocabulary activity once each week. It is fine to start by giving students (and the teacher) one or two good opportunities to experience math–literacy connections, in which case several boxes on the planning sheet would be left blank. The following sections explain Carole's planning sheet.

Math Vocabulary

Carole wanted to preteach vocabulary for the multidigit subtraction unit and so she planned and started this activity about five weeks prior to the teaching of the unit. She made a list of vocabulary words for the unit and decided to put six words each week into the class spelling (word study) lists during the time leading up to the unit. She planned to build background knowledge by using a "Word Think Sheet." This form asks students to think about a specific vocabulary word by drawing a picture, thinking of related words, using the target word in a sentence, and finally, expressing the word's meaning. The sheet is the basis for an exercise in shared thinking and for writing lessons during vocabulary instruction time. Once Carole's students were familiar with the Word Think Sheet, they could complete several more of them independently at centers during their literacy block. We will describe the Word Think Sheet's use in detail in Chapter 6.

Math Talk

To help the class strengthen their productive math talk with partners, Carole introduced the "Turn-and-Talk Clock." This activity is a scaffolding tool for student conversations. A question is asked and the children are given a short time to talk about it with a partner. (See Chapter 2 for a fuller description.) Carole decided to introduce the activity in the math game mini-block (Math Workshop 2 on Carole's schedule), using a general prompt: "What would the world be like without math?" She specifically wanted to teach partners to ask each other, "What do you think?" After introducing the Turn-and-Talk Clock, Carole would circulate and listen briefly to conversations, then let students know what she heard. She could point out examples where she had heard partners asking each other, "What do you think?" After a little practice during explicit teaching in Math Workshop 2 (see Figure 1.1), the class could use this strategy during the math lesson. Carole knew she could identify places in any lesson where children would benefit from turning and talking briefly about a concept, word, or problem. On the Math–Literacy Planning Sheet she also noted that students might take turns circulating and listening to conversations, using the teacher's behavior as a model. They could then report to the whole group about what they heard. Carole planned one more idea to keep in the back of her mind and use if the class were ready to do a little more: She could prompt students to notice anyone using good math vocabulary.

Reading

Third-grade students often need support for reading and comprehending word problems about subtraction situations. “Tom had $24.00. He spent $13.00 on goldfish supplies. How much does he have now?” For a problem like this, it helps students to draw a picture such as a flow chart, showing what the situation was at first, what happened, and what the outcome was. Carole planned to use a few minutes of math time to introduce this visualizing strategy as they read and solved problems. Knowing they would need to learn about flow charts and diagrams for reading nonfiction in general, she planned a shared reading lesson to focus on visualizing. They could examine and discuss flow diagrams from science- and social studies-related texts in the reading series. Children could then practice drawing their own flow charts and diagrams using math word problems.

Writing

At Carole’s school there was a year-long focus on writing poetry, so the class returned to it frequently in Writers’ Workshop. Carole planned to use a suggestion for “List Poetry” from *Teaching Children Mathematics* (Altieri, 2005). Children would choose a favorite number and then write about various ways the number is used, creating a poem in the form of a list. While planning, Carole recognized that this idea could be introduced quickly to third graders as part of a writing minilesson. She could read them several examples and then let them write and illustrate their own poems. She wrote “Writers’ Workshop” on the planning sheet, knowing it could be either a single assignment for the whole class or one of several topics the children would choose from for that week. While not included on the Math–Literacy Planning Sheet, Carole and the rest of the authors plan for independent practice of the math concepts taught during workshop by using math centers. They are included here because they relate to schedules and require planning in order to occur regularly and to be beneficial to students.

Math Centers

We all agree that it is important for students to have time to explore mathematics in a less structured environment than during the formal math lesson. We all use math centers but each of us uses them differently.

Patti Satz includes math as one of the centers available to her second-grade students during center time. She initially experimented with having math center as part of the math lesson but she found that only the students who finished the practice portion of the lesson regularly got to the math center. Therefore, she changed to her current structure so that all students would have the opportunity to participate in the math center activities. The math activities in the center are usually related to the season of the year and may also be related to other areas being studied. For example, each student made a place value building that went on "Place Value Lane" in November. When they study fractions, each student makes a sundae with each scoop of ice cream identified as a fraction. Patti has a variety of other centers going at the same time: listening center, writing center, reading center, and a word work center. Students choose a center and mark a ticket to remember what centers they worked at. While at the center, they record their work in their log.

Carole has experimented with a variety of schedules and groupings to include centers and independent time for math investigations. She currently organizes her third-grade students into five heterogeneous groups that stay the same for a couple of months. The student groups are assigned to a particular area of the room for center time. The groups have labeled tubs on a shelf that they pick up and take to their assigned work space. This works well because the students often leave their work in the tubs until they are finished. This system allows Carole to check on each student's work and the progress toward completion without having to search through other student work. Carole rotates the activities that are in the tubs. Each tub has Velcro-attached labels so she can easily change the activities in the tubs by simply changing the labels. During the time the students are working, Carole works with individuals or groups, or pulls out particular students to work on something else.

Summary and Implications

Teachers have the awesome responsibility of providing a challenging curriculum and powerful instruction that engages students and enables them to be successful in school and in life. In *Reading to Learn* (2002, p. 172), Allington and Johnston describe lessons from exemplary fourth-grade classrooms. The teachers they studied all integrated their instruction. Reading and writing were most often "emphasized as a tool in the study of other subjects." However, math was the least commonly integrated subject. We hope this book will help change that.

We are not only using language arts as tools in the study of mathematics, but are also helping students to meet standards in both disciplines. We believe that the ideas and strategies presented in this book can help students achieve more and become successful in middle school and beyond. In the chapters that follow, we offer practical strategies for integrating mathematics and literacy learning. In Chapters 2 and 3, we offer strategies and ideas for encouraging children to talk about math and learn math through talking. Getting children talking about math is a foundation for many of the other teaching activities that follow. In Chapters 4 and 5 we discuss the reading challenges presented by many math texts and how to address them successfully. This includes using literature with math content to prepare students and explicitly teaching them how to read and understand math problems. Chapter 6 offers a range of strategies for teaching math terms and concepts. As you will see, a great deal of writing is embedded in the various activities in all of the chapters, but writing is highlighted in Chapter 7. We end with a discussion of assessment. In the balance of this chapter, we offer suggestions for setting up a language-rich math classroom.

SETTING UP A LANGUAGE-RICH MATH CLASSROOM

The following are ideas on how to set up a language-rich math classroom. These suggestions are aimed at creating a culture that allows students to be active learners and show respect for ideas and for each other. In this kind of atmosphere, mistakes are considered opportunities to learn, risk taking is celebrated, and mathematics is presented as a way of thinking and exploring, and as a way to solve problems encountered in our daily lives.

Word Walls

We immerse students in the vocabulary of mathematics by using the walls and classroom space as reminders of the words under study or learned in previous units. Blachowicz, Fisher, Ogle, and Watts-Taffe (2006, p. 528) validate this practice. "Research studies in diverse contexts and with learners of varying ages all confirm that environments where language and word use are celebrated and noted encourage the development of word consciousness and attendant vocabulary learning." Math is a technical language that is not always integrated into a student's vocabulary and it must be if they are to communicate orally and in writing about their thinking and problem solving. Thus, the words are posted on the wall to remind students of the terms and to provide easy access for use in talk and writing. Math words are often kept on a separate chart with the unit of study at the top to help students categorize them by topic. In her fifth-grade classroom, Sandy Vitantonio includes a description and picture along with the word itself to help math language become a permanent part of her students' vocabulary. In her third-grade classroom, Carole keeps math words currently under study on a separate "mini-word wall" and then moves the words to the main word wall when the unit is over. A part of Carole's word wall is shown in Figure 1.3. She also includes some of the math words on the main word wall if they demonstrate the spelling patterns under study.

Number Lines

Number lines are placed on the wall in continuous order. Even if the number line is broken up by a doorway, it continues around the upper perimeter of the room.

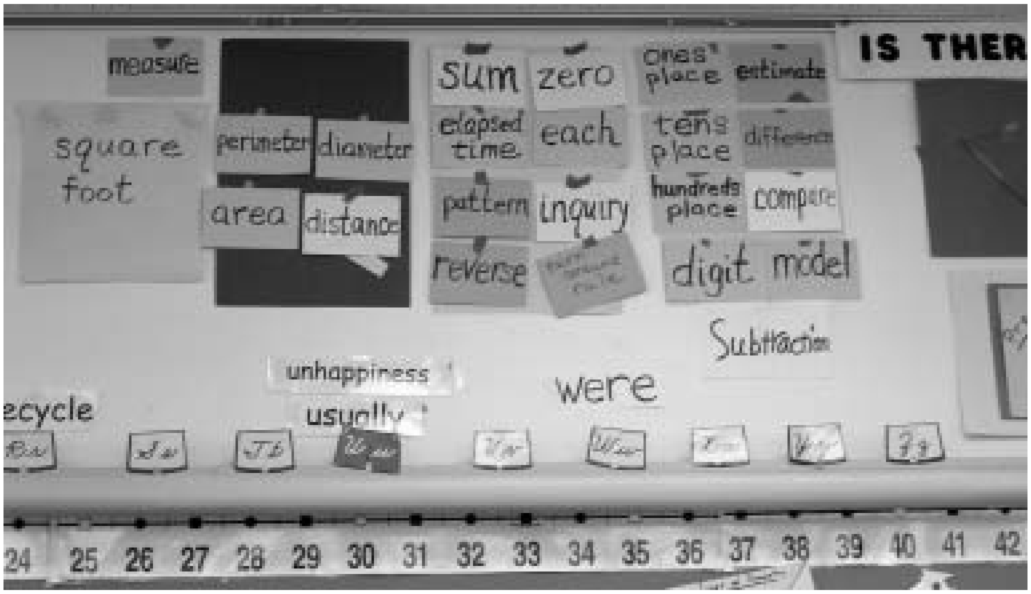

FIGURE 1.3. Word wall and number line.

The number line, like the word wall, is continually used by teachers as they demonstrate how to solve problems and to understand the order of numbers. When teachers notice that a student has used one of these resources, they will ask the student to tell the class how he or she figured out a solution. By helping students make public their use of these resources, we remind other students of their value.

Anchor Charts

Anchor charts such as the one shown in Figure 1.4 summarize a process or procedure for approaching a task, for solving particular kinds of problems, or for working through the text. They are co-constructed with students and serve as reminders of how to proceed or what to do when presented with a particular kind of text. For example, we create anchor

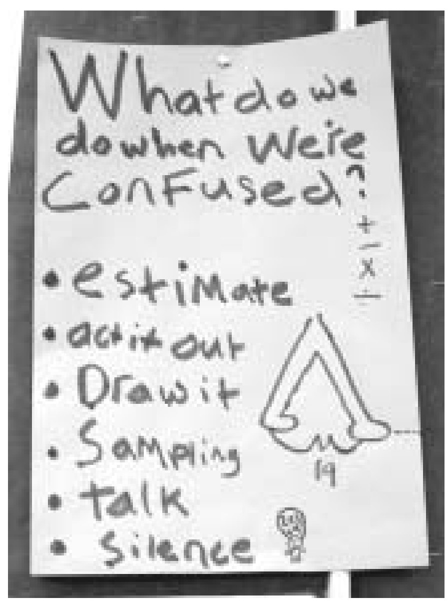

FIGURE 1.4. The children and teacher made an anchor chart about what to do when they are confused.

charts for how to choose a "just right" book, for how to solve problems, and to recount steps in a process for writing math explanations, among other uses. We say more about anchor charts in Chapter 2.

Math Words in the Real World

Along with math vocabulary and anchor charts, there should be visible connections of math to the real world. For her second-grade class, Patti set up a bulletin board with the question: "Where's the Math?" posted over pictures that changed weekly. Figure 1.5 shows what the board looks like. Soon, students began bringing in their own pictures to show how math is connected to many aspects of their lives.

Many teachers have number words spelled out and on display in the classroom: under number lines, on place-value charts, on calendars, and placed next to routines for the day. This provides students with sight word recognition of important math terms that are not always easy to spell or sound out (e.g., *one,*" "*two,*" "*four,*" "*eight,*" "*eleven,*" "*twelve,*" "*thirteen,*" "*fifteen,*" "*twenty,*" "*thirty,*" "*forty,*" and "*fifty*"). Lisa uses library pockets adhered to poster board in her third-grade class-

FIGURE 1.5. This interactive bulletin board gets second graders thinking about math in the real world.

room to keep track of borrowed books from the classroom library. Each pocket is labeled with a spelled-out number: “seven,” “eight,” “nine,” and so on.

Labeling Classroom Objects with Math Terms

Lisa also suggests that students describe and/or label items in the classroom using their mathematical vocabulary: a tabletop can be identified as a square, circle, or rectangle, a can might be labeled as a cylinder, and the globe can be labeled as a sphere. This practice is especially helpful for English language learners (ELLs). Student-created displays help students take ownership of the terms connected with the unit of study. Lisa asks students to find pictures or objects to display on a poster or bulletin board that represent the math concept under study. Students label the picture or object using the appropriate math terms to reinforce their use and to provide another opportunity to write the words. Figure 1.6 shows a student-made poster for the term *symmetry*. Since the students create the display, they are likely to notice and use the words in their talk and writing.

Hands-On Materials

The NCTM *Principles and Standards* (2000) state that teaching practices need to increase the use of manipulatives. Manipulatives can be any material—from pieces of paper to base-10 blocks to dice—that can be manipulated or rearranged by students to represent a problem or understand a concept. They serve as concrete objects for students to use as they solve problems and conceptualize abstract ideas. Manipulatives allow students to visualize concepts and to make concrete connections to problems: they “see” problem solving. Most published mathematics programs come with a supply list. Often, manipulatives are purchased by school districts when a program is adopted for classroom use. However, if this is not the case, Figure 1.7 provides a list of items that are needed in most elementary math programs.

FIGURE 1.6. Students’ illustrated examples of *symmetry*.

Calculators (age appropriate)	Yardsticks and metric sticks
Base-10 blocks	Tape measures
Geometric pattern blocks	Trundle wheel
Clocks	Scales and balances
100 chart	Measurement containers (e.g., cups, pints, quarts, gallons)
Number lines	Geoboards
Calendars	Rubberbands
Playing cards	Coin stamps
Dice (numbered, blank, 6-sided, 12-sided, 20-sided)	Play money
Spinners	Fraction sticks
Probability meter	Geometric solids
Percentage circles	Graph paper
Compasses	Writing journals
Protractors	
Rulers	

FIGURE 1.7. Manipulatives and supplies needed in most elementary math programs. Many of the manipulatives come as an overhead for instruction (e.g., geoboards, pattern blocks, coins).

As you will see from the activities in this book, writing has a significant role in a language-based math program. Thus, we include writing journals on the list of materials. The journals can be put on student supply lists or included in the school budget. Many of our teachers use theme books and train students not to remove pages so that the journal serves as a portfolio of students' yearly writing and problem-solving progress in math. We keep a section of the journal for students to record new math vocabulary and definitions. Some teachers use three-ring binders to serve the same purpose and to store student work. The teacher must decide if the journals are to be stored in the students' desks or on shelves.

Since manipulatives are central to mathematics study in the elementary grades, they must be placed so that they are accessible to students and packaged in such a way that they can be easily replaced to be used again. We have clearly labeled bins and plastic zip bags for storing manipulatives. Keeping the math tools and materials organized and returned to their proper place can become one of the "jobs" assigned to students. To emphasize the importance of this job, we designate a title such as "Mathematics Monitor" or "Tools Technician" and add the title to the classroom job chart. The formal job title also reminds students that the manipulatives are to be used as tools and not as toys.

Some math tools are shared and kept in a common storage area and others are personal and need to be kept in desks or in student storage containers. We suggest using plastic zip bags for personal student tools and manipulatives. We assign each student a number at the beginning of the year. The math tools and manipulatives that are for individual use are also marked with the student's number. Numbers can be designated by alphabetical order of the students' last names. This system makes it easy to return a stray straightedge or an eraser to the rightful owner because the objects have numbers on them. Students can also be asked to place the same number on the top of their work along with their names. Students love putting papers in numerical order and this makes it easy for the teacher to see who is missing an assignment.

Decks of cards can become a challenge if there is a lone card left on the floor and no one remembers which deck it fell out of. We suggest using colors and symbols to keep track of decks of cards. For example, one deck might have a small red circle on the top of every card. Another deck might have a small green triangle on the top. Although it takes time to mark each card in each deck, doing so will help these tools last from year to year.

When a classroom is physically set up to be rich in math language, the next step is getting the children to start talking math. Chapter 2 offers guidelines for how to do that.

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