Introduction

Work with data has traditionally received the type of attention in the elementary school, especially in the primary grades, where students keep track of attendance, take surveys about favorites, or chart the weather from day to day. However, this work has often not gone much beyond collecting the date, making a graph (usually organized by the teacher), and posting it. Until the last decade, teachers did not have access to materials that focused real attention on issues of data representation and analysis. As a consequence, students in sixth grade were often doing the same surveys of favorite ice-cream flavors (or favorite recording artists or TV programs) with the same kinds of representation and analysis that they had learned to use in first or second grade. As *Principles and Standards for School Mathematics* states, "The emphasis on working with data entails students' meeting new ideas and procedures as they progress through the grades rather than revisiting the same activities and topics" (NCTM 2000, p. 48).

In order to help students develop their ideas about collecting, representing, and analyzing data, teachers themselves must develop clear-cut ideas about the fundamental issues in learning to work with data. The cases in the *Modeling with Data Casebook* provide a window into the thinking of children as they develop questions, decide how to collect data, organize and graph the data, analyze their data, and determine whether their data shed light on their original question. As you read about their work and consider their data representations, you can think through important aspects of the mathematics involved in this work. The cases, spanning kindergarten–grade 5, also illustrate how students' ideas develop over time. Although there are no cases from grades 6 or 7, teachers of these grades who have taken this course report that many of their students' ideas are very similar to those that they read in these cases.

Through these cases you will see how students, over time, develop a sense of a data set as a whole that can be described and summarized. In the primary grades, students often focus on single pieces of data ("my favorite color is red; Alison likes blue") and don't see that their representation of the data tells them any more than what they know from just listening to each other. Gradually students learn that they can get certain kinds of information from their data by counting or comparing, as in this kindergarten class that has collected information on another class's favorite color for mittens:
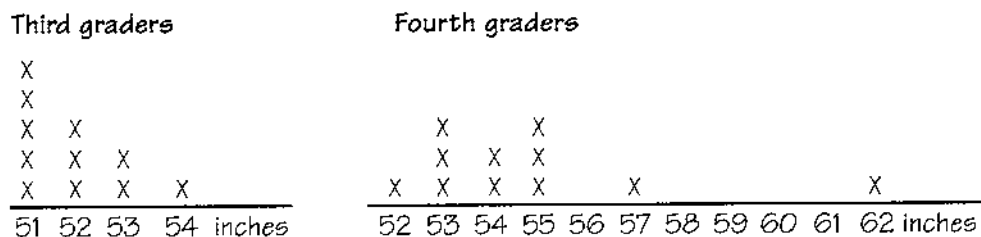
"They love purple, look at all the purples."
"Red is the next closest."
"Black and turquoise are the last."

In the upper grades, students are looking at a whole set of data, analyzing its overall shape—where the data are centered, how they are spread—and learning how to compare groups by summarizing the characteristics of data sets. Students must grapple with the fact that in order to summarize and compare, they must choose to focus on some aspects of the data and ignore others, as in these

observations by a third-/fourth-grade class that is trying to decide how to compare the heights of the third graders versus the fourth graders:

Third graders

```
X
X
X   X
X   X   X
X   X   X     X
----------------
51  52  53    54  inches
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Fourth graders

```
          X           X
          X   X   X
X   X   X   X       X               X
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52  53  54  55  56  57  58  59  60  61  62 inches
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"The data tell me that the fourth graders are bigger because the fourth graders have most kids in 53 and 55, and most of the third graders are at 51."

"The fourth graders have five taller than any third graders."

"But four of the fourths are shorter than the tallest third, so that doesn't mean all fourths are taller."

"If all the fourth graders stood on each other's shoulders, and the third graders did that too, I think the fourth graders would be higher."

"But I still think I know that more than half of the fourth graders are the same size as some of the third graders."

As students hold discussions like these, they are grappling with the fact that data work does not have the same certainty as solving a multiplication problem or finding the area of a rectangle. Different views of the data provide different information. When we represent and summarize data, some aspects are emphasized while others are submerged, depending on the kind of representation or the summary statistics we choose. Yet, in learning to deal with this uncertainty, we develop important tools for measuring and describing events and phenomena in our world. The more you and your students know about how to work with data, the better you can use these tools—and interpret others' use of them—to answer important questions.

The cases in the *Modeling with Data Casebook* were written by elementary and middle school teachers recounting episodes from their own classrooms. All had inclusive classrooms; the range represents schools in urban, suburban, and rural communities. The teacher-authors, who were themselves working to understand the "big ideas" of the elementary and middle grades mathematics curriculum, wrote these cases as part of their own process of inquiry. They came together on a regular basis to read and discuss one another's developing work.

The cases are grouped to focus on particular aspects of data representation and analysis. In chapter 1, the cases describe students' beginning work with data. These cases provide an intro-duction to collecting, representing, and describing data. Chapter 2 looks at the purpose of a data

investigation and how that guides the formulation of questions and the collection of data. In chapter 3, students represent and describe categorical data—data with values such as yes and no, or red and green, data that can be placed in categories, counted, and compared. In chapter 4, students are working to represent and describe numerical data—data with numerical values that can be ordered and compared as quantities, such as 54 inches and 62 inches, or 3 years and 10 years. Comparing data sets, a central purpose for data analysis, is the focus of chapter 5. Chapters 6 and 7 present students' developing ideas about averages.

Chapter 8, the last in the casebook, is the essay "Highlights of Related Research"; it summarizes some recent research findings that touch on the issues explored in the cases.