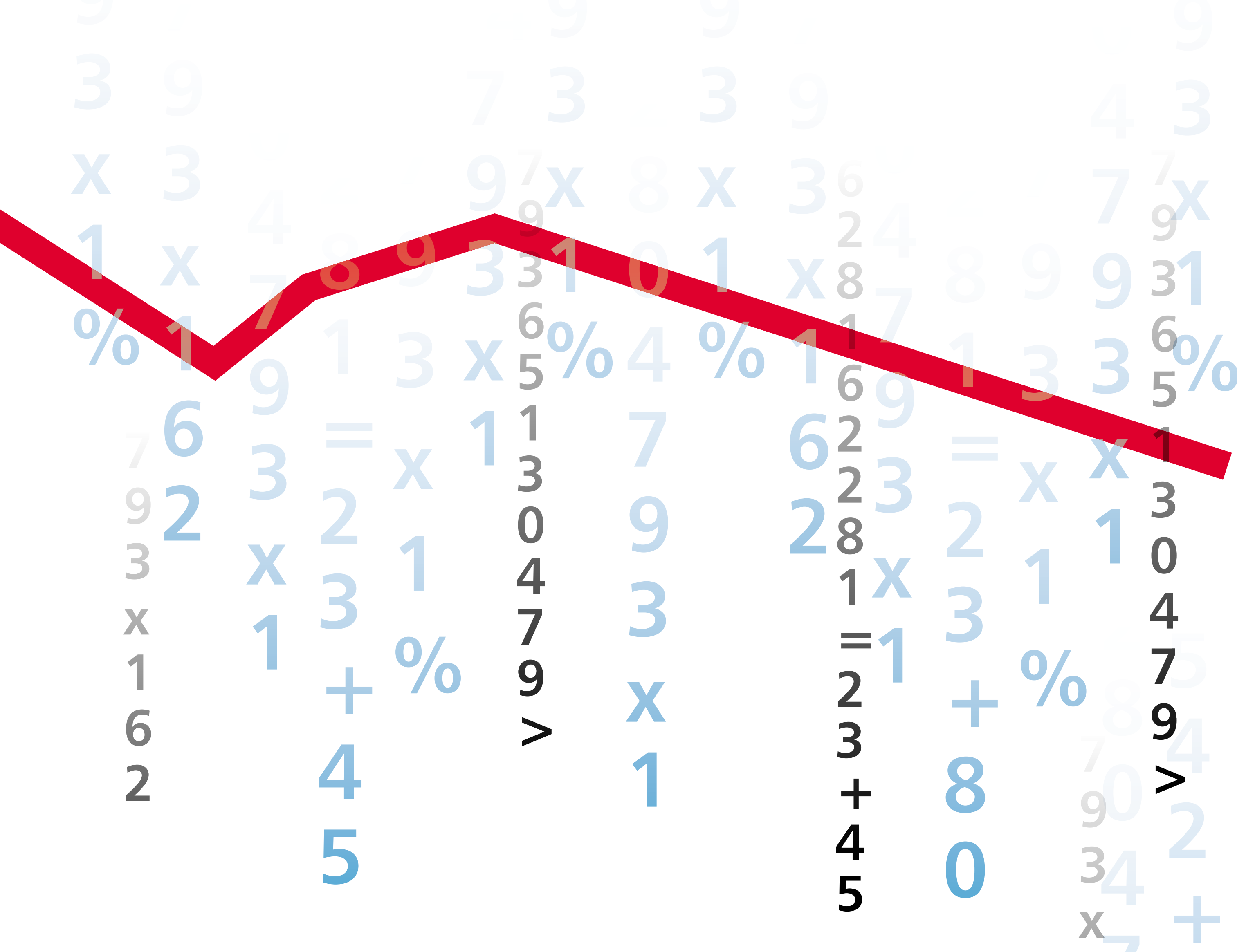
Surviving an Avalanche of Data

Help first-grade students learn to competently generate, test, revise, and represent data before being formally taught to do so.

Open the sports or business section of your daily newspaper, and you are immediately bombarded with an array of graphs, tables, diagrams, and statistical reports that require interpretation. Across all walks of life, the need to understand statistics is fundamental. Given that our youngsters' future world will be increasingly data laden, scaffolding their statistical understanding and reasoning is imperative, from the early grades on.

The National Council of Teachers of Mathematics (NCTM) continues to emphasize the importance of early statistical learning; data analysis and probability was the Council's professional development "Focus of the Year" for



By Lyn D. English

2007–2008. We need such a focus, especially given the results of the statistics items from the 2003 NAEP. As Shaughnessy (2007) noted, students' performance was weak on more complex items involving interpretation or application of items of information in graphs and tables. Furthermore, little or no gains were made between the 2000 NAEP and the 2003 NAEP studies.

One approach I have taken to promote young children's statistical reasoning is through data modeling. Having implemented in grades 3–9 a number of model-eliciting activities involving working with data (e.g., English 2010), I observed how competently children could create their own mathematical ideas and representations—before being instructed how to do so. I thus wished to introduce data-modeling activities to younger children, confident that they would likewise generate their own mathematics. I recently implemented data-modeling activities in a cohort of three first-grade classrooms of six-year-olds. I report on some of the children's responses and discuss the components of data modeling the children engaged in.

Designing data-modeling tasks

The data-modeling activities that I create for young learners engage them in multiple real-life experiences that incorporate other disciplines, such as health and nutrition and environmental studies. The children investigate meaningful phenomena; decide what is worthy of attention (by identifying complex attributes); and then progress to organizing, structuring, visualizing, and representing data (Lehrer and Schauble 2006). Drawing inferences and making predictions are also important components of data modeling (Watson 2006). The models (comprehensive products) that children create require them to describe, explain, justify, and communicate their ideas and approaches.

Besides taking the school's math program into consideration in designing data-modeling activities, I identified core learning ideas (see the **sidebar below**) from the work of Lehrer and Schauble (e.g., 2006) and Watson (2006).

FIGURE 1

A teacher-authored storybook tells how the dog Baxter Brown collects assorted items and hoards them in his bedroom until he becomes lost among the stacks.

Students' representational development

Because one of data modeling's pedagogical challenges is to support children's representational development, my colleagues and I designed our activities to encourage students to create, experiment with, and progress through multiple representations with the following strategies:

- Learn core ideas
- Pose questions
- Generate, select, and measure attributes
- Organize, represent, analyze, and re-represent data in different ways
- Draw inferences
- Make predictions
- Interpret tables of data
- Develop an understanding of caring for the environment

Selecting core learning ideas

Of the central ideas, supporting children's representational development—in constructing, interpreting, and re-representing—is one of data modeling's pedagogical challenges, as Lehrer and Schauble note. My colleagues and I thus designed our activities to encourage students to create and experiment with multiple representations, progressing from constructing simple displays to engaging with more mathematical and structured forms.

Selecting curriculum themes

My second step was to work with the teachers in reviewing their curriculum themes. We chose *looking after our environment*, which involved the notions of recycling, reusing, and reducing. Caring for the environment was thus included in the core ideas. Next, we identified a number of storybooks—namely, *Baxter Brown's Messy Room*, *Michael Recycle*, and *Litterbug Doug*—to support the three sets of activities we developed.

Classifying items

For the first set of activities, I wrote a storybook titled *Baxter Brown's Messy Room*, which tells how Baxter Brown, a West Highlander Poodle crossbreed, collects all sorts of miscellaneous items and hoards them in his bedroom, with the result that he becomes lost among the piles of items. The story invites children to help Baxter Brown clean up his room. Students received a set of cut-outs to represent items from Baxter Brown's room: one each of an apple core, a fish bone, a newspaper, a toy teddy bear, a shoe, a ribbon, a sandwich, an egg carton, a fruit juice container, a roll of paper, a dog biscuit, and a dog bone (see **fig. 1**). The children were asked to work in groups, identify their own attributes for classifying the items, and represent their classifications however they liked. On completion, they received a second set of the same items to classify and represent them in yet a different way.

Identifying complex attributes

The items that were presented to the children had characteristics that were more complex than those of typical classification activities (such as red squares, blue triangles, etc.). The complexity here lies in multiple attributes that might not be readily discerned or those that could define more than one classification group. Such features present a much greater challenge to young children. Deciding on a group definition of an attribute was a fundamental process for the children in working this activity—the items could be classified in many ways. Considerable debate was generated in defining an attribute, the children displaying a remarkable ability to identify quite obscure features (see the next **sidebar**, on **p. 368**).

In identifying different attributes, the children had to decide what was worthy of attention and what to place in the background. Their skills in switching their attention from one item characteristic to another were especially evident when they were asked to classify the same objects in a different way. For example, one student group classified the egg carton as *cardboard* and then reclassified it as *eat*, shifting their focus from its packaging to its contents. Other examples include the students who classified the items according to the traits *keep* and *can't keep*, then reclassified according to *what they are made of*, and in a third attempt, *how you use it*.

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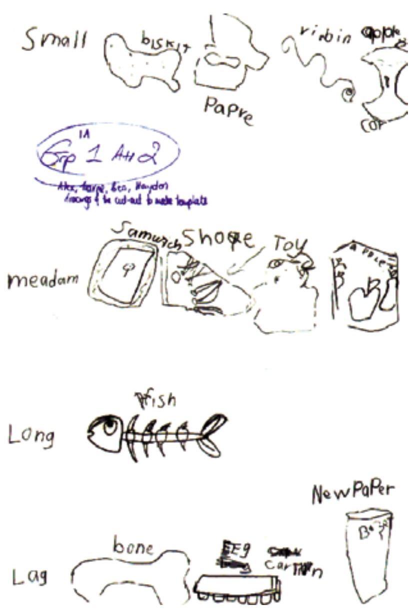
Assisted by their teacher's guiding questions, two first graders presented findings to the class.

FIGURE 2

When students construct their own representations and ways of understanding, they learn to think about their data. One group made templates, reducing the size of items by cutting around them.



Organizing and representing data

As students did the activity, we moved from group to group, observing and inquiring about their progress. Our aim was to scaffold the children's evolving skills in organizing and representing data rather than to impose any preconceived approaches. For example, we would encourage students to reflect on the attributes they had selected and consider different ways in which to organize and represent them:

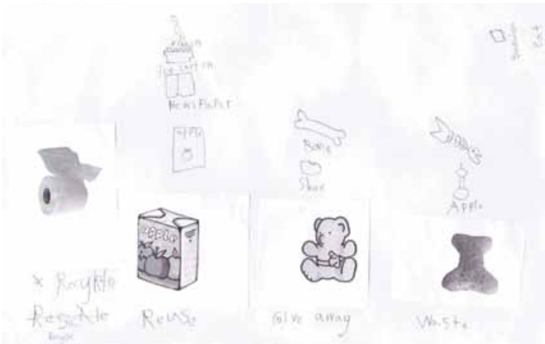
Teacher: Can you think about how you might sort them into a group? What things do we have? You know what, let's go with—we're going to have a couple of goes with this. Let's try that one idea [*the children's creation*], things that come from trees, things that are made out of trees, things that aren't, and let's see if we can represent that on your paper somehow. How do you think you could represent that?

Matilda: Write things that are made out of trees and things that are not made out of trees [*indicating two headings on the paper and the items listed underneath*].

Teacher: I think that's a brilliant idea, Matilda. Do

FIGURE 3

Teachers scaffolded first graders' emerging skills in representing attributes—here, as pictographs.



we have someone who can write in our group?
Stephen: I can!

The groups organized and represented their data in a variety of ways. For example (see **fig. 2**), some students cut around the given items to reduce their size, made templates and drawings of the items, made pictographs that incorporated cut-outs and illustrations of the items (see **fig. 3**), and recorded item names that they had circled (see **fig. 4**). Some groups created simple bar graphs (see **fig. 5**). Opportunities for young children to organize and display data in ways they choose and to analyze and revise their creations are important components of data modeling. Russell's words (1991, p. 160) are still timely:

> We have two choices in undertaking data analysis work with students: We can lead them to organizing and representing their data in a way that makes sense to us, or we can support them as they organize and represent their data in a way which makes sense to them. In the first case, they learn some rules—and they learn to second-guess what they are supposed to do. In the second case, they learn to think about their data. Students need to construct their own representations and their own ways of understanding, even when their decisions do not seem correct to adults.

Recycling fun

The next activity, Fun with *Michael Recycle* (Bethel 2008), was designed to further develop the children's use and understanding of representations, including an awareness of their purpose and structure. We introduced the activity with a storybook that tells of a character who came from the sky to clean up a dirty town with his motto, "I'm green, and I'm keen to save the planet." We set up the classroom with collections of reusable, recyclable, and waste items for the children to find. Each child in each group was given two Post-It® notes and directed to draw and name one item on each note. On returning to their group desks, they were to sort their items and display them however they liked on the chart paper provided.

Following this, the children were advised that Michael Recycle "really likes the different ways you have represented your recyclable, reusable, and waste items but would like you to represent them in a *different* way on your chart paper." Students received a second sheet of paper, leaving their initial representation sheet intact. On completion, the groups reported back to the class, during which time they were encouraged to indicate how their second representation differed from their first.

Re-representing data

Students depicted their data in many ways:

- Switching from rows to columns or vice

Student-defined attributes

Deciding on group definitions of attributes was a fundamental process for the children. Here is a sample of the variety of attributes they identified:

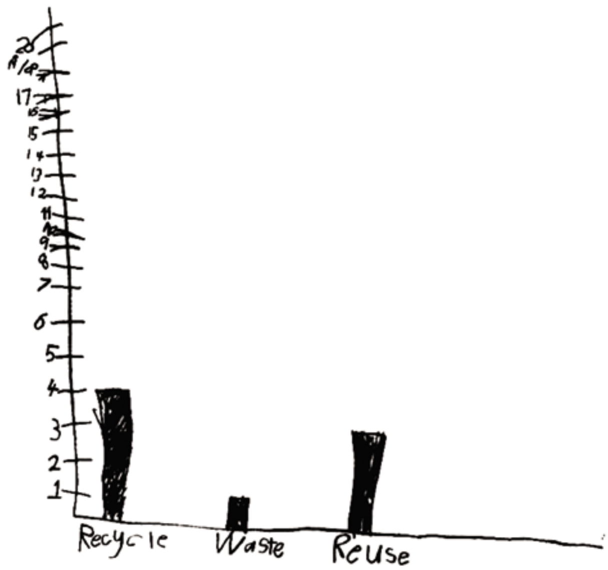
- Small, medium, long, large
- Fossils, eat, paper, fabric
- Fabric, bones, seeds, plastic, cardboard, sandwich, corn (what they are made of)
- Made out of trees; not made out of trees
- Soft; hard
- Has a tail; has no tail
- Healthy; not healthy
- Short pictures; long pictures
- Has eyes; has no eyes
- How you use it: drinking, put stuff in, recycle, make stuff out of
- Has writing on it when you buy it; has no writing on it when you buy it

FIGURE 4

A third group of first-grade students recorded item names and encircled them.

FIGURE 5

A group re-represented its data in this formal bar graph after initially creating a vertical pictograph with a combination of glued Post-it® notes and drawings in three columns labeled *waste*, *recycle*, and *reuse*.



versa in creating a new pictograph

- Changing their use of inscriptions, such as mixing item names and drawings; recording item names only; using drawings only; and using a mix of ticks, crosses, and drawings
- Changing the paper orientation, for example, from portrait to landscape or vice versa
- Adopting different ways of classifying their items
- Moving from an informal representation to a more formal bar graph

In explaining and justifying their re-representations, the children displayed an awareness of the purpose and structure of their representations. For example, the students who switched to a formal bar graph (see **fig. 5**) had initially created a vertical pictograph comprising three columns labeled *waste*, *recycle*, and *reuse*. When asked how their second representation differed from their first, group members Jackson and Yolanda explained to the teacher:

Jackson: We, um, put one in different places, the ones in different places.
Teacher: Can you tell me the words you used?
Jackson: *Waste*, *recycle*, and *reuse*.
Teacher: OK, and how did you do it? How did you represent it now, today, in a different way?
Jackson: We did a graph, and we put them at the bottom—recycle, waste, reuse. Reuse was up to three.
Teacher: Wait a minute; why did you put these [*pointing to the numbers on the vertical axis*] up the side here?
Yolanda: To show how many.
Teacher: Oh, OK, right; OK. So how many did you have in, in the first column; how many did you have in the first bar?
Jackson: Four.
Teacher: So, you had four what?
Jackson: Recycle things.
Teacher: Four recycle, yes, OK. What was the next one?
Jackson: Um, waste, and we had one waste.
Yolanda: We had people that drew apple core, apple core, apple core. We, um, so we made it one 'cause it was the same item.
Teacher: Oh, OK; so they had, so how many apple cores, I know, or pear cores, how many did you have, Yolanda? All together, you had?

Yolanda: Three.
Teacher: Three, but you represented it by having just …
Yolanda: One.

Extending the model

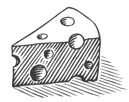
Through the next activity, the children learned to draw inferences and make predictions. To introduce this activity, we read *Litterbug Doug* (Bethel 2009), which tells how a dirty creature originally lived in a pile of rubbish in a very clean town. A "green-caped crusader" then swooped to Earth to reform Litterbug Doug. As a consequence, Litterbug Doug became the Litter Police for the town and enthusiastically monitored the town's environment.

The teacher explained, "Now that Litterbug Doug has become the Litter Police, the townsfolk are interested to see what he collects in Central Park during his first three days. They also want to know if Litterbug Doug is doing a good job of collecting litter in Central Park." The children were then shown the book cover, with the explanation that "as a start, the town's mayor asked Litterbug Doug to show him what he collected on his first day, Monday." Given that the children had had almost no exposure to such a table (see **table 1**), they were asked a few questions, such as, "Which item did Litterbug Doug collect the most of on his first day?" and "Is there anything else you notice about the numbers of items Litterbug Doug collected on his first day?" Students were also told, "Litterbug Doug does not think he has done a good job of collecting litter on his first day. What do you think?"

Next we explained, "Litterbug Doug has now collected litter in Central Park for three days, and the townsfolk are keen to see how much he has collected." We showed the children **table 2** and asked them to explore it by first noting the number of items collected on the second and third days. They were to then investigate how the data varied across the first three days and why this might be the case. The children's third task was to consider the blank Thursday column and predict how many different items Litterbug Doug might have collected on Thursday. On completion, the groups reported back to the class on data variations they noticed and on their predictions for Thursday.

TABLE 1

After Litterbug Doug became the Litter Police, the mayor asked him to show what he had collected on his first day.

What Litterbug Doug collected	Monday
	2
	4
	2
	1
	2

Identifying data variations

Students determined data variations in several ways:

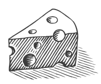
- They added each column, indicating that Monday's and Wednesday's totals were the same and that on Tuesday "he had collected the most items."
- They compared single quantities of items across three days: "He collected more apple cores on Tuesday and fewer on Monday."
  "On Monday he collected more drink cans than Wednesday."
  "He had less cheese on Wednesday, and he had more on Tuesday."

Predicting missing data

Awareness of the possible values and variation in the data of the *Litterbug Doug* table was also apparent in students' predictions for the missing data. Most groups recognized that wild outliers would be unlikely and gave predictions on the basis of existing values and variations in them. For example, one child considered a prediction greater than 10 to be "just too much and really silly." Likewise, another child, Kristy,

TABLE 2

From data in a second table, students investigated variations across the first three days, conjectured the reasons, and predicted how many different items Litterbug Doug might collect on Thursday.

What Litterbug Doug collected	Monday	Tuesday	Wednesday	Thursday
	2	5	4	
	4	3	2	
	2	6	3	
	1	4	2	
	2	3	0	

argued that their prediction should be in keeping with the nature of the existing values. One of her group members suggested new frequencies of 4, 10, 20, 30, 40 (referring to the cheese, banana skins, newspapers, cans, and apple cores, respectively). Kristy disagreed with his suggestion, claiming, “It’s kind of too high.” She elaborated:

> ’Cause if he could collect, if he could have collected that many, some of them might have been, it might have been on here [*meaning that those larger numbers would have appeared on previous days*]. So it’s too many.

Kristy explained further that the larger amounts do not appear in the existing data, so “they’d have to be lower than that.” She suggested five banana skins, three newspapers, four cans, six apple cores, and two pieces of cheese.

Scaffolding their abilities

We do not do justice to young children’s statistical capability if we fail to engage them in such experiences as data modeling (Leavy 2007). Rich, motivating contexts, including story picture books, play an important role in their statistical learning. As society becomes increasingly data intensive, we must begin scaffolding youngsters’ understanding and appreciation of statistics. Data modeling affords one promising avenue to do so.

REFERENCES

Bethel, Ellie. 2008. *Michael Recycle*. Mascot, Australia: Koala Books.

———. 2009. *Litterbug Doug*. Mascot, Australia: Koala Books.

English, Lynn D. 2010. “Modeling with Complex Data in the Primary School.” In *Modeling Students’ Mathematical Modeling Competencies,* edited by Richard Lesh, Peter Galbraith, Christopher R. Haines, and Andrew Hurford, pp. 287–300. New York: Springer.

Leavy, Aisling. 2007. “An Examination of the Role of Statistical Investigation in Supporting the Development of Young Children’s Statistical Reasoning.” In *Contemporary Perspectives on Mathematics in Early Childhood Education*, edited by Olivia N. Saracho and Bernard Spodek, pp. 215–32. Charlotte, NC: Information Age.

Lehrer, Richard, and Leona Schauble. 2006. “Cultivating Model-Based Reasoning in Science Education.” In *The Cambridge Handbook of the Learning Sciences*, edited by R. Keith Sawyer, pp. 371–88. New York: Cambridge University Press.

Russell, Susan J. 1991. “Counting Noses and Scary Things: Children Construct Their Ideas about Data.” In *Proceedings of the Third International Conference on the Teaching of Statistics,* edited by David Vere-Jones, pp. 158–64. University of Otago: Dunedin, NZ.

Shaughnessy, Michael. 2007. “Research on Statistics Learning and Reasoning.” In *The Second Handbook of Research on Mathematics Teaching and Learning*, edited by Frank K. Lester Jr., pp. 957–1008. Charlotte, NC: Information Age.

Watson, Jane M. 2006. *Statistical Literacy at School: Growth and Goals*. Mahwah, NJ: Lawrence Erlbaum Associates.

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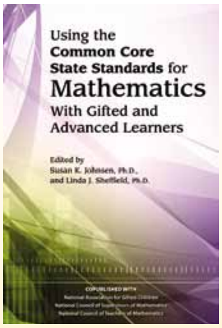

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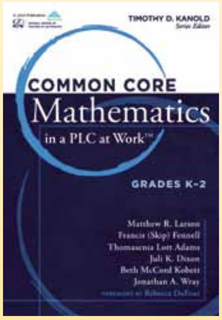

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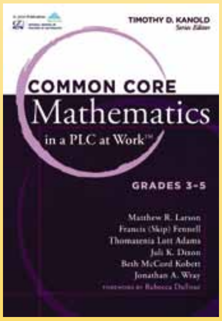

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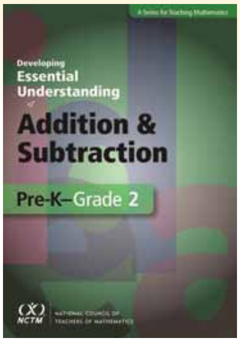

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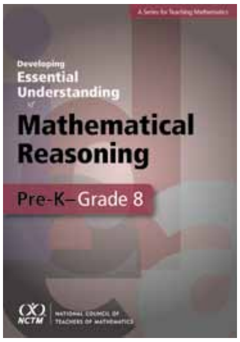

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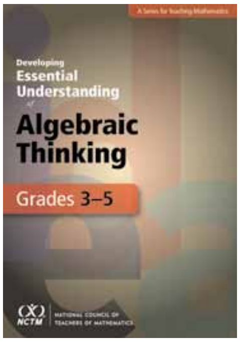

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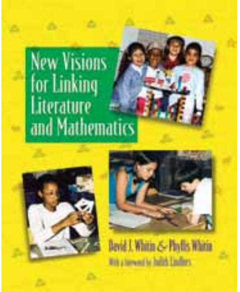

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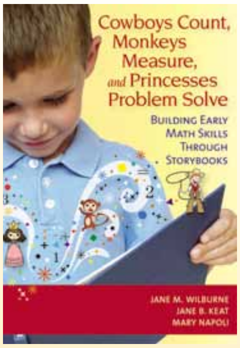

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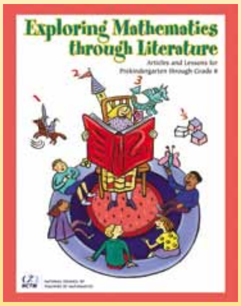

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