Power of the Circle

You have noticed that everything an Indian does is in a circle, and that is because the Power of the World always works in circles, and everything tries to be round. In the old days when we were a strong and happy people, all our power came to us from the sacred hoop of the nation, and as long as the hoop was unbroken, the people flourished. The flowering tree was the living center of the hoop, and the circle of the four quarters nourished it. The east gave peace and light, the south gave warmth, the west gave rain, and the north with its cold and mighty wind gave strength and endurance. This knowledge came to us from the outer world with our religion. Everything the Power of the World does is in a circle. The sky is round, and I have heard that the earth is round like a ball, and so are all the stars. The wind, in its greatest power, whirls. Birds make their nests in circles, for theirs is the same religion as ours. The sun comes forth and goes down again in a circle. The moon does the same, and both are round. Even the seasons form a great circle in their changing, and always come back again to where they were. The life of a man is a circle from childhood to childhood, and so it is in everything where power moves. Our teepees were round like the nests of birds, and these were always set in a circle, the nation's hoop, a nest of many nests, where the Great Spirit meant for us to hatch our children.

—Black Elk (1863–1950),
Oglala Sioux Holy Man

Chapter 1: Why Use Children's Literature in Mathematics?

Eula Ewing Monroe and Olivia Haworth Dial, with Stevie Carr and Bree De La Mare

> If I was as old as Ruise or Jesmarie, I could pick fifty, even a hundred pounds of cotton a day. It's a long time to night.
>
> —Sherley Anne Williams (*Working Cotton, 1992, p. 22)*

Are these the words of a slave child laboring in the cotton fields of Georgia just prior to the Civil War? No—this quote is from a young child laboring in the cotton fields of California in the latter half of the twentieth century. In *Working Cotton* (1992), Sherley Anne ("Shelan") Williams shares a day from her childhood—the poverty, the exhaustion, and the hard work, much too hard for a young child. Her day begins before sunrise and doesn't end till after sunset—a full day of exploited childhood. Shelan also expresses her conflicting motivations: the ambition to pick as much cotton as the older children, and the longing for evening to release her from the hot sun and backbreaking work.

This Caldecott Honor Book shares Shelan's circumstances through Carole Byard's expressive illustrations and Sherley Anne Williams' poetic portrayal of the dialect of the African American migrant family and culture. In their initial readings, teachers and students experience a world of emotion conveyed in minimal words and details, as Shelan's story offers poignant insights into her daily life and raises issues of social justice outside the world of most children in the United States. During subsequent readings and through different lenses, the teacher in us may also see many curricular possibilities.

The story begins as Shelan, her family, and other migrant workers ride to the fields in an old school bus in the coolness of the early morning. Shelan and the others huddle around an outdoor fire, trying to keep warm as they wait for sunrise. When daylight comes, Shelan begins picking cotton with her father, mother, and siblings. When the sun is high, they stop for their daily lunch: a simple meal of cornbread and greens, and sometimes a small piece of meat. Returning to the fields, they work until sundown, when the bus comes to take the families home.

Mathematics Potential in Powerful Literature

The book *Working Cotton* may not initially seem an obvious choice to make the abstract concept of *time* more relevant to young minds. However, in a grade 3 class project (Monroe, Orme, and Erickson 2002), students made connections to the story through a series of tasks in which Shelan's experience gave them a context to scaffold and enrich their growing knowledge about the overarching concept of time, as well as how to measure it. Monroe expressed the mathematics challenge explored by her research team:

> Teachers of young children generally concur that their students learn mathematical concepts best when they construct understanding through concrete experiences. When we remember that time can be neither seen nor touched but experienced and measured only indirectly with tools such as clocks, we can begin to understand why time-related concepts are difficult for our students to learn. (Monroe, Orme, and Erickson 2002, p. 475)

Beginning with *time* as contextualized in *Working Cotton*, this instructional project supported third graders in understanding multiple concepts related to time.

Intent of the Lessons

The content of this book supports students' development of the CCSSM (National Governors Association Center for Best Practices [NGA Center] and Council of Chief State School Officers [CCSSO] 2010) as identified in the SMPs and the Standards for Mathematical Content. The third-grade level in the domain of Measurement and Data, Cluster A, Standard 1 (3.MD.A.1), reads,

> Tell and write time to the nearest minute and measure time intervals in minutes. Solve word problems involving addition and subtraction of time intervals in minutes, e.g., by representing the problem on a number line diagram. (NGA Center and CCSSO 2010b)

References to specific CCSSM appear in this chapter as appropriate to the mathematics addressed, and the Content Standard is identified for each set of tasks described. A single mathematical task can typically support multiple SMPs; however, we identify one SMP as a focus for each task. (See chapter 3 for a more in-depth discussion of the SMPs.)

For ease of reference, the eight SMPs are included as appendix 1.A.

Working Cotton poses many possibilities for areas of mathematical focus, such as weight and measurement. For the purposes of this project, we focused on time-related concepts, which seem to emerge naturally—but not necessarily obviously—from the story, and to extend, also naturally, to related ideas. But unless a teacher has cultivated the mindset to look for opportunities to integrate mathematics, such possibilities may go unrecognized.

Application of the Story

The classroom teacher who participated in the project began by reading *Working Cotton* aloud to her students. The students brainstormed words from within and outside the text that could be used to identify times of day. The teacher then placed the students in small groups and assigned them the task of sorting the words into the appropriate segment of the day: morning, afternoon, evening, or night. For example, *dawn* was grouped with other morning words. These word groups were placed on the mathematics word wall (MP6).

After much conversation about time vocabulary, which included adding words for time intervals to the word wall (e.g., *day, week, month, second, minute*), students estimated how many times they could do a specific activity in a certain period of time: "How many times can I touch my knee, then my shoulder, in 15 seconds?" and "How many times can I write my name in cursive in one minute?" The students were interested to see how their conjectures stood up when they actually tried the activities, thus developing some understanding of the lengths of different time intervals as they connected them to their own actions (MP4).

In teaching about elapsed time, the teacher included only one task based on *Working Cotton*: finding the amount of time that passed between the arrival of Shelan and her family in the fields before sunrise and their departure for home after sunset. The other tasks dealt with contexts that students might experience more directly. Students developed their own strategies for solving problems involving elapsed time and were remarkably successful with this concept, one that many third graders find difficult to grasp (MP1; 3.MD.A.1).

The teacher and students then explored the sequence of events, which is addressed in the Common Core State Standards for English Language Arts (NGA Center and CCSSO 2010). CCSS.ELA-LITERACY.Rl.3.3 specifies, "Describe characters in a story (e.g., their traits, motivations, or feelings) and explain how their actions contribute to the sequence of events." This lesson used timelines, a powerful tool for representing chronology. Because timelines are a subset of number line diagrams, this strategy met the intent of content standard 3.MD.A.1, which suggests the use of number line diagrams for representing time intervals.

Several related lessons were organized to broaden students' understanding of time intervals. When students were able to retell the story of *Working Cotton*, putting the events of the story in order, they solved several problems of increasing difficulty related to the time intervals between events (e.g., "Shelan's family might have arrived at the fields at 4:15 a.m. and left for home at 6:45 p.m. How long were they in the fields that day?") Students could choose to solve these problems in ways that made sense to them by using representations such as clock faces, tallies, and drawings, with no expectation of a standard method (MP5, according to the emphasis of instruction).

Extensions of the Concepts

Related lessons expanded and reinforced students' understanding of concepts related to time:

- The teacher read aloud *Alexander and the Terrible, Horrible, No Good, Very Bad Day* by Judith Viorst (1972). Students examined the time vocabulary found in this book and used their knowledge to create a timeline of what happened during Alexander's day (MP4).
- Just as *Working Cotton* chronicled a day in Shelan's life, each student chronicled either a typical day or one of the worst days in his or her life in a personal mini-book (see figure 1.1) (MP4).

Fig. 1.1. Example of an event from a student's worst day (Monroe, Orme, and Erickson 2002, Figure 5, p. 478)

- After making a timeline of the typical events of a school day, students worked in small groups to represent and illustrate time for five events: "mathematics time, recess, writer's workshop, library time, and close of the school day" (Monroe, Orme, and Erickson 2002, p. 478) (MP4).
- Students made individual timelines to sequence events from their own lives (MP4).

Through these and other tasks, students deepened their understanding of time-related concepts. While they relied on various tools to create representations, the emphasis was on timelines, which connected both conceptually and procedurally to their previous uses of number lines.

Underlying the use of timelines is a linear notion of time, common in Eurocentric cultures. This perspective is important for children to learn, as our informational and technological society functions primarily within it. However, those involved in the project realize in retrospect that we missed opportunities to guide students in noting naturally occurring regularities—such as daily sunrises and sunsets, months, repeating seasons, and years—that contribute to a cyclical view of time for some peoples and cultures (see Black Elk's "Power of the Circle" that precedes this chapter). Perhaps Shelan and her family organized their lives according to cycles of various harvests in season and thus viewed time accordingly, as did Chico in *First Day in Grapes* (Pérez 2002). Ethnomathematics—the study of the relationship between mathematics and culture—teaches us that not everyone has, or has always had, equal devotion to a strictly Eurocentric view of time.

Because time is ephemeral—"Time is the stuff that slips away, never to return" (Robbins 2010, p. 42)—it can be an especially difficult concept for elementary school students to grasp. However, many if not most mathematical ideas can be difficult at some level and may be seen as irrelevant by students if conceptual understanding is bypassed and replaced immediately by procedures.

> Many children view mathematics as a series of rules to follow or facts to memorize; they do not see the relevance of mathematics to their own lives. Using math-related children's literature can help children realize the variety of situations in which people use mathematics for real purposes. (Whitin 1994, p. 4)

In the reality of the classroom, *understanding* time may be equated simply with *telling* time, which may not be addressed beyond the procedural level.

Children's Literature in the Mathematics Classroom

Using children's literature in the mathematics classroom is a relatively new practice. Its gradual development and increasing popularity reflect some recent changes in how mathematics instruction is conceived and implemented.

Progress in Professional Recognition

The years 1967 and 1969 were the two earliest dates for which we found publications on this topic. In 1967, Grossman published a chapter titled "Developing Cognitive Abilities with Mathematics Trade Books" in an edited volume on the use of supplementary books in the classroom. Soon afterward, an article by Strain (1969) titled "Children's Literature: An Aid in Mathematics Instruction" appeared in *The Arithmetic Teacher*. However, these publications, as helpful as they may have been, were not enough to propel the practice into the mainstream, and we found little more published on this topic until the late 1980s. Even at that time, the ideas published were based more on wisdom of practice gained from classroom use (e.g., Harsh 1987) than on research. By the early ’90s, using children’s literature to teach mathematics had gained a foothold in some classrooms, encouraging a flurry of titles published by already accomplished authors of children’s literature and others who joined the effort to supply teachers with “mathy” books.

The quality of the children’s literature itself soon became a concern, and in the next few years several articles appeared on how to choose children’s literature for use in teaching mathematics (e.g., Hellwig, Monroe, and Jacobs 2000; Hunsader 2004). While those writing about children’s literature and mathematics have demonstrated some shades of difference in their perceptions of whether a book can be considered “quality” literature, most would agree that books appearing to be mathematics practice pages sandwiched between two colorful covers are really not “literature” at all.

For us, the criterion developed by C. S. Lewis (1966) has remained constant: “I am almost inclined to set it up as a canon that a children’s story which is enjoyed only by children is a bad children’s story. The good ones last” (p. 24).

Books to Consider

When examining literature to use in deepening children’s knowledge of mathematics, we considered the many subgenres of fiction and nonfiction literature as an open palette from which to choose. Our primary concern was not genre or subgenre, but whether the mathematics flows naturally from the context of the selection. In some books, the mathematics is both explicit and beautifully presented. We suspect that an extra measure of the ability to write and illustrate gracefully is needed to create such books. In this chapter we focus on *One Grain of Rice: A Mathematical Folktale* by Demi (1997) and *The Librarian Who Measured the Earth* by Kathryn Lasky (1994) as two exemplars. If we substitute quirky for graceful as our adjective, we would add *Counting on Frank* by Rod Clement (1991). (Selecting children’s books for use in mathematics instruction is addressed thoroughly in chapter 2.)

One Grain of Rice: A Mathematical Folktale tells the story of a selfish raja who kept all the villagers’ rice during a time of famine. He was successful until a young girl in his kingdom used the power of doubling to trick the raja so she could help her hungry community. In *The Librarian Who Measured the Earth*, Lasky tells of the Greek philosopher Eratosthenes and his amazing feat of using geometry to measure Earth’s circumference accurately. In *Counting on Frank*, both the text and the illustrations contribute to the appeal of this story about a boy who made use of his dog, Frank, and other animals and objects as units of measurement.

In some books, including *Working Cotton*, the mathematics is implicit—“content invisible,” according to the categories provided by Columba, Kim, and Moe (2005, p. 33). For these books, appropriate uses may be seen by readers who are especially attuned to the beauty of the mathematics within the beauty of the words or the illustrations.

While any efforts to force connections with mathematics should, in our opinion, be discouraged, once authentic mathematics connections are observed or discovered, the teacher may use those points of connection to design tasks that launch exploration and help children develop and extend mathematical meaning.

Construction of the Research Base

Before we could answer the question that titles this chapter—“Why use children’s literature in mathematics?”—we needed to explore the research grounding this practice. We also needed to know what teachers are learning as they use children’s literature in their classrooms—their *wisdom of practice*—even if they do not choose to conduct research on what they learn.

We know that teachers employ many effective practices for which there may be little research evidence. But as accountability increases in education and research-based best practices are highly valued, policymakers may give little support to practices such as using children’s literature to teach mathematics. Such instruction may not be perceived as directly related to content instruction or may be considered merely “fun” for children. Some teachers may even think, “How dare we use 15, 10, or even 5 minutes of precious academic learning time during mathematics to share a children’s book?”

Search for Sources

We undertook a search, review, and analysis of sources on using children’s literature in teaching mathematics. We started by searching ERIC using *children’s literature* and *mathematics* as descriptors, which yielded 809 hits—333 educational journals (EJs) and 476 educational documents (EDs). Using *trade books* and *mathematics* as descriptors, we found 100—19 EJs and 81 EDs, with some overlap between the two searches. Google Scholar, which searches more broadly, brought up thousands of sources.

We searched exhaustively through these results, as well as their reference lists and bibliographies, for sources with national or international circulation that teachers and librarians might readily access. In our database, we did not include sources accessible only on the Internet, partially due to the transitory nature of many links. With the help of several research assistants over a period of many years, more than 400 articles and books were reviewed and annotated. These documents are dated from 1967 through January 2015, and their annotations are included as entries in a Children’s Literature Bibliograhy in More4U. Approximately 88 percent of these entries have an elementary school focus.

We selected from this Annotated Bibliograpy the entries that reported research on the effects of using children’s literature in teaching K–6 mathematics—in all, twenty-one sources. The preponderance of the research was conducted with children at or below third grade. (Chapter 7 reports research at the pre-K level on using children’s literature to teach mathematics; research on this topic appears almost nonexistant for students beyond the middle school level.)

We considered as *research* those sources that stated a question to be answered; described some form of systematic plan for collecting, organizing, and analyzing data (quantitative, qualitative, or both); and reported and discussed their findings. Most of the sources in the Annoted Bibliograpy described "what happened" when teachers used children's literature in teaching mathematics, which contributed to our knowledge of wisdom of practice but did not meet the parameters of rersearch as we defined it for this study.

Sources for *wisdom of practice* included articles and books that discussed the use of children's literature in mathematics classrooms but were not reports of research studies. The first author of this chapter has interviewed teachers incidentally over the years at various professional development presentations and workshops she has conducted on this topic, and her informal findings corroborate the wisdom of practice that we report. We chose not to privelege one of those knowledge bases over another, we believe that there is much to be learned through the differing lenses that each perspective provides.

Description of Sources

We reviewed a total of twenty-one studies: fourteen articles, four master's theses, two doctoral dissertations, and one ERIC document. Seven studies were quantitative, eight were qualitative, and six employed mixed methods—both quantitative and qualitative—to study the effects of using children's literature to teach mathematics. Most studies involved children in grade 3 or below. (See appendix 1.B for a listing of the studies reviewed.)

The quantitative studies specified the variables (e.g., achievement, interest, attitude) that researchers examined among students as they incorporated children's literature into mathematics. Most quantitative studies derived their data from pre- and posttests targeting a specified variable or variables under study. Five of the qualitative studies specified *a priori* codes. The remaining three qualitative studies employed tasks for the students, using open coding to analyze a variety of data collected during the study, including student work.

Summary of Study Content

Children's literature selections used in instruction for these studies, regardless of the methodology, were primarily content-explicit, strategically chosen to contribute to the mathematics being examined. Implementation varied according to individual classrooms and teachers. After we combed each study for research-based effects of the implementation, we grouped the findings according to these effects and tallied them by occurrence. Together, the studies found fifteen distinct benefits of using children's literature to teach mathematics:

- Increases mathematics achievement
- Builds interest in and a positive attitude toward mathematics
- Engages students in mathematical discourse

- Deepens conceptual understanding
- Provides connections to students' lives and/or other mathematics content
- Provides a meaningful context for learning mathematics
- Improves problem-solving abilities
- Increases mathematics vocabulary
- Enhances justification and reasoning
- Enhances numeracy learning
- Increases mathematical confidence
- Integrates mathematical content across subject areas
- Reduces mathematics anxiety
- Helps students access prior knowledge
- Develops critical-thinking skills

All but two of these findings, the last two listed, were replicated in at least one other study. Of particular note is that no negative findings were identified, regardless of the type of methodology used, and each methodology appeared to be effective in surfacing benefits. Labeled in truncated form to fit the space available, these benefits are shown in figure 1.2.

Of the sixty-two occurrences of benefits in the research literature, approximately 39 percent fell into three categories: (*a*) increased mathematics achievement (found in eleven studies), (*b*) increased interest in and a more positive attitude toward mathematics (seven studies), and (*c*) increased engagement in mathematical discourse (six studies). Each benefit is illustrated in greater detail below.

Increased Mathematics Achievement

As anticipated in our achievement-driven world of schooling, mathematics achievement was a major focus of study—and researchers were not disappointed with their findings. Three of the seven quantitative studies examined achievement when children's literature was used in mathematics instruction, and all showed significant increases for this variable. Similarly, all six mixed-methods studies demonstrated increases in mathematics

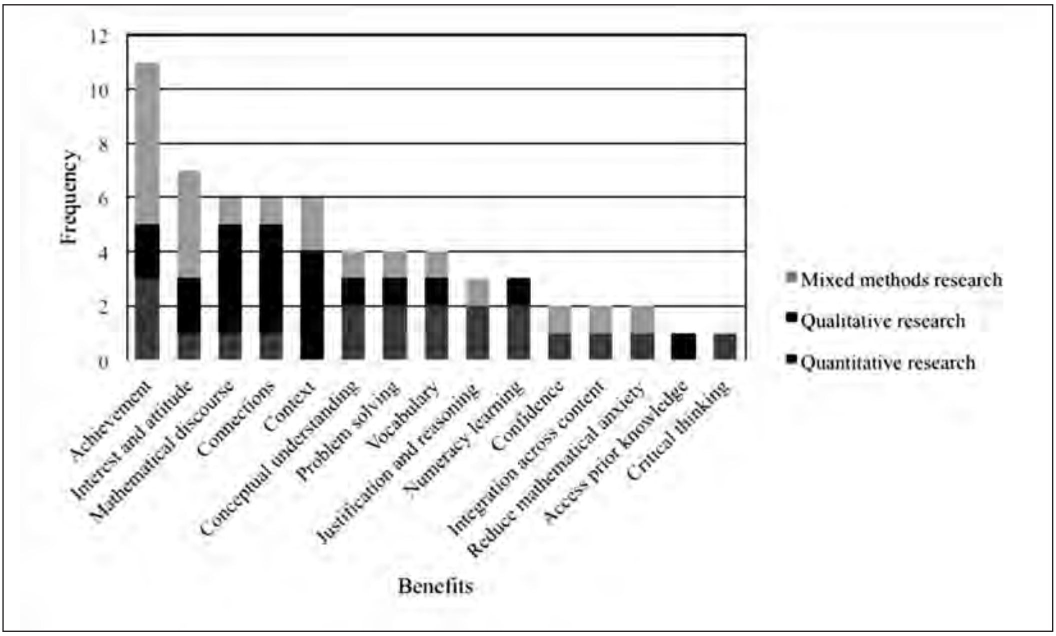

Fig. 1.2. Research-based benefits of using children's literature to teach mathematics

achievement, and achievement emerged as one of several findings in two qualitative studies.

A number of research studies revealed increased mathematics achievement with the use of children's literature across all elementary school grade levels and a wide variety of mathematics concepts and skills. Two representative studies included success in teaching multiplication and division with mid-level elementary school students. In a quantitative study that compared instruction using children's literature with direct instruction on the same content, Thomas and Feng (2015) found that using *The Doorbell Rang* by Pat Hutchins (1986) with fourth graders resulted in gains in both conceptual and procedural knowledge of division. In a mixed-methods study, Morgan (2007) similarly worked with an experimental and a control group, each consisting of thirty-six third graders, in teaching multiplication and division. He used four stories to construct lessons for the experimental group: *Two of Everything* by Lily Hong (1993) and *One Hundred Hungry Ants* by Elinor Pinczes (1999) for multiplication, and *The Doorbell Rang* by Pat Hutchins (1986) and *17 Kings and 42 Elephants* by Margaret Mahy (1987) for division. Morgan reported that students in the experimental groups performed better on multiplication and division posttests than did students in the control groups. His conclusion:

> Storytelling, using children's literature, can increase student achievement in mathematics. Combined with opportunities for student interaction, discussion, and application, students develop a connection between the stories and mathematics and are able to apply what they learn to assessments. (p. 89)

Capraro and Capraro (2006) analyzed one sixth-grade teacher's use of *Sir Cumference and the Dragon of Pi: A Math Adventure* by Cindy Neuschwander (1998) to supplement geometry instruction, specifically, a study of circles. Through mixed methods, the researchers found an increase in students' justification and reasoning, understanding, connections, and vocabulary.

Increased Interest and a More Positive Attitude Toward Mathematics

Interest and attitude are generally recognized as factors that affect how learners engage in tasks and persevere with them—and they are particularly important in learning mathematics (Jennings et al. 1992, p. 271). An increased interest in and improved attitude toward mathematics were found in seven of the studies we reviewed. For example, Keat and Wilburne's (2009) study was designed "to understand how storybooks might influence both achievement of learning objectives and positive approaches to learning mathematics in three kindergarten classes" (p. 62). The classroom teachers shared and discussed with their students several children's literature selections related to money, including *Benny's Pennies* by Pat Brisson (1995) and *Minnie's Diner: A Multiplying Menu* by Dayle Dodds (2004). The researchers' commentary, based on their field notes, revealed the following:

> The children's comments and questions during the reading of each storybook pointed out that they were "enthusiastically interested" in the storybook characters and "actively engaged" in making meaning of the story actions and contexts. Further, the children "enjoyed" imagining about the story as it was written and also as the children themselves re-imagined. . . . Simultaneously, the children maintained "interest" in the characters and the related mathematics activity over a period of time. Even when achieving understanding that was difficult and required persistent effort, the children continued to talk, manipulate materials, ask questions and struggle for comprehension. (p. 66) (MP1)

Increased Engagement in Mathematical Discourse

Engaging students in mathematical discourse has been promoted by mathematics educators for many years (e.g., National Council of Teachers of Mathematics [NCTM] 1989, 1991, 2000). More recently, *Principles to Actions: Ensuring Mathematical Success for All* (NCTM 2014) included the facilitation of meaningful mathematical discourse as one of eight recommended mathematics teaching practices: "Effective teaching of mathematics facilitates discourse among students to build shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments" (p. 10). What better way to encourage development of mathematical discourse than to use an inviting children's book that contributes to building mathematical ideas?

The benefits of engaging students in mathematical discourse were noted in six of the studies we examined: one quantitative, four qualitative, and one mixed-methods study. Two qualitative studies—Adams and Lowery (2007) and Anderson and Anderson (1995)—are especially illustrative of these benefits.

According to Adams and Lowery (2007), "*Moira's Birthday* [by Robert Munsch (1987)] demonstrates how complex mathematical languages can be embedded in children's literature. As children are taught to read the language of mathematics in literature, they develop better strategies" for communicating mathematically (p. 174) (MP6). The researchers also emphasize the role of *terminology* (academic vocabulary) in mathematical discourse.

In a two-year case study of parents and their daughter from age 4 to age 6, Anderson and Anderson (1995) found that mathematical discourse was promoted through parent-child interactions during shared reading of children's literature selections, which included *The Brave Little Tailor* (retold) by Anne McKie (1983), *La Maison de Barbapapa* by Annette Tison and Talus Taylor (1972), *The Foot Book* by Dr. Seuss (1968), *Seven Eggs* by Meredith Hooper (1985), *One Snowy Night* by Nick Butterworth (1989), and *Les Animaux du Zoo* by Pierre Coran (1983). According to the researchers:

> It is the parent-child interactions which encourage talking about mathematics and communicating mathematical ideas. In addition, the interactive nature of shared reading permits either participant to extend or elaborate upon the mathematical concepts present as well as use talk as a scaffold to develop the child's mathematical thinking. (p. 7)

Additional Benefits

Although the remaining twelve benefits appear less frequently in the literature, they may be equally compelling to many readers. As the research base is thin, attempting assertions about the generalizability or transferability of the findings of our review would likely be unwise.

Wisdom of Practice

Our wisdom of practice database was by no means exhaustive in representing the wisdom of practice of teachers in the field. We included articles and books that dealt with children's literature and mathematics but were not research reports, as well as notes from various professional development workshops conducted by the first author of this chapter.

more4U

Research reports can be found in the Children's Literature Annotated Bibliography, located in the More4U section of the NCTM website (www.nctm.org/more4u).

We found that wisdom of practice and research findings regarding the benefits of using children's literature in mathematics instruction were, to a large extent, mutually confirming. As with research reports, to this point wisdom of practice has revealed no prevailing negative effects or observations regarding the use of children's literature in the mathematics classroom. However, we did note two common concerns expressed by teachers:

- Some teachers are concerned about cutting into the time devoted to teaching mathematics. Using the same children's book for meeting a language or literacy goal in addition to mathematics instruction, we learned, can allay this concern.
- Some teachers are concerned that they have inadequate knowledge of and access to children's books that contribute to worthwhile mathematical tasks. Our hope is that this book and the accompanying More4U materials will reduce this concern.

A survey of the wisdom-of-practice resources in the Children's Literature Annotated Bibliography and the records of professional workshops on the topic revealed eleven common benefits of using children's literature to teach mathematics:

- Positively impacts student experiences with and attitudes toward mathematics
- Gives a context to help students better understand mathematical concepts
- Helps students make connections between (*a*) mathematics and real life, (*b*) mathematics concepts, and (*c*) mathematics and other content areas
- Provides language that can be useful for proposing problems to be solved in a meaningful way
- Elicits curiosity and interest in the mathematics concepts presented in the stories or other text being read
- Offers a nonthreatening approach to subject areas that can be intimidating, such as mathematics or science, serving as a natural motivator for many children
- Makes abstract ideas represented with numbers and symbols seem more concrete and easier to understand
- Helps students see mathematics as relevant, and gives personal meaning to mathematics in their lives
- Acts as a springboard for exciting mathematical tasks that are based in the children's literature, thus encouraging students to become immersed in mathematical concepts
- Promotes deeper discussion among teachers and students about the concept being explored
- Encourages learners to be mathematical problem solvers

Invitation to Readers

This chapter has focused on the *why* of using children's literature in teaching mathematics. Our hope is that the combination of our detailed examples based on *Working Cotton,* the body of research literature we have summarized, and the wisdom of practice we have reported have effectively demonstrated why this practice continues to grow in use and acclaim. Nonetheless, this chapter remains incomplete; there is much still to be learned about why teachers do and should use children's literature in the mathematics classroom.

While this chapter does not focus on the *how* of this practice, numerous sources—both research and wisdom of practice—in the Children's Literature Annotated Bibliography do include this focus. The Annotated Bibliography can be found in the More4U section of the NCTM website (www.nctm.org/more4u).

Those who desire to contribute to this increasing knowledge base might be interested in conducting teacher research and submitting a manuscript to a journal such as *Teaching Children Mathematics* or *Mathematics Teaching in the Middle School* (both are NCTM publications). Those who do not wish to conduct "teacher research with a capital R" may want to write more generally about how they used a specific children's book and what they learned from it, thus contributing to wisdom of practice. The journals named above accept informative and carefully written manuscripts of both types.

Others may want to contribute what they are learning about using children's literature in mathematics teaching by speaking at a conference on this topic, sharing in grade-level team meetings, starting and maintaining a blog, or participating in an online discussion group—all of which are important ways to build the knowledge base and continue to refine and extend this practice.

All these venues, and others that readers may know of or discover, can empower educators to make a difference in deepening what is understood in the education professions about teaching mathematics through children's literature.

References

Adams, Thomasenia Lott, and Ruth McKoy Lowery. "An Analysis of Children's Strategies for Reading Mathematics." *Reading and Writing Quarterly* 23, no. 2 (2007): 161–77.

Anderson, Ann, and Jim Anderson. "Learning Mathematics Through Children's Literature: A Case Study." *The Canadian Journal of Research in Early Childhood Education* 4, no. 2 (1995): 1–9.

Black Elk as told through John Gneisenau Neihardt. *Black Elk Speaks: Being the Life Story of a Holy Man of the Oglala Sioux.* Lincoln: University of Nebraska Press, 1979.

Capraro, Robert M., and Mary M. Capraro. "Are You Really Going to Read Us a Story? Learning Geometry Through Children's Mathematics Literature." *Reading Psychology* 27, no. 1 (2006): 21–36.

Columba, Lynn, Cathy Y. Kim, and Alden J. Moe. *The Power of Picture Books in Teaching Math and Science: Grades PreK–8*. Scottsdale, AZ: Holcomb Hathaway, 2005.

Grossman, Anne S. “Developing Cognitive Abilities with Mathematics Trade Books.” In *Reading and Thinking: Using Supplementary Books in the Classroom,* edited by Maurice J. Eash. Garden City, NY: Doubleday & Co., 1967.

Harsh, Ann. “Teach Mathematics with Children’s Literature.” *Young Children* 42, no. 6 (1987): 24–29.

Hellwig, Stacey, Eula E. Monroe, and James S. Jacobs. “Making Informed Choices: Selecting Children’s Trade Books for Mathematics Instruction.” *Teaching Children Mathematics* 7, no. 3 (2000): 138–43.

Hunsader, Patricia D. “Mathematics Trade Books: Establishing Their Value and Assessing Their Quality.” *The Reading Teacher* 57, no. 7 (2004): 615–29.

Jennings, Clara M., James E. Jennings, Joyce Richey, and Lisbeth Dixon-Krauss. “Increasing Interest and Achievement in Mathematics Through Children’s Literature.” *Early Childhood Research Quarterly* 7, no. 2 (1992): 263–76.

Keat, Jane B., and Jane M. Wilburne. “The Impact of Storybooks on Kindergarten Children’s Mathematical Achievement and Approaches to Learning.” *US-China Education Review* 6, no. 7 (2009): 61–67.

Lewis, C. S. “On Three Ways of Writing for Children.” In *Of Other Worlds: Essays and Stories,* edited by Walter Hooper, pp. 23–27. New York: Harcourt, 1966.

Monroe, Eula E., Michelle P. Orme, and Lynnette B. Erickson. “*Working Cotton:* Toward an Understanding of Time.” *Teaching Children Mathematics* 8, no. 8 (2002): 475–79.

Morgan, André Sandell. “Alternative Methodologies for Teaching Mathematics to Elementary Students: A Pilot Study Using Children’s Literature.” Doctoral dissertation, American University, Washington, D.C., 2007.

National Council of Teachers of Mathematics (NCTM). *Curriculum and Evaluation Standards for School Mathematics.* Reston, VA: NCTM, 1989.

———. *Professional Standards for Teaching Mathematics.* Reston, VA: NCTM, 1991.

———. *Principles and Standards for School Mathematics*. Reston, VA: NCTM, 2000.

———. *Principles to Actions: Ensuring Mathematical Success for All*. Reston, VA: NCTM, 2014.

National Governors Association Center for Best Practices and Council of Chief State School Officers (NGA Center and CCSSO). *Common Core State Standards for English Language Arts*. Washington, DC: NGA Center and CCSSO, 2010a, http://www.corestandards.org.

———. *Common Core State Standards for Mathematics.* Washington, DC: NGA Center and CCSSO, 2010b, http://www.corestandards.org.

Robbins, Ken. *For Good Measure: The Ways We Say How Much, How Far, How Heavy, How Big, How Old*. New York: Roaring Brook Press, 2010.

Strain, Lucille B. “Children’s Literature: An Aid in Mathematics Instruction.” *The Arithmetic Teacher* 16, no. 6 (1969): 451–55.

Thomas, Lynsey, and Jay Feng. "Integrating Children's Literature in Elementary Mathematics." Presentation at the annual convention of the Georgia Educational Research Association, Savannah, GA, October 16–17, 2015.

Whitin, David J. "Literature and Mathematics in Preschool and Primary: The Right Connection." *Young Children* 49, no. 2 (1994): 4.

Williams, Sherley Anne. *Working Cotton*. Orlando, FL: Harcourt Brace Jovanovich, 1992.

Children's Books Cited in Chapter 1

Brisson, Pat. *Benny's Pennies*. Illustrated by Bob Barner. New York: Dragonfly, 1995.

Butterworth, Nick. *One Snowy Night*. New York: HarperCollins, 1992.

Clement, Rod. *Counting on Frank*. Milwaukee, Gareth Stevens, 1991.

Coran, Pierre. *Les Animaux du Zoo*. Roubaix, France: Chantecler, 1983.

Demi. *One Grain of Rice: A Mathematical Folktale*. New York: Scholastic Press, 1997.

Dodds, Dayle. *Minnie's Diner: A Multiplying Menu*. Illustrated by John Manders. Somerville, MA: Candlewick Press, 2004.

Hong, Lily T. *Two of Everything*. Park Ridge, IL: Albert Whitman & Company, 1993.

Hooper, Meredith. *Seven Eggs*. Illustrated by Terry McKenna. New York: Harper & Row, 1985.

Hutchins, Pat. *The Doorbell Rang*. New York: Greenwillow Books, 1986.

Lasky, Kathryn. *The Librarian Who Measured the Earth*. Illustrated by Kevin Hawkes. Boston: Little, Brown Books for Young Readers, 1994.

Mahy, Margaret. *17 Kings and 42 Elephants*. Illustrated by Patricia MacCarthy. New York: Dial Books for Young Readers, 1987.

McKie, Anne (retold). *The Brave Little Tailor*. Illustrated by Ken McKie. London, UK: Ladybird Books, 1983.

Munsch, Robert. *Moira's Birthday*. Illustrated by Michael Martchenko. New York: Annick Press Ltd., 1987.

Neuschwander, Cindy. *Sir Cumference and the Dragon of Pi: A Math Adventure*. Illustrated by Wayne Geehan. Watertown, MA: Charlesbridge Publishing, 1999.

Pérez, L. K. *First Day in Grapes*. Illustrated by Robert Casilla. New York: Lee & Low Books Inc., 2002.

Pinczes, Elinor J. *One Hundred Hungry Ants*. Illustrated by Bonnie MacKain. New York: Houghton Mifflin Company, 1999.

Seuss, Dr. *The Foot Book*. New York: Random House, Inc., 1968.

Tison, Annette, and Talus Taylor. *La Maison de Barbapapa*. Paris, France: Ecole des Loisirs, 1972.

Viorst, Judith. *Alexander and the Terrible, Horrible, No Good, Very Bad Day*. Illustrated by Ray Cruz. New York: Atheneum Books for Young Readers, 1972.

Appendix 1.A

CCSSM Standards for Mathematical Practice

Standard	Description
MP1	**Make sense of problems and persevere in solving them.** Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems, and try special cases and simpler forms of the original problem in order to gain insight into its solution. They monitor and evaluate their progress and change course if necessary. Older students might, depending on the context of the problem, transform algebraic expressions or change the viewing window on their graphing calculator to get the information they need. Mathematically proficient students can explain correspondences between equations, verbal descriptions, tables, and graphs or draw diagrams of important features and relationships, graph data, and search for regularity or trends. Younger students might rely on using concrete objects or pictures to help conceptualize and solve a problem. Mathematically proficient students check their answers to problems using a different method, and they continually ask themselves, "Does this make sense?" They can understand the approaches of others to solving complex problems and identify correspondences between different approaches.

MP2	**Reason abstractly and quantitatively.** Mathematically proficient students make sense of quantities and their relationships in problem situations. They bring two complementary abilities to bear on problems involving quantitative relationships: the ability to decontextualize—to abstract a given situation and represent it symbolically and manipulate the representing symbols as if they have a life of their own, without necessarily attending to their referents—and the ability to contextualize, to pause as needed during the manipulation process in order to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.
MP3	**Construct viable arguments and critique the reasoning of others.** Mathematically proficient students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They are able to analyze situations by breaking them into cases, and can recognize and use counterexamples. They justify their conclusions, communicate them to others, and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose. Mathematically proficient students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in an argument—explain what it is. Elementary students can construct arguments using concrete referents such as objects, drawings, diagrams, and actions. Such arguments can make sense and be correct, even though they are not generalized or made formal until later grades. Later, students learn to determine domains to which an argument applies. Students at all grades can listen or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments.

MP4	**Model with mathematics.** Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. In early grades, this might be as simple as writing an addition equation to describe a situation. In middle grades, a student might apply proportional reasoning to plan a school event or analyze a problem in the community. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. Mathematically proficient students who can apply what they know are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.
MP5	**Use appropriate tools strategically.** Mathematically proficient students consider the available tools when solving a mathematical problem. These tools might include pencil and paper, concrete models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software. Proficient students are sufficiently familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations. For example, mathematically proficient high school students analyze graphs of functions and solutions generated using a graphing calculator. They detect possible errors by strategically using estimation and other mathematical knowledge. When making mathematical models, they know that technology can enable them to visualize the results of varying assumptions, explore consequences, and compare predictions with data. Mathematically proficient students at various grade levels are able to identify relevant external mathematical resources, such as digital content located on a website, and use them to pose or solve problems. They are able to use technological tools to explore and deepen their understanding of concepts.

MP6	**Attend to precision.** Mathematically proficient students try to communicate precisely to others. They try to use clear definitions in discussion with others and in their own reasoning. They state the meaning of the symbols they choose, including using the equal sign consistently and appropriately. They are careful about specifying units of measure, and labeling axes to clarify the correspondence with quantities in a problem. They calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the problem context. In the elementary grades, students give carefully formulated explanations to each other. By the time they reach high school they have learned to examine claims and make explicit use of definitions.
MP7	**Look for and make use of structure.** Mathematically proficient students look closely to discern a pattern or structure. Young students, for example, might notice that three and seven more is the same amount as seven and three more, or they may sort a collection of shapes according to how many sides the shapes have. Later, students will see 7×8 equals the well remembered $7 \times 5 + 7 \times 3$, in preparation for learning about the distributive property. In the expression $x^2 + 9x + 14$, older students can see the 14 as 2×7 and the 9 as $2 + 7$. They recognize the significance of an existing line in a geometric figure and can use the strategy of drawing an auxiliary line for solving problems. They also can step back for an overview and shift perspective. They can see complicated things, such as some algebraic expressions, as single objects or as being composed of several objects. For example, they can see $5 - 3(x - y)^2$ as 5 minus a positive number times a square and use that to realize that its value cannot be more than 5 for any real numbers x and y.

MP8	**Look for and express regularity in repeated reasoning.** Mathematically proficient students notice if calculations are repeated, and look both for general methods and for shortcuts. Upper elementary students might notice when dividing 25 by 11 that they are repeating the same calculations over and over again, and conclude they have a repeating decimal. By paying attention to the calculation of slope as they repeatedly check whether points are on the line through (1, 2) with slope 3, middle school students might abstract the equation $(y - 2)/(x - 1) = 3$. Noticing the regularity in the way terms cancel when expanding $(x - 1)(x + 1)$, $(x - 1)(x^2 + x + 1)$, and $(x - 1)(x^3 + x^2 + x + 1)$ might lead them to the general formula for the sum of a geometric series. As they work to solve a problem, mathematically proficient students maintain oversight of the process, while attending to the details. They continually evaluate the reasonableness of their intermediate results.

Appendix 1.B

Bibliography of Research Studies Examined

Annotations for these studies can be found in the Children's Literature Annotated Bibliography, located in the More4U section of the NCTM website (www.nctm.org/more4u).

Quantitative Studies	
Reference	**Benefits**
Azad, Antoinette. "Children's Literature and Math: How ELLs Benefit." Master's thesis, Hamline University, St. Paul, MN, 2008.	• Mathematical discourse • Vocabulary
Burnett, Sarah J., and Ann M. Wichman. "Mathematics and Literature: An Approach to Success." Master's thesis, St. Xavier University, Chicago, IL, 1997.	• Connections • Problem solving • Reduction of mathematics anxiety
Carlson, Angela, Deborah Floto, and Barbara Mays. "Using Children's Literature to Develop and Advance Problem Solving and Critical Thinking in Mathematics." Master's thesis, St. Xavier University, Chicago, IL, 1997.	• Critical thinking • Problem solving
Jennings, Clara M., James E. Jennings, Joyce Richey, and Lisbeth Dixon-Krauss. "Increasing Interest and Achievement in Mathematics Through Children's Literature." *Early Childhood Research Quarterly* 7, no. 2 (1992): 263–76.	• Achievement • Interest and attitude • Vocabulary
Roberts, Nicky, and Andreas J. Stylianides. "Telling and Illustrating Stories of Parity: A Classroom-Based Design Experiment on Young Children's Use of Narrative in Mathematics." *ZDM Mathematics Education* 45, no. 3 (2012): 453–67.	• Achievement • Conceptual understanding • Justification and reasoning • Numeracy learning

Thomas, Lynsey, and Jay Feng. "Integrating Children's Literature in Elementary Mathematics." Presentation at the annual convention of the Georgia Educational Research Association, Savannah, GA, October 2015.	• Achievement • Conceptual understanding • Confidence • Integration across content • Justification and reasoning
Young-Loveridge, Jennifer M. "Effects on Early Numeracy of a Program Using Number Books and Games." *Early Childhood Research Quarterly* 19, no. 1 (2004): 82–98.	• Numeracy learning
Qualitative Studies	
Reference	**Benefits**
Adams, Thomasenia Lott, and Ruth McKoy Lowery. "An Analysis of Children's Strategies for Reading Mathematics." *Reading and Writing Quarterly* 23, no. 2 (2007): 161–77.	• Access to prior knowledge • Connections • Context • Mathematical discourse • Problem solving
Anderson, Ann, and Jim Anderson. "Learning Mathematics Through Children's Literature: A Case Study." *The Canadian Journal of Research in Early Childhood Education* 4, no. 2 (1995): 1–9.	• Context • Mathematical discourse • Numeracy learning
Blessman, Jennifer, and Beverly Myszczak. "Mathematics Vocabulary and Its Effect on Student Comprehension." Master's thesis, St. Xavier University, Chicago, IL, 2001.	• Vocabulary
Castle, Kathryn, and Jackie Needham. "First Graders' Understanding of Measurement." *Early Childhood Education* 35, no. 3 (2007): 215–21.	• Connections

Elia, Iliada, Marja van den Heuvel-Panhuizen, and Alexia Georgiou. "The Role of Picture Books on Children's Cognitive Engagement with Mathematics." *European Early Childhood Research Journal* 18, no. 3 (2010): 275–97.	• Mathematical discourse
Leonard, Jacqueline, Moore, Cara M., and Wanda Brooks. "Multicultural Children's Literature as a Context for Teaching Mathematics for Cultural Relevance in Urban Schools." *The Urban Review* 46 (2014): 325–48.	• Achievement • Connections • Context • Interest and attitude
Van den Heuvel-Panhuizen, Marja, and Sylvia van den Boogaard. "Picture Books as an Impetus for Kindergartners' Mathematical Thinking." *Mathematical Thinking and Learning* 10 (2008): 341–73.	• Mathematical discourse
Wilburne, Jane Murphy, Mary Napoli, Jane B. Keat, Kimberly Dile, Michelle Trout, and Suzan Decker. "Journeying into Mathematics Through Storybooks: A Kindergarten Story." *Teaching Children Mathematics* 14, no. 4 (2007): 232–37.	• Achievement • Conceptual understanding • Connections • Context • Interest and attitude
Mixed-Methods Studies	
Reference	**Benefits**
Beard, Leigh A. (2003). "The Effects of Integrated Mathematics and Children's Literature Instruction on Mathematics Achievement and Mathematics Anxiety by Gender." Doctoral dissertation, University of Georgia, Athens, GA, 2003.	• Achievement • Reduction in mathematics anxiety

Capraro, Robert M., and Mary M. Capraro. "Are You Really Going to Read Us a Story? Learning Geometry Through Children's Mathematics Literature." *Reading Psychology* 27, no. 1 (2006): 21–36.	• Achievement • Conceptual understanding • Connections • Justification and reasoning • Mathematical discourse • Vocabulary
Hong, Haekyung. "Effect of Mathematics Learning Through Children's Literature on Math Achievement and Dispositional Outcomes." *Early Childhood Research Quarterly* 11, no. 4 (1999): 477–94.	• Achievement • Context • Interest and attitude
Keat, Jane B., and Jane M. Wilburne. "The Impact of Storybooks on Kindergarten Children's Mathematical Achievement and Approaches to Learning." *US-China Education Review* 6, no. 7 (2009): 61–67.	• Achievement • Confidence • Context • Interest and attitude • Problem solving
Mink, Deborah V., and Barry J. Fraser. "Evaluation of a K–5 Mathematics Program Which Integrates Children's Literature: Classroom Environment and Attitudes." *International Journal of Science and Mathematics Education* 3, no. 1 (2005): 59–85.	• Achievement • Integration across content • Interest and attitude
Morgan, André Sandell. "Alternative Methodologies for Teaching Mathematics to Elementary Students: A Pilot Study Using Children's Literature." Doctoral dissertation, American University, Washington, DC, 2007.	• Achievement • Interest and attitude