*The NCTM has three publications which have influenced—and will continue to influence—K–12 mathematics education in Alberta schools. The documents offer well-thought-out perspectives on the teaching, learning and assessment of mathematics.*

*i.* Curriculum and Evaluation Standards for School Mathematics *(1989)*
*ii.* Professional Standards for Teaching Mathematics *(1991)*
*iii.* Assessment Standards for School Mathematics *(1995)*

*This year, every issue of* delta-K *will devote a section to the NCTM Standards. In this issue, the focus for the elementary level will be on Curriculum Standard 4: Mathematical Connections. Mathematics should include opportunities to make connections through investigations, interplay among various mathematical topics and their applications. "Connecting Literature, Language, and Fractions" by Betty Conaway and Ruby Bostick Midkiff deals with that Standard. It also involves students modeling various ways of communicating their mathematical understanding of fractions.*

*At the middle-school level, the focus is on Evaluation Standard 9: Mathematical Procedures. It is important that the assessment of students' knowledge of procedures should provide evidence that they can—among other things—recognize when a procedure is appropriate, give reasons for the steps in a procedure, and reliably and efficiently execute procedures. The article "Conceptual Understanding and Computational Skill in School Mathematics" by Thomas R. Scavo and Nora K. Conroy shows that procedural knowledge is intertwined with conceptual knowledge. Students must be encouraged to appreciate the nature and role of procedures in mathematics; that is, they should appreciate that procedures are created or generated as tools to meet specific needs in an efficient manner and thus can be extended or modified to fit new situations.*

*The focus of the article at the senior high school level, "Apply the Curriculum Standards with Project Questions," by Richard T. Edgerton, is on Evaluation Standard 4: Mathematical Power. The assessment of students' mathematical power can be done in the context of real-life projects. Project questions from different areas of study offer a rich context which yields information about a student's ability to apply his/her knowledge to solve problems within mathematics and in other disciplines; to use mathematical language to communicate ideas; to reason and analyze; as well as their knowledge and understanding of concepts and procedures. The assessment should examine the extent to which students have integrated and made sense of information, whether they can apply it to situations that require reasoning and creative thinking, and whether they can use mathematics to communicate their ideas.*

# Connecting Literature, Language, and Fractions

***Betty Conaway and Ruby Bostick Midkiff***

Because of the symbolic nature of fractions and the procedural operations required to manipulate fractions mathematically, the concept is often difficult for students in early grades to master (Van de Walle 1990). Perhaps this difficulty results in part from the numeral contradictions presented by fractions. Furthermore, fractions are part of a mathematical language that is often foreign to students until they develop a personal understanding. "Children's literature presents a natural way to connect language and mathematics" (Midkiff and Cramer 1993, 303) and furnishes a foundation on which an understanding of the concepts can be based. As students read, write and discuss real-life situations requiring the use of fractions, they develop personal meanings for the abstract concepts.

## Numerical Contradictions

Elementary school students have had many experiences with numbers. They know that as numbers

increase in size, the amount represented by that number also increases. However, the amounts represented by fractional numbers do not always have the same relationships as those expressed in whole numbers. For example, as denominators increase numerically, the portion represented by that fraction actually decreases in size when the numerator remains constant.

Another complication is that a fractional number is read from top to bottom, but the top number cannot be fully understood unless the bottom number is visualized first. For example, 1/4 is read as "one-fourth," but the "one" has meaning only when the segment "fourth" is visualized as a section of a whole or a part of a set. Reading this fraction as "one part of four" or "one of four equal parts" may be more meaningful for some students. Other children will benefit by referring to the numerator as the "counting number" and the denominator as "what is being counted" (Van de Walle 1990, 178). In other words, students must develop a concrete and personal understanding of fractions on the basis of knowledge of both terms (Cruikshank and Sheffield 1992).

## Developing Personal Understandings

Students cannot develop a thorough understanding of the characteristics of fractions if they only listen to the teachers "tell" about the concepts. Children must discover the mathematical relationships themselves, creating this information from their own experiences visually, tactually and auditorily. Furthermore, opportunities to develop an understanding of fractions through writing should be offered so that students can express the characteristics of fractions in terms that are meaningful to them.

For example, after students have experienced fractions through the use of patterning-block manipulatives and selections of children's literature, ask them to write personal definitions for such fractions as 1/2. When students have worked with the manipulatives (tactile), seen illustrations in books (visual) and talked about the relationships (auditory), their definitions will contain specific examples instead of simple repetitions of the definitions stated by the teacher. These experiences enable students to see that the quantity represented by 1/2 changes according to the context. As a result, one-half may be half of the class (12 people), half of a pizza (four pieces) or two of four triangles.

One way to assist students in developing a schema for fractional concepts is to use children's literature. Almost all students in the early grades have developed a firm understanding of story grammar (Brown and Murphy 1975). They recognize that stories have a beginning, a middle and an end, and they know that stories communicate information (Whaley 1981). This existing schema for the story can be used to introduce new concepts in other content areas, especially mathematics. This instructional strategy not only builds background information for mathematical concepts but also enhances children's ability to communicate mathematically, which is one of the standards in the NCTM's *Curriculum and Evaluation Standards for School Mathematics* (1989). Numerous children's books suitable for students in K–6 include specific mathematical concepts as part of the story. The stories "can help build bridges between the concrete and the abstract" (Slaughter 1993, 4). Books of this type also present opportunities for extension activities that focus on developing a thorough understanding of fractional concepts.

## Fractions in Children's Literature

Students in Grades K–3 will enjoy reading *Eating Fractions* by Bruce McMillan (1991). This book introduces the fractional concepts of whole, halves, thirds and fourths using photographs of real children dividing and eating various foods. *Eating Fractions* is essentially a wordless picture book, because only the fraction words and the numerals are included in the text. Two children are pictured eating two halves of a banana and two halves of an ear of corn. Thirds are demonstrated as the children divide a yeast roll into three pieces and a gelatin salad into three portions. Fourths are illustrated using a small pizza and a strawberry pie. Each food is first pictured as a whole and then pictured after it has been segmented into fractional parts.

This book offers many opportunities for discovery-learning activities. Simple recipes for the foods pictured in the book are given in an appendix at the end of the book. Each recipe uses fractions to measure the ingredients. Students can measure the ingredients and later divide the cooked foods. Older students can calculate new quantities for the ingredients if the recipes were to be doubled, tripled or halved. Primary students enjoy working with foods that require no cooking and are "soft" or easy to divide, such as bananas, English muffins or peanut butter sandwiches. Ask the children to use plastic knives to divide the bananas into halves, the English muffins into thirds and the peanut butter sandwiches into fourths. Encourage them to compare the sizes of the portions and finally eat the foods.

An additional activity using raisins, small crackers or bite-sized cookies can demonstrate the parts of a set. During this lesson, the teacher should ask

students to work individually or in small groups to arrange the foods in sets of various sizes on paper plates. Then the teacher leads a discussion of the way to represent various fractional parts of each set. The following is an example:

> Show me a set of five cookies on your plate. What number represents 1/5 of the cookies? Divide your set to show 1/5 of the cookies. How do you know that 1/5 of the cookies are represented this way? Divide your set to show 3/5 of the cookies. How do you know 3/5 of the cookies are represented this way?

*The Doorbell Rang* by Pat Hutchins (1986) can be used to extend the understanding of fractions. The book tells the story of Victoria and Sam as they prepare to share a dozen cookies. As the two children begin to divide the 12 cookies equally between themselves, the doorbell rings and two more children arrive, then two more children and finally six more come to visit. After each group arrives, the children decide how to divide the cookies evenly among those present. Although this book does not directly discuss fractional concepts, the story provides a real-life problem-solving situation using fractional portions of 12. After the students have listened to the teacher read the book and discussed ways to divide the 12 items, ask the students to divide 12 paper cookies, 12 real cookies or 12 pieces of popcorn. Extend this discussion by writing similar problems using a different number of children and cookies. For example, these two bags contain 12 cookies each. How many cookies do we have? (24) We have 12 students in our group. How many cookies will each student receive? (2) What fractional part of the cookies is that? (2/12) Then, depending on the grade level, explore the concept of simplifying or renaming.

*Moira's Birthday* by Robert Munsch (1987) incorporates the concept of dividing a whole into portions while working with large numbers. Moira invites all the students who attend her school in "grade 1, grade 2, grade 3, grade 4, grade 5, grade 6, a-a-n-n-d-d kindergarten" to her birthday party. Then she orders 200 pizzas and 200 birthday cakes. The story explains the complications resulting from the delivery of the food and dividing the food among all the children. Although very young children enjoy hearing this story, the situation described is an opportunity to discuss with middle-grade students how many children 200 pizzas would feed if each one received one piece and each pizza was divided into eighths. Apply the same situation to the classroom. How many pizzas would be needed to feed all the students in this class? In the whole school? If each student ate two pieces, how many students would 200 pizzas serve?

Using the same procedures, lead students in a discussion of how to divide the cakes to serve all those attending the party. What fractional portion of each cake would each student receive? Other applications for older students include determining the total cost of the pizzas and the cakes, as well as the cost for each guest. Extend this activity by asking students to measure the number of servings in a quart or two-litre container of punch and then determine how many containers would be needed to serve all of the students at Moira's party. Ask older students what fractional parts of a quart or a two-litre bottle each guest will receive.

Another book that includes fractions and food is *Tom Fox and the Apple Pie* by Clyde Watson (1972). Tom Fox is the youngest in a family of 14 little foxes. With Ma and Pa Fox, they live at the end of Mulberry Lane. Tom buys an apple pie at the fair. As he walks home, he imagines the pie being divided into 16 pieces to serve everyone in the family, and he concludes that each piece will be very small. Tom decides to wait until 8 of his brothers and sisters are outside counting stars, divide the pie into 8 pieces, and serve 1 piece to himself and 1 each to each of the remaining 7 family members. Again he concludes that these pieces will be too small to satisfy his appetite. Next he visualizes the pie cut into fourths, with one piece for Ma, one for Pa, one for Lou-Lou, his favorite sister, and one for himself. Tom finally concludes that he would much rather eat the whole pie himself, which he does. This book is one way to reinforce the concept that as the denominator decreases, the portion it represent becomes larger. Sample questions that lead students to visualize this concept follow:

- What happens to the pieces of the pie when they are changed from sixteenths to eighths? From eighths to fourths?
- What would happen if the pie were divided into halves?
- As the denominator decreases in these fractions—1/16, 1/8, 1/4, 1/2—what happens to each piece of pie?
- Match these fractions to pie-shaped pieces. Which piece would you rather have? Why?

Extension activities for this book include asking students to draw a pie on paper and divide it into 16 sections using one colored marker. Next ask students to use a different color to divide the pie into eight sections and then to use another color to divide the pie into four sections. Ask the students how many sixteenths are in each eighth and in each fourth.

Practising with fractional parts using patterning blocks or other manipulative counters also builds understanding. When patterning blocks are used, a

hexagon can represent one whole. The trapezoid would then represent one-half; the parallelogram would represent one-third; and the triangles, one-sixth. Construct a variety of shapes to reinforce the concept that as the denominator of a fraction increases and the numerator stays the same, the portion the fraction represents becomes smaller. Ask students to cut one paper pie into four pieces, another into eight pieces and another into sixteen pieces and to compare the sections. Ask students to reassemble the pie using different numbers of pieces of each size. Another way to use the same type of activity would be to use circular pieces of felt. Use one color of felt for the whole pie. Use different colors of felt for halves, fourths, eighths and sixteenths. Students will compare the various fractional parts by arranging the halves, fourths, eighths and sixteenths on top of the whole.

The concept of one-half is presented in a variety of formats in *The Half-Birthday Party* by Charlotte Pomerantz (1984). Daniel's sister, Katie, who is six months old, has just learned to stand and Daniel wants to have a half-birthday party to celebrate. He invites his friend Lily, Mr. Bangs, Grandma, Mom and Dad. Each guest is to bring half of a gift and a whole story about the half present. Lily brings one slipper, or half of a pair. Mother brings one earring, or half of a pair. Mr. Bangs and Grandma each bring half of a birthday cake. Daniel shows Katie the half-moon. Ask older students to determine their own half-birthdays. Ask younger students to select a half present for Katie and write a whole story explaining their choice.

## Other Connections in Literature

Other books that are easily integrated into the study of fractions can be found through such resources as *How to Use Children's Literature to Teach Mathematics* (Welchman-Tischler 1992); *Books You Can Count On* (Griffiths and Clyne 1988); and *Read Any Good Math Lately? Children's Books for Mathematical Learning, K–6* (Whitin and Wilde 1992). *Book Cooks* (Bruno 1991) is a collection of recipes and extension activities based on 35 different books. This resource gives teachers a wide variety of activities for teaching fractions in the primary grades through classroom cooking.

Reviewing classroom collections for a mathematical point of view yields another source of books related to the study of fractions. A few of these might include the following:

- *Caps for Sale* (Slobodkina 1968) is an entertaining story for children in the primary grades that tells of a peddler who sells caps and whose caps are stolen by monkeys while he is resting. Use the illustrations of caps in five different colors as the basis for a discussion of fractions.
- *The Toothpaste Millionaire* (Merrill 1972) is embedded with mathematical content suitable for students in the middle grades. For example, the story includes one middle passage that reads, "You will need 2 1/4 yards of 36-inch-wide nylon, which is 97 cents a yard at Vince's, which will come to $2.18 1/4 plus sales tax" (p. 12).
- *A Rainbow Balloon* (Lenssen 1992) introduces such concepts as *rise* and *fall*, and *one* and *many* while following a hot-air balloon. Ask primary students to draw a picture of the balloon in the story. Then ask students to draw a set of three balloons. Discuss how individual balloons in each set can be identified. Although this book is intended for younger audiences, it could also be used in the middle grades to integrate mathematics and science. Building and launching miniature hot-air balloons as a class project is one way to incorporate numerous mathematical concepts, including fractions, as well as to develop an understanding of the science concepts presented in the book.
- *Wilbur's Space Machine* (Balian 1990) tells the story of a couple who builds a space machine to get away from pollution and noise. Illustrations of balloons furnish excellent examples of parts of sets to discuss and identify with primary students.
- *Earrings!* (Viorst 1990) tells the humorous story of a young girl who wants to have her ears pierced. Girls of all ages will enjoy reading this story, which could serve as the foundation for numerous problems involving fractions for several grade levels.
- *Seven Little Hippos* (Thaler and Smath 1991) uses a predictable pattern rhyme to tell the story of seven little hippos who enjoy jumping on the bed. Each hippo falls off the bed one at a time until none are left. This story presents an opportunity to introduce primary children to the concept of the numerator as the "counting" part of the fraction and the denominator as the "number of things counted." After the students have listened to the story, give them a set of seven small plastic bears. As the story is read a second time, ask the children to arrange the set of seven into subsets that represent the hippos still on the bed and those that fell off the bed. Identify each of the fractions and discuss the changing relationship with the students.
- *Ten Little Rabbits* (Grossman and Long 1991) is a counting book for primary children. Read the story aloud to the children. As the book is read a second time, write the fraction representing the part of the set of rabbits counted on each page (1/10, 2/10, 3/10 and so on). Young children enjoy drawing pictures of rabbits to illustrate each fraction.

## Conclusion

Effective and meaningful instruction in fractional computation requires students to have a thorough understanding of basic fractional concepts. The books described here are only a small sampling of children's literature that can assist in the formation of personal understandings of this topic. When students are actively engaged in activities that portray fractions as one-third of a yeast roll, one-half of a dozen cookies, one-eighth of a pizza, one-fourth of an apple pie and one-half of a birthday gift, they form concrete connections between abstract number concepts and real-life experiences. When students work with fractions in a variety of formats, including literature, communication and manipulatives, they are able to form personal definitions and thus able to develop the understandings and readiness necessary to master more complex fractional concepts

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Prove that one half of the perimeter of any triangle is always greater than any of its sides.