

Introduction

This book is about math-related literature and how to use it effectively in the elementary classroom. It is a book *for* teachers because it came *from* teachers. It is teachers who showed us the mathematical possibilities of math-related literature by connecting it to the lives of their students. It is teachers who discovered the language arts potential of these same books, as their students used the predictability of mathematical patterns and the clues from illustrations to make sense of these texts. And it is teachers who remarked that using the same literature book in both literacy and mathematics blocks allowed them to effectively address curricular objectives in each of these areas.

We have also had discussions with teachers about how to appropriately select math-related literature. Because of the ever-increasing number of such books on the market, we felt it was important to begin this book with an examination of criteria for evaluating math-related literature. We have linked these criteria to the National Council of Teachers of Mathematics' (NCTM) *Principles and Standards for School Mathematics* (2000) and the National Council of Teachers of English (NCTE) and the International Reading Association's (IRA) *Standards for the English Language Arts* (1996). Highlighting the Standards from both organizations draws attention to the many parallels between them. Both make explicit the importance of reasoning and communicating effectively through writing, talking, and graphic representation. It is our intent that this tying together of both sets of Standards will help teachers justify the decisions they make as they integrate curriculum.

The next three chapters explore effective strategies for using these books with students. In Chapter 2, "Books for a Wide Range of Ages," we show how the same book is used by teachers of many different grade levels, emphasizing how good books have a range of applicability in terms of grade level and mathematical/language arts possibilities. In Chapter 3, "Problem Posing with Children's Literature," we again use specific classroom examples, this time to demonstrate how fruitful extension activities can emerge from children's own questions and observations. In Chapter 4, "Using the Strategy of Book Pairs," we discuss how teachers select two math-related books that provide an interesting comparison and contrast, sharing a range of books and grade-level examples to demonstrate the wide applicability of this strategy. We conclude each of these chapters with a list of additional books for teachers to investigate further.

Finally, in Chapter 5, “Best Books for Exploring,” we provide an annotated list of the best math-related literature available, as well as suggestions for introducing these books to children.

Having described what this book *is*, let’s take a moment to clarify what this book is *not*. First, this book is *not* intended as an entire mathematics or literacy program. At the same time, the experiences we describe are not “enrichment activities” to be added to an already crammed schedule.

We expect that you, like the teachers in this book, will use the books discussed here for a variety of purposes. Some of these purposes include:

- To introduce a mathematical concept or to assess your students’ prior experience and knowledge: What do my students know about fractions? What language do they use to describe fractional situations? What personal experiences do they describe when they hear this story?
- To address mathematical misconceptions: Why is $1/8 < 1/2$? How is perimeter different from area?
- To show another representation of a mathematical idea, such as counting-on by a multiple versus an array (area) model of multiplication.
- To examine the author’s craft and purpose across a wide range of genres.
- To inspire meaningful research and support a variety of individual and collaborative pieces of writing.

Second, we offer the activities in this book *not* as prescriptions to follow but as possibilities to adapt and explore. As you begin to envision these possibilities and plan investigations with your own students, we invite you to consider these questions:

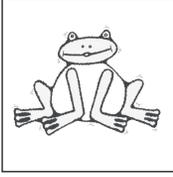
- What are my curricular objectives and standards?
- How might mathematical experiences cross over into language arts, social studies, or science blocks?
- What kind of experiences can I manage most successfully? Do I have the resources that are necessary? How can I adapt this book or activity to fit my own teaching situation?
- When my students hear and view a book, what seems to intrigue them the most? What do they ask questions about? How do their responses tie to other curricular areas?

Just as teachers provided the spark for our writing of this book, we’re confident that you and your students will adapt and transform these strategies in exciting new ways. We hope to hear from you.

References

National Council of Teachers of English and International Reading Association. *Standards for the English Language Arts*. Urbana, IL: National Council of Teachers of English, 1996.

National Council of Teachers of Mathematics. *Principles and Standards for School Mathematics*. Reston, VA: National Council of Teachers of Mathematics, 2000.



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Criteria for Selecting Math-Related Books

It's exciting to visit the exhibit areas of mathematics and language arts conferences these days. Baskets of math-related books beckon us from publishers' booths. We mentally calculate how much our budgets will allow, or how much weight we can bear to carry, as we browse the displays. Just a dozen or so years ago, this scenario would not have occurred. Several factors have contributed to the current interest in integrating literature and mathematics. When the National Council of Teachers of Mathematics (NCTM) first published *Curriculum and Evaluation Standards for School Mathematics* (1989), the role of written and oral communication in promoting mathematical understanding gained new attention. At the same time, literature-based reading programs gained popularity. Soon several resources for teachers (Burns 1992; Whitin and Wilde 1992, 1995) appeared that elaborated on the benefits of using stories as real-life contexts for mathematical ideas; they named specific books that inspire mathematical exploration and outlined strategies for using those books with children. Most mathematics textbook series began to include suggestions for links to literature or provided copies of children's books as part of ancillary materials. More recently, NCTM published *Principles and Standards for School Mathematics* (2000), which further articulates the role of communication in mathematics.

Authors and publishers capitalized on this opportunity to link literature and mathematics. Over the years, the market has been increasingly flooded with hundreds of titles. Not all of these books, however, are of equal quality. Many math-related books seem more like workbooks than stories (Austin 1998; Whitin and Whitin 2001). Some give detailed prescriptions for reading, much like a teaching manual for a basal reader, while others mask doses of "skills" with comical illustrations or popular food products to "motivate" young learners. Others claim to be aligned with the NCTM Standards but with little or no substantiated evidence. Faced with this situation, educators today need specific tools with which to evaluate books for classroom use. In this chapter, we define and explain criteria from

two different perspectives: the mathematical and the language arts. We base our discussion of the mathematical perspective on an opening overview of the Principles and Standards. Next we examine the ways all the criteria apply to one book, *If You Hopped Like a Frog* (Schwartz 1999). Finally, we describe in depth a range of books that specifically exemplify each of the criteria as well as those that do not. Through this illustrated discussion of the book selection process, we set the stage for discussing effective ways of engaging children with that literature.

The Criteria

First and foremost, math-related books should be good *literature*. Both fiction and nonfiction books of good quality engage, inspire, and delight young readers yet appeal to adults as well. They beg rereading. When illustrated, a book's pictures and graphics complement and extend the text. Good books are inclusive by valuing, portraying, and drawing in readers of all ethnicities, cultures, and genders.

You might be saying to yourself at this point, "These are the factors I consider when I choose good read-alouds or books for my classroom library." Absolutely! When selecting and evaluating math-related literature, we begin with these crucial elements. We then specify criteria that focus on mathematics: that books convey sound and accurate content and that they promote healthy attitudes and dispositions about mathematics. Since the mathematical features distinguish these criteria from more general ones, we devote a large part of this chapter to examining these dimensions in depth. We invite you also to keep in mind the implications of our discussion for meeting the National Council of Teachers of English (NCTE) and International Reading Association (IRA) Standards for the English language arts (Table 1.1), such as reading and writing a wide variety of genres for different purposes; examining authors' and illustrators' craft; interpreting graphs, charts, and other visual formats; and so forth. In other words, we want you to explore with us the reciprocal benefit of using math-related literature to strengthen both your language arts and mathematics classrooms.

Summarizing the preceding discussion, we offer the following criteria as a guide. We believe that good math-related books for children should demonstrate:

1. *Mathematical integrity*: The mathematical components of the book are accurate. In fiction, the mathematics reflects functional use in believable contexts. The ideas and concepts in all genres are accessible to the reader. The tone of the book promotes healthy mathematical attitudes and dispositions.
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Table 1.1
NCTE/IRA Standards for
the English Language Arts

1. Students read a wide range of print and nonprint texts to build an understanding of texts, of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classic and contemporary works.
2. Students read a wide range of literature from many periods in many genres to build an understanding of the many dimensions (e.g., philosophical, ethical, aesthetic) of human experience.
3. Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and of other texts, their word identification strategies, and their understanding of textual features (e.g., sound-letter correspondence, sentence structure, context, graphics).
4. Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.
5. Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.
6. Students apply knowledge of language structure, language conventions (e.g., spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and nonprint texts.
7. Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.
8. Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.
9. Students develop an understanding of and respect for diversity in language use, patterns, and dialects across cultures, ethnic groups, geographic regions, and social roles.
10. Students whose first language is not English make use of their first language to develop competency in the English language arts and to develop understanding of content across the curriculum.
11. Students participate as knowledgeable, reflective, creative, and critical members of a variety of literacy communities.
12. Students use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

National Council of Teachers of English and International Reading Association. *Standards for the English Language Arts*. Urbana, IL: National Council of Teachers of English and Newark, DE: International Reading Association, 1996, p. 3.

2. *Potential for varied response*: The tone of the book is invitational rather than didactic.
3. *An aesthetic dimension*: The book heightens the reader's awareness and appreciation of form and design. The language and/or the illustrations appeal to the reader's senses and emotions. The design and format of informational graphics (charts, tables, graphs) are visually pleasing and pique young readers' interest. Visual material complements and extends the text.
4. *Ethnic, gender, and cultural inclusiveness*: The content, language, and illustrations promote racial, cultural, and gender equity. There are no instances of stereotyping or tokenism. Cultural representations are authentic.

Before examining these criteria more closely and describing books that exemplify them, as well as some that don't, we give a brief overview of NCTM's *Principles and Standards for School Mathematics* (2000). Familiarity with this document lays the foundation for evaluating books for their mathematical integrity as well as the other criteria.

A Brief Look at NCTM's Principles and Standards

NCTM developed *Principles and Standards for School Mathematics* (2000) in order to identify and describe features of mathematics education for today's world. First, the document addresses the need for this vision, stressing that *all* children need to learn mathematics with understanding and be able to use it in everyday life (p. 4). In the twenty-first century, it is not sufficient for children simply to be able to perform rote operations. Being mathematically literate today means being able to solve complex problems, make decisions through evaluating alternatives, and communicate effectively. Society is increasingly mathematical and technological. Citizens are bombarded with statistical information in the news media and in the workplace. Voters must make sense of financial information in the billions (and trillions) and comprehend the implications of economic decisions for international relations. Consumers face a multitude of purchasing and investment decisions. An ever-widening range of careers involves mathematical thinking, problem solving, and the use of technological tools. Mathematics and technology affect leisure time: recreation, the arts, and travel. The future of our planet depends on an understanding of issues such as global warming and the distribution of resources. Given the degree to which mathematics permeates today's world, excellence in mathematics cannot be reserved for an elite few.

NCTM developed six Principles, five Content Standards, and five Process Standards to describe this excellence in mathematics education. As you read through the following three lists, we invite

you to consider the potential of children’s literature to address the Principles and Standards.

Principles

- The Equity Principle: High expectations and strong support for all permeate the mathematics program.
- The Curriculum Principle: The curriculum is well developed and articulated throughout the grades; various strands of mathematics are integrated.
- The Teaching Principle: Teachers understand what students know, what they need to know, and support them in their learning by developing the classroom environment.
- The Learning Principle: Students demonstrate understanding, connect and apply mathematical ideas, and exhibit key attitudes and dispositions of mathematical thinkers.
- The Assessment Principle: Assessment informs instruction and learning; assessment benefits both teachers and students.
- The Technology Principle: Technology impacts and enhances both teaching and learning.

Content Standards

- Number and Operations: This strand includes numbers, ways of representing numbers, relationships among numbers, and number systems. Flexible use of strategies is a key part of computational fluency.
- Algebra: Algebraic thinking spans all grades. It includes experience with understanding, representing, and analyzing patterns, relations, and functions.
- Geometry: This strand encompasses analysis of two- and three-dimensional geometric shapes, spatial relationships and their representations, symmetry, transformation, and geometric problem solving.
- Measurement: This strand includes understanding measurable attributes, the units, systems, and processes of measurement, and flexible use of tools and strategies.
- Data Analysis and Probability: This strand addresses the collection of data, its representation and interpretation. Probability is a key part of data analysis as well as a dimension of many other areas of mathematics.

Process Standards

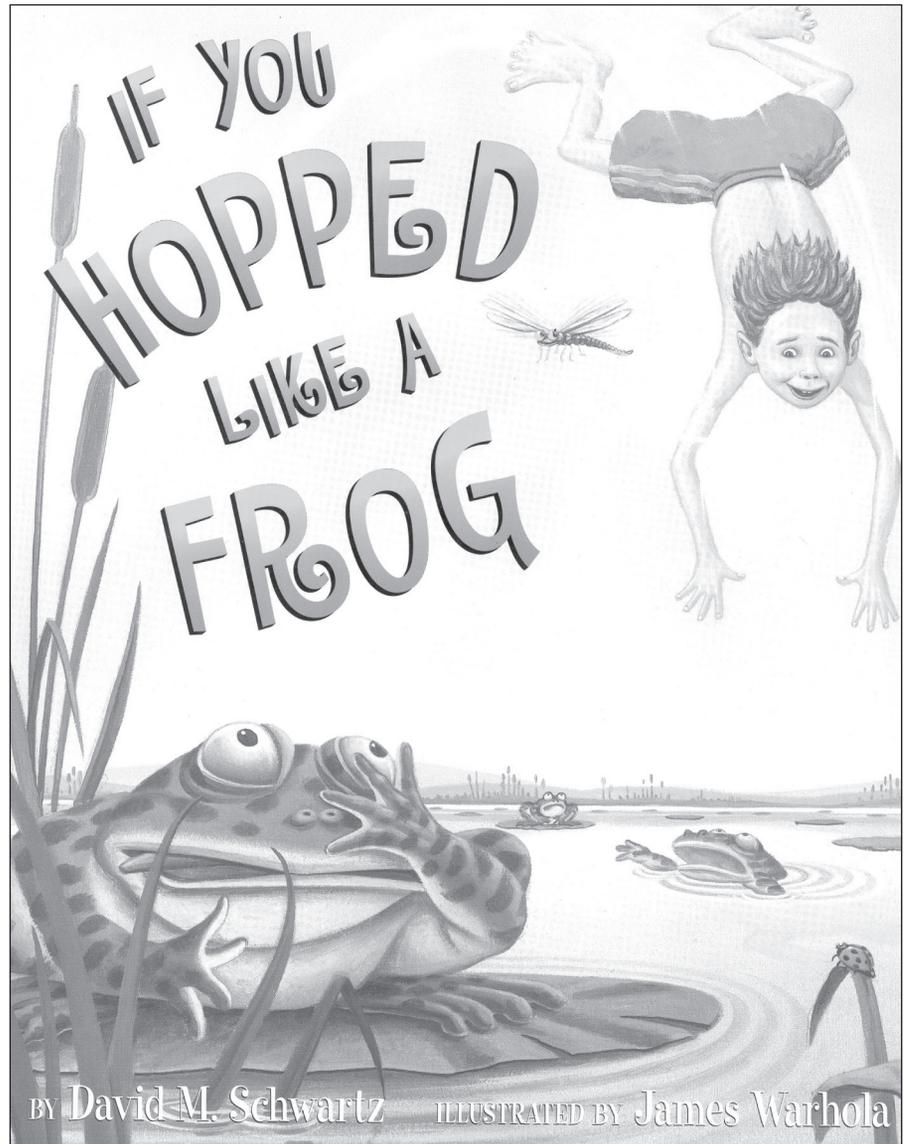
- Problem Solving: Students identify and solve problems that arise from a variety of experiences and encompass connected mathematical ideas. They analyze problems and apply a wide range of strategies in flexible ways.
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- Reasoning and Proof: Students make conjectures (informed guesses), express these conjectures in multiple ways (through language and other forms of representation), and analyze and evaluate their reasonableness.
- Communication: Students organize their thinking by expressing their ideas clearly, and by considering and analyzing the ideas of others. Students use the language of mathematics effectively.
- Connections: Students recognize the connections among mathematical ideas and across experiences. They acknowledge, appreciate, and apply mathematical ideas outside the mathematics curriculum.
- Representation: Representation is both a process (to represent) and a product (or artifact). Representations include such forms as symbols, pictures, charts, models, and graphic displays. Representations are not ends in themselves, but tools for understanding and communication.

The Principles and Standards connect to our four criteria for evaluating math-related books in many ways. The Content Standards serve as a guide for considering the range of mathematical topics to identify in literature. Good books can promote the Process Standards by incorporating a variety of representations (illustrations, charts, models, etc.), showing mathematics in interdisciplinary contexts, and, most important, inviting children to talk, reason, and solve problems in multiple ways. Good books embody the Principles by fostering positive attitudes and dispositions toward mathematics and by providing an inclusive context for all children to discuss and explore mathematical ideas. In addition, these discussions and explorations can give teachers opportunities to assess their students' understandings.

Have you noticed some surprising parallels between the goals of NCTM and the NCTE/IRA Standards? Both documents, for instance, stress communication (NCTE/IRA Standard 4; NCTM Process Standard, Communication). They acknowledge that effective communication develops through multiple experiences using written, spoken, and visual language in a variety of contexts and purposes. Both mathematics and language are viewed as tools for meeting the demands of everyday life: to acquire information, to participate in society (NCTE/IRA Standard 1), to identify and solve problems in a variety of experiences (NCTM Process Standard, Problem Solving), and to connect ideas across experiences (NCTM Process Standard, Connections; NCTE/IRA Standards 7, 11).

With these ideas in mind, we turn to a discussion of specific pieces of literature to explore how these books reflect the criteria and the beliefs that undergird them.



Examining One Book in Depth

We've selected one math-related book, *If You Hopped Like a Frog* by David M. Schwartz (1999), in order to examine its classroom potential, using the criteria as a lens. Schwartz opens the book with a letter to the reader in which he describes his boyhood fascination with a frog's ability to leap: "I imagined soaring through the air with grace and ease, landing gently on my big, springy legs. How far could I hop?" (Unpaged). This hypothetical situation, as well as

other musings about the attributes and abilities of animals, became challenging problems for Schwartz to solve with some reasoning and research: “Once you know that a frog can jump twenty times its body length, you can figure out how far you could hop if you hopped like a frog.” In the text that follows, Schwartz names a variety of other animals and their special adaptations and playfully imagines humans with proportional powers. With the strength of an ant, for example, a child could lift a car. It would be possible for humans to see a moving rabbit from “high in the clouds” if only they had the vision of an eagle. Having the capacity of a pelican’s beak for a mouth would enable a person to drink a “triple root beer float in one mouthful.” James Warhola’s comical illustrations make these and other imaginative scenarios come to life. In the endnotes following the story, Schwartz describes and defends his problem-solving procedures and invites the reader to try these ideas or extend them in new ways. He explains, for example, that an eagle owes its sharp vision to the fact that it has 1,000,000 cones per square millimeter of retina, whereas a human has only 200,000. Therefore, an eagle can see a moving rabbit from a distance of 1,500 meters, whereas a person can only see the same rabbit from 300 meters away. Schwartz calls for readers to extend this reasoning: “Measure (or estimate) 1,500 meters. What can you see from that distance?”

In what ways does *If You Hopped Like a Frog* meet the four criteria of effective math-related books?

**Math-Related Books
Should Demonstrate:**

1. Mathematical integrity
2. Potential for varied response
3. An aesthetic dimension
4. Racial, cultural, and gender inclusiveness

Mathematical Integrity. *If You Hopped Like a Frog* reflects several of NCTM’s Content Standards. The entire book illustrates the concept of ratio in a wide range of contexts, thus addressing the Algebra Standard. Measurement is reflected in many forms: linear, weight, area, volume, capacity, and time, with examples of both metric and customary systems. The Process Standards are evident as well. Schwartz’s opening letter demonstrates the Problem-Solving Standard by opening a window into the way the problems emerged from a real-life context of observing frogs. His demonstration of curiosity, research, and perseverance helps “to promote the development of all students’ dispositions to do mathematics” (NCTM 2000, p. 91). In the endnotes, readers are invited to pose and solve related problems. Consistent with the Communication, Representation, and Reasoning and Proof Standards, Schwartz explains his calculations through language, symbols, and drawings. Reflecting the Connections Standard, the book connects mathematics and science in meaningful ways. In addition, connections are made between mathematical topics, such as relating fractions to decimals.

The mathematical content is also presented in ways that are accessible to a wide range of readers. One of the easiest calculations

involves the snake. If a snake has a head measuring 1 inch across, it can swallow prey that measures 2 inches across. It follows that “If your head were 5 inches across from ear to ear and you swallowed like a snake, you could gulp down something 10 inches thick—like a telephone pole!” The eagle example is more complex and therefore presents a more sophisticated challenge for more experienced readers: it relates an example of density (number of cones contained per square millimeter of retina) in a context that involves distance (number of meters of visual acuity). From the very simple to the most challenging examples, Schwartz conveys an attitude that mathematics is intriguing, enjoyable, and satisfying. His description of his boyhood musings also serves as a powerful demonstration of entries that children might include in writers’ notebooks (Fletcher 1996).

Potential for Varied Response. Schwartz’s book meets this criterion in several ways. Since it naturally integrates mathematics and science, the book promotes varied response by inspiring readers to research other animals, study the nature of adaptation, observe animals closely, and design their own mathematical stories and informational texts. The book appeals to a wide range of ages, another aspect of varied response. One group of first-grade children explored how long their tongues would be if they were like a chameleon ($1/2$ body length). They cut pieces of adding machine tape as long as their bodies and then folded the tape in half to represent their “chameleon tongue” (Schwartz 2001). A sixth-grade class researched interesting attributes of other animals, applied Schwartz’s strategies for comparison, and composed their own “if” stories and illustrations (Schwartz 2001).

“You can almost divide the nonfiction [children] read into two categories: nonfiction that stuffs in facts, as if children were vases to be filled, and nonfiction that ignites the imagination, as if children were indeed fires to be lit.”

Source: Jo Carr, “Filling Vases, Lighting Fires,” *Horn Book* 63 (November/December 1987): 710.

An Aesthetic Dimension. Both the text and the illustrations of *If You Hopped Like a Frog* tickle the imagination and inspire awe about the wonders of nature. Young readers better appreciate the activity of shrews, spiders, and other creatures through comparisons that relate directly to children’s common experiences and interests, such as eating hamburgers and running on a football field. By addressing readers directly (“If you . . .”), Schwartz draws them directly into his hypothetical world. The exaggerated, humorous illustrations further accentuate these natural feats and add emotional appeal.

Racial, Cultural, and Gender Inclusiveness. Throughout the book, the accessibility of mathematical ideas reflects strong support for all learners. In addition, the illustrations promote positive gender attitudes. Both genders are dressed appropriately for physical

activity and take active roles, such as lifting a car or flying like an eagle. The illustrations do, however, portray a majority of white children, and in one picture a mother wears a stereotypical apron. These reservations should be kept in mind and can be addressed when you're reading the book with children.

In summary, *If You Hopped Like a Frog* demonstrates value from both mathematical and language arts perspectives (see Figure 1.1). The book naturally embeds mathematical ideas in scientific settings. It appeals to readers through its humor and intriguing facts, and it invites readers to join the author in pursuing mathematical investigations and writing about them.

How Do Books Show Mathematical Integrity?

We now turn to a wide range of books to illustrate examples of both exemplary and poor quality for the criterion of mathematical integrity, since sometimes criteria become clearer through contrast. The following features further elaborate on this criterion:

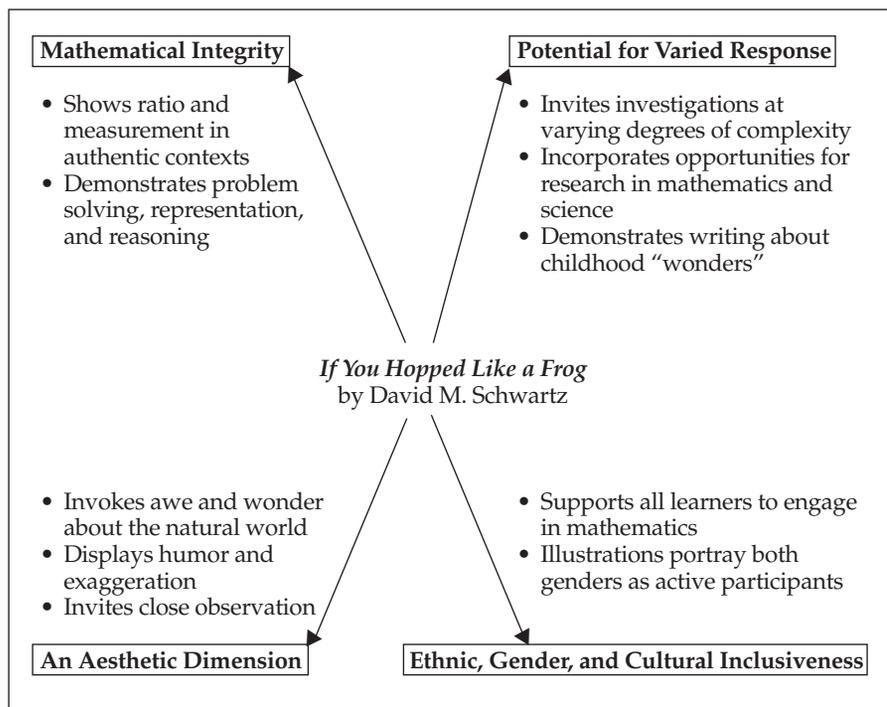
- The mathematical components of the book are accurate.
- The mathematics reflects functional use in believable contexts.
- The ideas and concepts are accessible to the reader.

Mathematical Components Are Accurate

Using vocabulary appropriately is part of the Communication Standard. Although the focus of math-related books should not be on teaching vocabulary in a didactic way, when vocabulary is used accurately and in meaningful contexts, books can be powerful teaching tools about language as well as mathematical concepts. Concept books by Tana Hoban demonstrate appropriate use of mathematical vocabulary. Children who read her book *Cubes, Cones, Cylinders, and Spheres* (2000), for example, have the opportunity to become familiar and comfortable with mathematical terms. Throughout the book, photographs show these geometric solids in a variety of familiar contexts, such as traffic cones, bubbles, and smokestacks. Simple labeled sketches on the copyright page serve as a reference for the reader. Hoban's use of precise vocabulary rather than colloquial terms such as *box* or *ball*, or inaccurate labels such as *square* (for a three-dimensional *cube*) or *circle* (for *sphere* or *cylinder*), makes her books wise choices for the mathematics classroom.

On the other hand, an examination of *A Triangle for Adaora* (Onyefulu 2000) reveals mathematical inaccuracies. Although the book depicts cultural aspects of Nigeria through excellent photographs, the author confuses terminology for two- and three-dimensional figures. A three-dimensional conical hat, for example, is described with the two-dimensional term *triangle*. Furthermore, the story line seems forced and inauthentic. The main character, Adaora,

Figure 1.1
An Illustration of the
Criteria in Use



refuses to eat a pawpaw because of its star shape, and her cousin embarks on a quest to appease her by “finding” a triangle. The problem of the story is merely a contrivance to assist the author in teaching geometric shapes.

Functional Use in Believable Contexts

Books that meet this criterion embed mathematical ideas in ways that are natural and useful. *Tiger Math: Learning to Graph from a Baby Tiger* (Nagda and Bickel 2000) incorporates two parallel texts. A wide variety of graphs on each left-hand page conveys mathematical information, while the right-hand pages relate events in narrative form.

In the narrative, T. J., the cub, faces danger when his mother dies. Veterinarians at the Denver Zoo must keep careful records to document the status of his health. Although T. J. accepts some food, his weight gain is slow. The accompanying line graph traces T. J.’s weight over time and compares it to his father’s record of development. This graph demonstrates the functional uses of a line graph: to show change continuously over time and to compare and contrast sets of data. The book also includes several other graphical formats, such as pie charts, bar graphs, and pictographs. By comparing the various formats, learners can appreciate the benefits and limitations

of each. Readers can, for example, compare the kinds of information that are represented on a pictograph and on a pie chart. One pictograph shows the population of several species of tigers and uses a scale of one picture to represent 500 tigers. Because only about 40 South China tigers exist in the world, it is too difficult to include this species on the pictograph, but the tigers are represented on the pie chart that follows. Readers see that a pie chart can show even small percentages, whereas pictographs might not be able to. It is these functional uses of data representation that lend mathematical integrity to the story (see Figure 1.2).

In contrast, we do not find that the portrayal of mathematics in *Inchworm and a Half* (Pinczes 2001) rings true. In this story, an inchworm uses its body to measure garden plants. When an item is too short to use a full body length, a smaller worm, representing a fraction, solves the dilemma. At one point, a “one-third”-inch worm comes to help. Do you find this fractional element a bit surprising in this context? We felt uncomfortable with the author’s choice since rulers are *not* marked in thirds, but rather in fourths, eighths, and sixteenths. We would argue that this story does not portray the mathematics in a meaningful, authentic way.

Accessibility of Ideas

Authors make mathematical ideas accessible through illustrations, analogies, real-life examples, and clear explanations. *On beyond a Million* (Schwartz 1999) and *Big Numbers* (Packard 2000) both use pictures, symbols, and narrative comparisons to describe large numbers. Think about these features as we examine how each book introduces the term *exponent*.

In Schwartz’s (1999) book, Professor X explains:

The little numbers are called exponents. An exponent tells you how many times to multiply a number by itself. (Unpaged)

A sidebar illustration on the same page shows the professor’s dog, Y, in front of a chalkboard, on which is written:

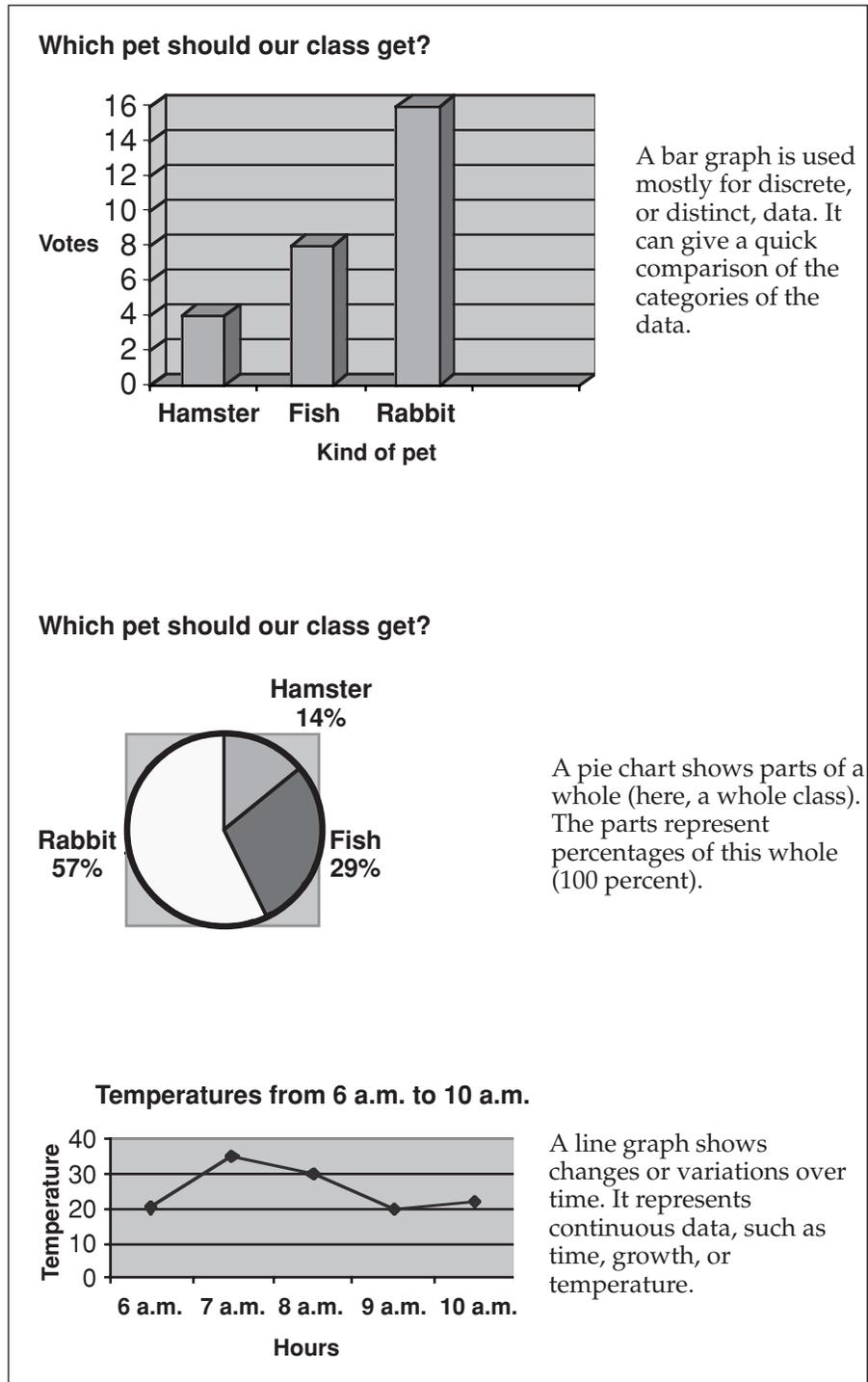
10^2 is called ten to the second power.

$$10^2 = 10 \times 10 = 100.$$

$$10^3 = 10 \times 10 \times 10 = 1,000.$$

The dog Y is listening to a student, who asks, “So ten multiplied by itself three times is 10^3 ?”

Figure 1.2
Formats for Displaying Data

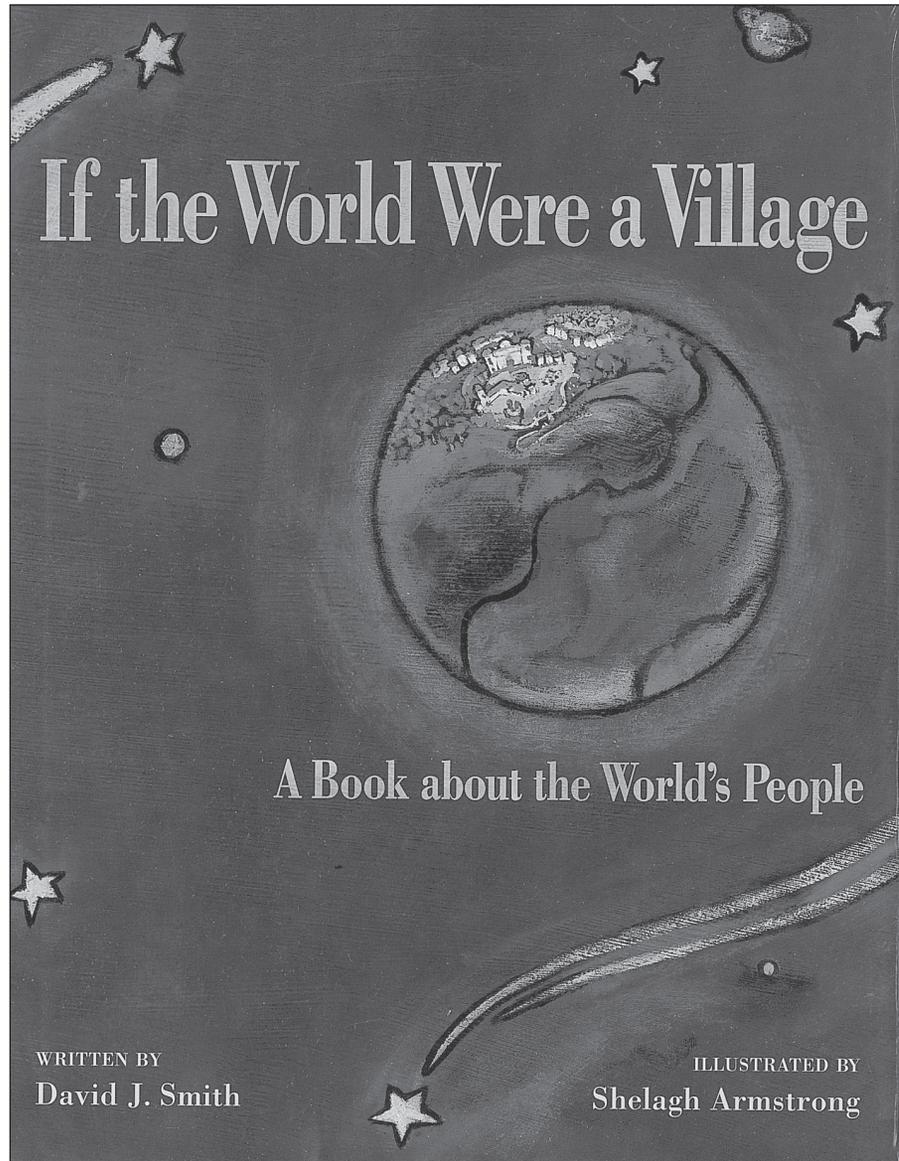


Some Books That Make Large Numbers Accessible:

How Much, How Many, How Far, How Heavy, How Long, How Tall Is 1000? (Nolan 1995)

If the World Were a Village: A Book about the World's People (Smith 2002)

What's Faster Than a Speeding Cheetah? (Wells 1997)



In *Big Numbers*, Packard (2000) explains the same term, *exponent*, in a different way. On a page labeled “One Million,” a text box reads:

10^6 with a little ‘6’ is a short way to write 1,000,000. The little ‘6’ is called an exponent. (Unpaged)

The text is accompanied by illustrated characters making comments in speech bubbles: “A million is a thousand thousands,” and “Or one hundred times ten thousand.” A second text box appears on the next page:

If you ever want to write “ten million” fast, don’t bother writing 1 and seven zeros. Just write 10^7 . That’s ten to the seventh power.

When we compared these two treatments of the same mathematical term, we concluded that a child reading Packard’s book might learn only the mechanics of writing exponents. For several reasons, we believe that Schwartz makes the ideas more accessible to the reader. His definition of exponents includes the meaning behind the notation; that is, the exponent stands for the number of times a number is multiplied by itself. This information better helps readers generate other examples of exponents. Further, the expanded notation (e.g., $10 \times 10 \times 10$) pictured in the sidebar helps illustrate the relationship between the place value of the numbers and exponential notation. Thinking back to NCTM’s Learning Principle, a guiding question might be, “Will children demonstrate understanding and connect and apply mathematical ideas after reading this book?”

Illustrations play a key role in counting books and are therefore especially important to consider when evaluating books for accessibility of mathematical ideas. Illustrations in counting books should be clear and make counting easy. Well-designed counting books also have objects grouped in interesting ways that encourage children to count by sets or help them visualize number relationships. The sea life in *One Lonely Seahorse* (Freyman and Elffers, 2000), for example, is made up of easy-to-count, colorful shapes created from fruits and vegetables. On some pages, readers can count the animals in a variety of ways. Seven cranberry-bean eels, for instance, are arranged in two groups: four on one side, three on the other ($3 + 4 = 7$). There are ten pepper fish: four yellow, four red, and two green ($4 + 4 + 2$).

Accessibility of ideas can also be achieved through multiple forms of representation. Numbers in *Let’s Count* (Hoban 1999) are represented by the numeral, the word, a photograph, and columns of dots that demonstrate place value for numbers greater than 10. One example shows 15 cookies arranged in a 3×5 array, the numeral 15, the word *fifteen*, and two columns of dots showing one ten and five ones.

In other books, the illustrations are not clear enough for children to count easily. *Ten Go Tango* (Dorros 2000) is a rollicking rhyme illustrated with fanciful watercolor drawings, but it is not as

Pose Questions That Encourage Children to Count in Different Ways

- a. Where shall we start counting?
- b. What is another way we can count?
- c. Why did we get the same answer?
- d. What groups of things do you see?

Effective Illustrations for Beginning Counting Books

- Objects are not crowded on the page
- Objects are about the same size
- Objects to be counted are whole, not cut off
- Objects are easy to distinguish from the background

helpful a book for children learning to count. Even though the largest group is only composed of 10 animals, some are difficult to count. Seven of the nine rhinos, for example, crowd one another across a double-page spread. One rhino has only one leg on the page, and two have parts of their heads off the page. For a small child

learning to count, these kinds of illustrations are confusing. They make it difficult for the child to identify members of a set and to keep track of the items that have been counted.

How Do Books Invite Varied Response?

Good math-related books can invite varied response in many ways. They can include a range of mathematical ideas for children to investigate, discuss, and extend. They inspire children to collect mathematical musings and observations in their writer's notebooks and to use mathematical ideas in a variety of genres in writers' workshop. They sharpen a viewer's eye for specific details and relationships. They can also reflect an interdisciplinary perspective and thereby grant readers the opportunity to respond mathematically as well as historically, scientifically, and so on. As children engage in research, problem posing, and problem solving, they develop important attitudes and dispositions about the nature of mathematics and themselves as mathematicians. In order to evaluate a book's potential for varied response, a criterion to keep in mind is that the tone of the book should be invitational rather than didactic.

The Book Is Invitational

Grandpa's Quilt (Franco 1999) incorporates several mathematical ideas in a predictable story structure and can elicit a range of responses. In this humorous story, loving children try to solve a problem for their grandfather: his square coverlet, made of 36 quilt blocks in a 6×6 array, does not cover his feet. The children cut apart the quilt, rearrange it, and resew it as they strive to increase its length. Their first attempts, such as cutting the bottom row of 6 and sewing it to the top of the quilt, are unsuccessful. The story structure, the mathematical descriptions of the quilt, and the pictures all help readers predict and justify whether each attempt will succeed. The problem is solved when the children finally arrange the quilt blocks in a 4×9 rectangle. After reading the story, children might want to investigate numerical relationships, such as factors for 36 (the total number of quilt blocks) or the relationships between perimeter and area (the area of 36 blocks in the quilt remains constant, even though the perimeter changes as the rows are rearranged). Readers also

might be inspired by the illustrations to use paper squares and triangles to create quilt block patterns, such as a rhombus or a star. The humorous story line might encourage children to dramatize the tale or to write and illustrate their own tales of exaggeration. Thus, the book demonstrates strong potential for promoting mathematical reasoning, representation, and communication and for developing language arts skills such as critical analysis, storytelling, and writing. This book is a valuable choice across a wide age range.

Books that are interdisciplinary in nature often invite varied response. *Ten Seeds* (Brown 2001), for example, invites both mathematical and scientific investigations. On the opening page, a child has just planted ten seeds, which are clearly illustrated and easy to count. An ant is carrying away one of the seeds. On each of the subsequent pages, a seed, or later a plant, succumbs to an unfortunate event, until just one plant remains. The book supports mathematical response by encouraging children to count backwards, to subtract successively by one, and to analyze the resulting mathematical pattern. There is also an opportunity for scientific response. The beautiful and scientifically detailed illustrations inspire readers to do some planting and observing themselves. Such a project could easily lead to data collection about germination success as well as growth over time. The book also embeds specific scientific vocabulary, such as *shoot* and *seedling*, in the delightful, poetic text. Finally, *Ten Seeds* engenders awe and wonder about the natural world. After nine of the original plants die, the one remaining plant replenishes the ten seeds, and the cycle can start again. What a miracle!

The Tone Is Not Didactic

An image that might come to mind as you read the word *didactic* in relation to literature is one of a controlled-vocabulary reader. We teachers have traditionally objected to forced, stilted stories and the way their narrow focus limits readers' responses. Here we are arguing that these considerations apply to the mathematical dimensions of books as well. *Subtraction Action* (Leedy 2000) portrays the operation of subtraction in only one way, but current research in mathematics advocates that children explore subtraction in a variety of contexts from the start of mathematics instruction (Kamii and Joseph 1989; Carpenter 1999; Trafton and Thiessen 1999). Let's take a close look at this book.

The story opens with a teacher introducing to her class a lesson in subtraction. The speech bubbles follow a traditional initiation-response-evaluation sequence of questioning:

Books That Portray Subtraction Situations

Comparison: *More, Fewer, Less* (Hoban 1998)

Separating: *How Will We Get to the Beach?* (Luciani 2000)

Part/Whole: *Ten Flashing Fireflies* (Sturges 1995)

Teacher: What do these things have in common? [holding signs dealing with “less”]

Child: They are all about **LESS!**

Teacher: Right, Ginger, and to get less, we are going to **subtract**. (p. 4)

The teacher continues by posing a problem about the upcoming school fair. The class has 10 tickets to the fair. If they use 6 tickets, how many will be left over? The teacher leads the children through the conventional algorithm, which she illustrates on the board. She directs the children to begin by writing the “biggest number,” then a minus sign for “take away,” the equal sign, and finally the 4 to complete the equation.

$$\begin{array}{r} 10 \\ -6 \\ \hline 4 \end{array}$$

She then quizzes the children: “Does anyone know what the answer is called?” (p. 5). The remainder of the book describes instructions for regrouping (represented by crossing out the numeral in the tens place) and for computing examples involving money. From time to time, the book directs specific questions to the reader, such as, “What is the difference between 10 and 5?” and supplies the answers on the last page. Like the students in the story, a child reading this book has little to contribute in response other than the correct answer.

You might be thinking, “How can a problem with one correct answer invite varied responses?” The key is not the answer itself but the processes that children use to arrive at the correct solution. Just as children draw on multiple strategies to make sense of print, so do they in mathematics. To find the difference between 10 and 6, some children might count up from 6 to 10 rather than subtract. Other children might build on their knowledge of 5 plus 5 and think, “I’ll subtract 5 first ($10 - 5 = 5$) and then subtract one more ($5 - 1 = 4$).” Sharing these strategies would place emphasis on reasoning and number sense rather than on the manipulation of symbols. The long-term goal would be for children to choose efficient strategies for computation, which would vary depending on each problem’s context.

We’re also concerned with the attitudes and dispositions that might be conveyed through books such as *Subtraction Action*. Leedy’s book implies that mathematical proficiency is synonymous with the memorization of rules, vocabulary, and procedures; that mathematics is learned by listening and following an expert rather than through collaboration and exploration; that mathematics is only palatable when it is “jazzed up” with cartoon characters or other “motivational” features; and that mathematics is not creative or

rewarding. These are dangerous beliefs to perpetuate. This message is in contrast to NCTM's description of autonomous learners who are:

[C]onfident in their ability to tackle difficult problems, eager to figure things out on their own, flexible in exploring mathematical ideas and trying alternative solution paths, and willing to persevere. Effective learners recognize the importance of reflecting on their thinking and learning from their mistakes. . . . When students work hard to solve a difficult problem or to understand a complex idea, they experience a very special feeling of accomplishment, which in turn leads to a willingness to continue and extend their engagement with mathematics. (2000, p. 21)

The issue with Leedy's book, however, is *not* that it contains symbolic notation. Other books use conventional notation quite effectively. In *Bats on Parade* (Appelt 1999), for example, a marching band parades in a formation of successively large arrays (a single drum major-ette followed by four piccolo players in two rows and two columns, etc.). On each page, a mouse holds a banner that displays the corresponding equation, such as $3 \times 3 = 9$. At the same time, the illustrations of each group of instrumentalists provide geometric representations of this mathematical idea. Thus, the book opens avenues for further exploration of square numbers geometrically as well as numerically.

We've summarized the "warning signs" of didactic books to consider in the sidebar on this page, and we conclude this discussion with a caveat: No book, no matter how invitational the tone, can guarantee the development of mathematical knowledge or healthy attitudes. How

teachers, parents, and children interact with a book is the most critical consideration. We return to this idea in later chapters.

Questions to Consider When Evaluating a Book for Didactic Tone Might Include:

- Does the book direct a large number of single-answer questions to the reader?
- Do frequent explanations or definitions interrupt the flow of the story in an awkward way?
- Does the story seem contrived in order to fit an instructional purpose?
- Does the author include prescriptive directions for parents to follow when reading the book with their children?
- Is the book labeled with designations for a specific grade or sequential level?

How Does a Book Incorporate an Aesthetic Dimension?

Books that have a didactic tone rarely have an aesthetic dimension. Since we have already discussed didactic books in depth, we devote this section to books of exemplary aesthetic quality.

We teachers all have favorite books that we read aloud every year, or that we return to again and again as demonstrations for writers' workshop. These books usually earn such high regard through their aesthetic appeal. When we focus our attention on math-related books, the aesthetic dimension also plays a key role. Good books appeal to the emotions and senses of the reader, provide

a fresh perspective, and free the imagination. Here we discuss books that promote aesthetic response through:

- well-crafted language
- compelling illustrations, charts, diagrams, photographs, or other graphics
- a heightened awareness of form or design

Books that demonstrate well-crafted language and/or compelling illustrations and graphics: We discuss language and illustration together because ideally they complement and extend each other. Language can move readers with powerful imagery, rhythmic sounds, ironic twists, and striking comparisons. Well-chosen language can inspire laughter, tears, and wonder. In *Spots: Counting Creatures from Sky to Sea*, Carolyn Lesser (1999) portrays creatures with spotted fur or skin that live in the earth's ten biomes. The words that describe each animal, such as "[s]unning, slipping, diving" seals or "loping, gazing, nibbling" giraffes, roll from the tongue. Together with Laura Regan's stunning oil and gouache paintings, this text evokes wonder and respect for nature.

Aesthetic language and illustrations can be humorous as well. *Math Curse* (Scieszka 1995) is replete with wordplay, including puns and hyperbole. The math teacher's name is Mrs. Fibonacci; the science teacher is Mr. Newton. The narrator breaks the "curse" by adding $1/2$ and $1/2$ to make an escape "hole." The wide range of mathematical and verbal humor as well as the hilarious illustrations make this book accessible and entertaining to a range of readers.

When searching for good math-related literature, don't forget to include both humorous and serious poetry. By crafting language, "[p]oets help us see anew that which is a taken for granted part of our everyday world" (Bishop 2000). We suggest several individual poems as well as anthologies in Chapter 2.

Books that heighten awareness of form or design: Books can beckon readers to slow down, observe closely, and appreciate the world around them, the heavens, and the built environment. Such mathematical topics as spatial relations, weight, and geometric form are naturally embedded in *Nature Got There First* (Gates 1995). Gates reveals the engineering and design feats of plants and animals that have served as models for human invention, calling life "[a] natural experiment that began 3.5 billion years ago on Earth and is still in progress" (p. 7). In the living world, survival depends on meeting basic needs for food, shelter, and air, as well as protection from harm. Prairie dogs, for example, build above-ground ventilation

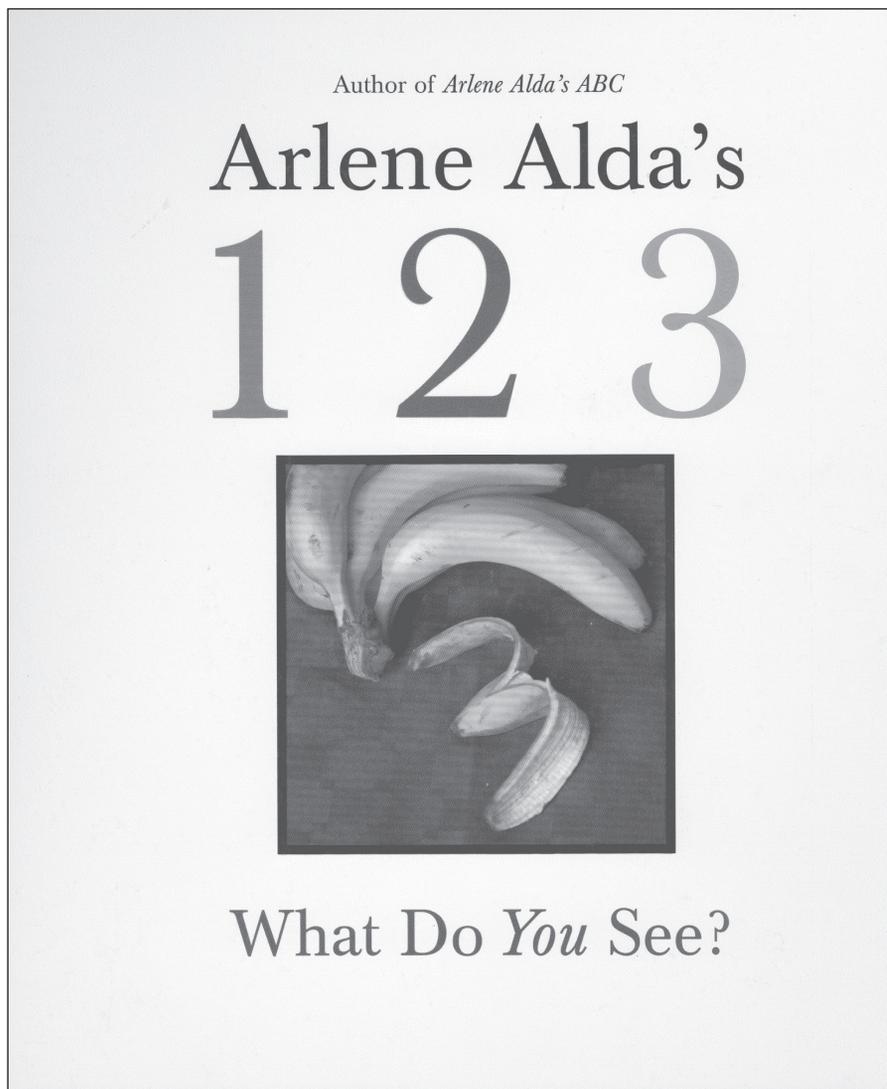
towers that draw fresh air into their tunneled homes. Moving air above the towers lowers air pressure, and currents form, expelling stale air from the tunnels and letting fresh air in. Humans making tunnels, such as the rail tunnel under the English Channel, create similar ventilation systems, aided by fans, to keep air moving and fresh and to remove dangerous gases. Principles of design inspired by fish and other animals, such as the chambered nautilus, allow humans to sink in submarines or float with life preservers. The bases of 150-foot tropical rain forest trees need to be wide enough to balance their large crown of branches; architects use this principle to design buildings with buttresses. Gates helps readers appreciate not only the role of mathematics in the natural world but also the “cultural and intellectual achievements of humankind . . . including its aesthetic and even recreational aspects” (NCTM 2000, p. 4).

Without words, Arlene Alda opens readers’ eyes to the beauty of both natural and manufactured objects in *Arlene Alda’s 1 2 3* (1998) and *Arlene Alda’s ABC* (1993). Each book is a collection of photographs that reveal the shapes of numerals and letters. The graceful curve of a swan’s neck, mirrored by the surface of a pond, forms an exquisite 3, while a door handle and latch form a 5. Close-up photographs, such as a curly strand of hair for 6, encourage readers to notice small details.

Other books inspire awe of and appreciation for humanity. *One Hundred Is a Family* (Ryan 1994) broadens the definition of family to include neighborhoods and other large groups of people working together. Many of the best examples of books that honor humanity in aesthetic ways also promote ethnic and cultural equity, so we now turn to this last criterion of effective math-related books.

How Do Books Promote Gender, Ethnic, and Cultural Inclusiveness?

Math-related books for children should be free from bias. They should provide inspiration and role models, open doors for growth, and build appreciation for the historical and cultural contributions of all people. We have described this criterion in the following way: *The content, language, and illustrations promote racial, cultural, and gender equity.* Although much progress needs to be made in this area (Bishop 1994; Barrera 1997; Yokota 2001; Lehr 2001), there are some excellent books that meet this criterion. *The History of Counting* (Schmandt-Besserat 1999) is a particularly good example. The author, a prominent archaeologist, documents human inventiveness in developing mathematical tools across cultures and over time. She shows early forms of keeping records without numbers, such as notches etched on bones in the Middle East, and a system of body counting (pointing to different parts of the body to represent differ-



ent numbers) that people in Papua New Guinea used. She also celebrates the invention of abstract systems of counting and, in particular, representations of zero. One strength of the book is her explanation for the diversity of number systems across time:

Why did it take thousands and thousands of years to invent abstract numbers? Why weren't they invented sooner? It was not a question of intelligence: The size of your brain is the same as that of a child who lived fifty thousand years ago. Probably it was a matter of need. . . . It makes a lot of sense that counting became important when the

life of a community depended on knowing how many bags of grain to keep for planting the next harvest and how many animals would feed the village during the winter season. . . . But it was the tax system that had the biggest impact on counting. (pp. 20, 22)

Schmandt-Besserat truly appreciates mathematics as “one of the greatest cultural achievements of humankind” (NCTM 2000, p. 4) while honoring the ingenuity of diverse cultures across time and place. Her book encourages readers to do likewise.

Thirteen Moons on Turtle’s Back: A Native American Year of Moons (Bruchac and London 1992) and *An Algonquian Year: The Year According to the Full Moon* (McCurdy 2000) both describe the measurement of time used by many Native American nations. Bruchac and London’s book, however, is the stronger, while McCurdy’s has the potential to perpetuate common stereotypes. *Thirteen Moons on Turtle’s Back* opens as an Abenaki grandfather explains to his grandson that the pattern on the turtle’s shell corresponds to the thirteen annual lunar cycles. Although many Native American peoples measure the year in this way, different nations have their own names and stories to describe each one. The authors carefully identify the origins of each of the thirteen captivating poems that follow. In the endnotes, readers learn that other Native nations in different climates divide the year in different ways, such as by dry times and times of rain, which further demonstrates diversity among Native peoples. From a mathematical perspective, this additional information helps to highlight that systems of measurement are arbitrary; like all mathematics, they reflect human invention.

In his introduction to *An Algonquian Year*, McCurdy describes the wide geographical range of Algonquian peoples and names several tribes. In the text, however, descriptions of seasonal activities, such as gathering maple sap, obscure tribal individuality, because not all tribes engage in that practice. Blending people together as if they were all the same reflects a biased view of culture (Slapin and Seale 1998). In addition, only twelve months are described in *An Algonquian Year*, but the lunar calendar consists of thirteen moons. Each page is labeled with the Gregorian term, such as January, as well as the Native label, such as Hard Times Moon, thus inaccurately implying a direct temporal correspondence. For these reasons, *Thirteen Moons on Turtle’s Back* is the better choice from an equity perspective.

One Little, Two Little, Three Little Pilgrims (Hennessy 1999) reflects another poor treatment of Native Americans. Although Hennessy documents her research of Wampanoag life in the endnotes, she reverts to the historically demeaning practice of counting “Indians” (or here, Wampanoag) like objects (Slapin and Seale 1998). The greeting card-style illustrations perpetuate stereo-

typical caricatures, and the simplistic format conveys a romanticized harmony between Pilgrims and Wampanoag (Dorris 1978).

Another dimension of equity in math-related books is the portrayal of females. *One Grain of Rice* (Demi 1997), a folktale set in India, features a strong female protagonist. In this story, the greedy raja hoards almost all of the village's rice. The people face starvation until Rani takes clever and courageous action. She finds some grain that spilled from a basket during transit and, under the guise of obedience and respect, brings it to the raja. He offers her a reward, but instead Rani dupes him into an alternative plan: that the raja give her one grain of rice, to be doubled each day for thirty days. Rani's quick thinking and concern for equity save her fellow citizens. The story is valuable, then, not only for its positive gender role but also for its demonstration of political action on behalf of social justice. For these reasons, *One Grain of Rice* is a particularly good choice among the many books that involve a geometric progression.

Books such as *The Most Beautiful Roof in the World* (Lasky 1997) can serve as powerful demonstrations of career opportunities in the fields of mathematics and science for both girls and boys. In this book, Lasky chronicles the work of Meg Lowman, a rain forest scientist. Meg's interest in botany began very early; as a fifth grader, she won her state's science fair competition for her detailed study of flowers. Today Meg travels to rain forests around the world, where she focuses her inquiry on forest canopies. She must meet the physical challenges of climbing more than 100 feet above ground on specially designed apparatus and face the dangers of various poisonous creatures while gathering data. Much of her research focuses on the leaf-eating activity of insects, which involves precise measurement, data tabulation, and analysis. She examines the conditions of leaves over time, documenting rates of consumption. Meg's mathematical work has led her to generate several scientific hypotheses about the impact of leaf eating on the delicate balance of canopy health, and she has created experimental studies to gather additional data. At one point in the book, Meg invites her two sons to join her in collecting data about both plant and animal life, which further inspires young readers to investigate nature. Thus, this book is a valuable demonstration of career opportunities for both genders.

In a final word about equity, it is unfortunate that there are few examples of math-related books that reflect inclusion of people with disabilities. One book of note is *1 2 3 for You and Me* (Girnis 2001). Each page of this counting book consists of a photograph of a child wearing, playing with, or enjoying a variety of objects. The children represent many ethnicities; each has Down syndrome. The book helps to highlight the fact that this area of inclusiveness, like

the others discussed in relation to this criterion, deserves increased attention in literature for children.

Looking Back and Looking Ahead

In this chapter, we have proposed criteria for teachers to use as they select math-related books for classroom use. These criteria incorporate important literary qualities, such as engaging story lines, well-crafted language, and illustrations that complement and extend the text. They also embody NCTM's *Principles and Standards for School Mathematics* (2000) in several ways. Good books demonstrate accurate mathematics used in functional, authentic contexts. They do not limit mathematical content to prescriptive procedures; instead, they open multiple avenues for all learners to explore ideas and to build understanding. Through these varied opportunities for investigation, these books support readers in developing healthy attitudes and dispositions about mathematical activity.

Since different books reflect each of the four criteria to varying degrees, it is teachers who must ultimately decide which books are best for their students. The overall guiding question should therefore be, "Is this book opening doors in the language arts and mathematical lives of *all* children in my classroom?" And, finally, it is important to remember that books reach their potential through the acts of reading and sharing. In the following chapters, we describe strategies that teachers have found to be helpful in using math-related books effectively with young students.

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