Pre-K–Grade 2

Data Analysis *and* Probability

Chapter 1
Data Collection, Organization, and Display

Data can be thought of as information that is collected about people or objects, such as information for a United States Census or a health survey. Young children are naturally very curious about the world. Data collection helps them answer some questions that arise naturally as they try to understand the world that they see around them every day. For example, they might want to know what time other children have to go to bed each night, or they might be interested in finding out how many children like the food that is served in the cafeteria. Such interest gives teachers and parents opportunities to introduce the concepts underlying the study of statistics as early as preschool.

Statistics can be thought of as numerical descriptions of samples of the things that surround us. For children, these descriptions might be counts or measurements of people, favorite objects, or events that are important in their lives. *Statistics* also refers to the science or study of obtaining, organizing, and interpreting data to make decisions or to answer questions.

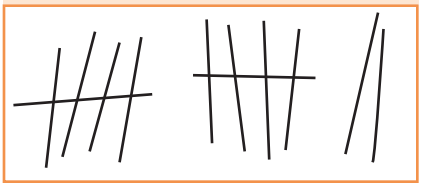
If children are to develop "data sense" very early, they first must be equipped with tools for gathering, sorting, and exhibiting data. "A fundamental idea in prekindergarten through grade 2 is that data can be organized or ordered and that this 'picture' of the data provides information about the phenomenon or question" (National Council of Teachers of Mathematics [NCTM] 2000, p. 49). Young children should experiment with organizing and displaying data in a wide variety of ways, and this work can lead to discussions about which methods of data organization and display are the most effective and the easiest to understand.

In this chapter, the activities focus on collecting, organizing, and displaying data. In Build a Graph, children use actual objects to make three-dimensional object bar graphs and then draw the corresponding two-dimensional bar graphs. Object bar graphs are also explored in All about Shoes, Chain It, Families, and What's Your Favorite? In Families, students also compare parts of the data set to the whole set when they compare data about brothers or sisters to the combined data about siblings.

A bar graph is a way to display information that uses bars of varying lengths to stand for the number of discrete pieces of data. Bar graphs are not used for continuous data, such as temperature or time. The bars may be either horizontal or vertical and may represent numerical data or other categories of data. For example, bars might show the members of a group of children in numerical categories (e.g., their ages, such as five, six, or seven years). Or the bars could represent the children in nonnumerical categories (e.g., the colors of their eyes, such as blue, brown, or green). The bars should be separate, not touching. In a vertical bar graph, the bars begin at the bottom, and in a horizontal bar graph, the bars begin at the left. All graphs should have a title. The bars make it easy for viewers to make visual comparisons of the sizes of groups.

Other methods for organizing and displaying data, including tallies and frequency tables, are explored in Chain It, Row Your Boat, and What's Your Favorite? The tally is one of the earliest methods humans used to keep track of quantities such as the number of sheep in a herd or the number of tools to be traded with another tribe of people. Young students learn that it is much easier to keep track of a tally if every fifth mark is a horizontal line segment that crosses the first four vertical ticks, as shown in figure 1.1. Many young students find that they are less likely to miscount if they use a horizontal mark—rather than a slanted one—across the other four ticks. Because students learn to count by fives at a very young age, they find that keeping track of objects using tallies helps them visualize the objects they are counting.

Fig. **1.1.**
A tally



A frequency table organizes data by using numbers to show how often an event happens. In the frequency table in figure 1.2, the number of students who voted for each dessert is shown.

Fig. **1.2.**
A frequency table

Favorite Dessert	Votes
Pie	6
Ice Cream	12
Cake	8

As students collect data, they should make tally marks, construct frequency tables from the tallied data, and then use the data in the tables to construct bar graphs. They will thus enhance their understanding of how these forms of data display are related. Teachers should also discuss with their students the differences and similarities among the various representations.

In Junk Sort, students learn to use Venn diagrams to represent objects that they have sorted according to one or more attributes. A Venn diagram uses loops to show how objects are categorized and how they are related. For example, two nonintersecting loops may be used to show the number of boys and of girls in a classroom. Two intersecting loops may be used to show the number of girls in the class and the number of students in the class wearing shorts.

On the CD-ROM that accompanies this book, the applets for organizing data, Get Organized, and for making Venn diagrams, Shape Sorter, can give students practice with those skills.

When students are first learning to sort and classify objects, they might begin by putting them in piles of objects that share a common attribute (e.g., all the objects are red or all are round) or a common function (e.g., all the objects are kitchen utensils or all are used to transport people). Young students may also classify objects together because they belong with each other (e.g., a student might put a male doll and a female doll in the same circle because they are "Mommy and Daddy and they belong together." At this beginning stage, students may not be consistent in their criteria for sorting. They might put the male doll and the female doll together because Mommy and Daddy belong together and then add a purse because Mommy needs her purse. Or they might put a blue triangle, a blue square, and a blue circle together and then add a red circle because it goes with the blue circle. Students may or may not be able to verbalize a rule for grouping the objects. Teachers may need to help the students verbalize their rules, and if the students are having difficulty, the teachers should ask questions to help the students clarify their thinking—for example, "This circle is for all the blue objects; is that blue?"

After students have some experience with sorting, they will be able to sort an entire collection of objects according to one rule. They could begin by sorting objects into two piles—those that belong and those that do not (e.g., all blocks that are red and all blocks that are not red). In such a simple task, a single attribute, for example, a color or a shape, is the sorting criterion. Students who are more advanced can sort objects into intersecting sets according to, for example, both color and shape. In such a task, students might put dogs in one category and black animals in another category and realize that black dogs must be placed in the intersection of the two loops representing the categories.

Students practice sorting objects and guessing rules for sorting while playing the game What's my rule? Students also learn to communicate their reasoning and justify it. The final activity in this chapter, Morley Most and Lutie Least, introduces students to picture graphs. Students collect data from and about their classmates and then use pictures to represent the collected data. Young students are curious about themselves and their immediate surroundings. This activity gives them an opportunity to explore their immediate world, to compare themselves with their classmates, to work cooperatively to solve a mathematical problem, and to practice their communication skills both verbally and graphically.

All the graphing activities afford students opportunities to analyze and talk about which methods give the clearest picture of the data collected. The choice of the best display to use depends on the information that is being represented and the way in which it will be used. The importance of labels on all types of data displays is emphasized in the activities.

Expectations for Students' Accomplishment

By the end of grade 2, students should be able to sort and classify objects according to two intersecting attributes, such as shape and color. Some students may have difficulty sorting objects into just two categories—objects that have a certain attribute and those that do not. With more experience, however, students should be able not only to

categorize objects into distinct, nonintersecting categories but also to decide where objects belong in a Venn diagram if they possess none, one, or two of the specified attributes. Some students may be able to place objects in three intersecting categories, such as color, shape, and size, but such sophistication should not be expected until students complete grade 3.

By the end of grade 2, students should be able to construct and interpret object graphs, vertical and horizontal bar graphs, frequency tables, two-loop Venn diagrams, and tallies. In grades 3–5, those representations will be extended to include other such graphical forms as line graphs, three-loop Venn diagrams, and double-bar graphs.

By the end of grade 2, students should understand that titles and labels are needed on data representations so that the information can be interpreted correctly. The ideas about identification will be extended in grades 3–5.

Build a Graph

Prekindergarten–Kindergarten

Summary

Students sort cubes by color and construct three-dimensional, color-cube bar graphs. They use the graphs to compare the numbers of cubes of different colors and answer questions about the data displayed. They then construct two-dimensional bar graphs to show the same data.

Sort and classify objects according to their attributes and organize data about the objects

Goals

- Construct three-dimensional graphs
- Construct two-dimensional graphs to represent the data in three-dimensional graphs
- Interpret simple two- and three-dimensional graphs in horizontal and vertical forms

Prior Knowledge

- Counting up to ten objects
- Identifying the numerals 0 through 10
- Identifying colors
- Identifying some bars as taller, longer, or shorter than others
- Comparing two sets of objects to determine which has more (or fewer) objects or if both sets have the same number of objects

Materials

- Forty colored linking cubes, ten of each of four colors
- Four containers—one for each color—to hold the cubes
- Four three-inch-by-five-inch index cards, each colored to match a different color of cube and with the name of the color printed on the card
- One copy of the blackline masters "Vertical Graph Mat" and "Horizontal Graph Mat" for each student. If you are using cubes that are two centimeters on an edge, copy the blackline masters at 133 percent; if the cubes are one inch on an edge, copy them at 167 percent.
- Crayons
- A poster-board graph having squares the same size as the faces of the cubes and labeled with the numerals 0–10, as shown in figure 1.3
- Removable cellophane tape
- Velcro

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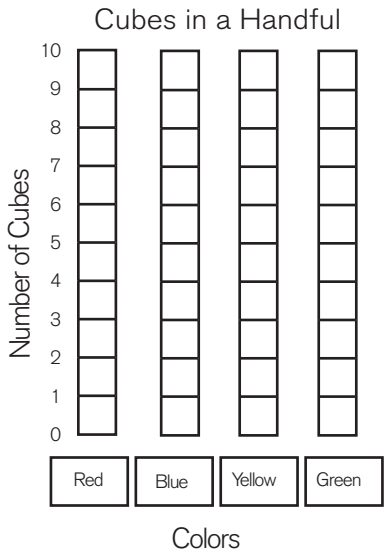
Activity

Engage

Seat the students in a circle. Place the forty colored cubes on the floor. Hold up four cubes, one of each color, and call on students to

Fig. **1.3.**

A poster-board graph representing the numbers of colored cubes



identify the colors. Then have a pair of children sort all the cubes by color. Ask other students to count the cubes of a particular color and tell the number. Have the students then place all the cubes of each color in a separate container.

Explore

Call on each of four students to take one handful of cubes of the same color, with each student selecting a different color. Have each of those students count the cubes and tell the number of cubes of her or his color. Show the students the color cards. Point to and read the names of the colors. Arrange the cards in a row on the floor or a table.

Call on students to place or connect the cubes of each of the four colors face-to-face to make cube "trains." Position the trains vertically above the corresponding color cards (see fig. 1.4). Talk about the arrangement of the cube trains. Say, "This is a bar graph. It is called a *bar graph* because each of the trains (*point to the colored-cube trains*) looks like a bar. The bar graph makes it easier for us to compare the numbers of cubes of different colors."

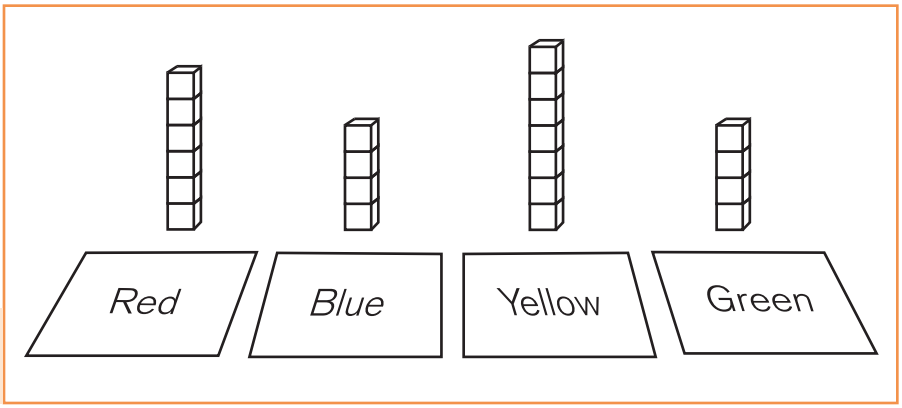


Fig. **1.4.**

A vertical colored-cube bar graph

Ask graph-interpretation and comparison questions like the following:

- How many red cubes are there?
- Are there more red cubes or more blue cubes? How did you decide? If the students give counting as their method of comparison, ask, "Can you tell without counting? Yes, you can compare the bars. The red bar is taller than the blue bar. So there are more red cubes than blue cubes."
- Are there fewer blue cubes or yellow cubes? How did you decide? If both sets contain the same number of cubes, ask, "What can you say about the numbers of blue cubes and yellow cubes? (They are the same.) How can you tell from the graph? (The bars are the same height.)

Repeat this activity with other groups of four children. Have the students build the bars from the bottom up. Be sure that the cubes in each bar are stacked neatly face-to-face.

Tell the students that the bar graph can also be made in a different way. Use one of the last vertical graphs made by a group of students. Arrange the color cards above one another on a table or other flat surface, turn the cube trains so that they are horizontal (i.e., arranged left to right), and place the trains to the right of the color cards (see fig.

1.5). Ask the same questions as before. Ask the students whether any of the answers to the previous questions changed when the orientation of the bars changed from vertical to horizontal. Point out to the students that the tallest bar has become the longest one.

Extend

Set up the poster-board graph shown in figure 1.3, and tape color cards in the rectangles along the bottom of the graph. Call on students to identify the numbers on the graph. Have four students arrange their handfuls of cubes on the poster-board graph (attach strips of Velcro to the cubes and to the squares on the poster board), and call on students to identify the number of each color. Demonstrate how to read across a graph, from the top of a bar to the number on the left of the graph. Have the students count the cubes to verify that their reading of the number on the graph is correct. Ask questions that elicit comparisons of the information represented by the bars, as before. Include questions that require the students not only to make comparisons but also to tell "how many more" and "how many fewer."

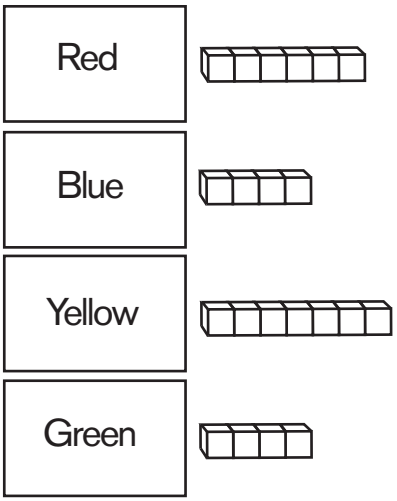
Give each student a copy of the blackline master "Graph Mat." Have the children make two-dimensional representations of their group's three-dimensional vertical graph. As you walk around the room, question the students about their graphs.

Discussion

Build a Graph not only introduces students to the construction and interpretation of bar graphs but also gives them practice in counting and in comparing sets of objects—two big ideas in the number strand. As students count to tell how many more or fewer, you will be able to note if they are counting systematically and if they understand the comparison terms *more* and *fewer*.

Having students compare the vertical and horizontal graphs also reinforces relationships involved in measurement. Students see that the tallest bar becomes the longest bar when the bar graph is rotated. They also observe that to compare the bars, the bars must have a common beginning point or baseline. For more practice with this activity, you may wish to have the students use the graphing applet, Get Organized, on the CD-ROM that accompanies this book.

Fig. **1.5.**
A horizontal colored-cube bar graph



You may want to have the students make two-dimensional copies of horizontal colored-cube bar graphs. If so, distribute copies of "Horizontal Graph Mat" for the students to complete.