The ability to respond to different levels of questions

A number of authors (Bertin 1983; Curcio 1987, 1989; McKnight 1990; Wainer 1992) have characterized both the kinds of questions (e.g., fig. 2) and, to a greater or lesser extent, the nature of the responses to these questions that address different levels with respect to reading graphs. Three levels of questioning emerge: (1) extracting data from a graph, (2) interpolating and finding relationships in the data as shown on a graph, and (3) extrapolating from the data and interpreting the relationships identified from a graph. Examples of questions explored with upper-elementary and middle-grades students (fig. 1) provide possible directions for assessing various components of graph sense.

Question 1 in figure 1 may be categorized using Curcio’s scheme (fig. 2) as a “read between the data” question. A “read the data” question might be “How many boxes of raisins had thirty raisins in them?” or “What is the fewest number of raisins found in any box?” and may serve as a way to clarify the structure of the graph for students before they move to the “read between the data” and “read beyond the data” questions.

Question 3 in figure 1 may be categorized using Curcio’s scheme as a “read beyond the data” question. This question involves inferring from the representation to make a prediction about an unknown case, namely, opening another box of raisins. It draws on students’ abilities to think about such topics as measures of the center or clustering of the data. In response to this question, students offer a variety of explanations, which involve identifying the mode, focusing on identifying clusters of data, attending to the absence of data and arguing that new data will “fill in the holes,” identifying the median by recreating the data set from the graph, and determining the middle of the range rather than the middle of the data. Not all responses are appropriate; we need to think carefully about which responses demonstrate an understanding of the display of the data and build appropriate links to other statistical concepts.

It seems clear that students need to talk more about graphs, both those given to them to read and those constructed by them. They need to talk about the structure of graphs and how this structure affects the statements that they can make about what is pictured. In addition, we need to think about the questions that we ask and how these questions may focus students’ attention on the information pictured by a graph.

Share Your Reflections

With the increasing inclusion of statistics content across the K–12 curriculum, it is possible both to clarify key concepts and to explore the development of students’ thinking with respect to these concepts. The material presented in this article begins to focus this discussion on the role of graphs as part of the process of statistical investigation. We encourage you (1) to explore your students’ thinking when they respond to these or similar questions in light of behaviors that you think demonstrate graph sense, (2) to examine how your own thinking is changing as a result of listening to your students, (3) to create your own tasks that help students develop their graph sense, and (4) to share the results of your experiences through the “Teacher to Teacher” feature in this journal.

Curcio conducted a study of graph comprehension assessing fourth and seventh grade students’ understanding of four traditional ‘school’ graphs: pictographs, bar graphs, circle or pie graphs, and line graphs. She identified three components to graph comprehension:

1. Reading the data involves “lifting” information to answer explicit questions for which the obvious answer is right there in the graph. As an example, “How many students have 13 letters in their names?”
2. Reading between the data involves interpolating and finding relationships in the data presented in a graph. This includes making comparisons (e.g., greater than, greatest, tallest, smallest, etc.) as well as applying operations (e.g., addition, subtraction, multiplication, division) to data. As an example, “How many students have more than 13 letters in their names?”
3. Reading beyond the data involves extrapolating, predicting, or inferring from the representation to answer implicit questions. As an example, “If a new student joined our class, how many letters would you predict that [that] student would have in her name?”

<table>
<thead>
<tr>
<th>Total Letters in Names of Students in Class</th>
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<tr>
<td>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17</td>
</tr>
</tbody>
</table>

Fig. 2 Components of graph comprehension (Curcio 1987, 1989)


Friel, Susan, Bright, George, and Curcio, Frances (November–December, 1997). Understanding Students’ Understanding of Graphs. *Mathematics Teaching in the Middle School*, 3 (3), 224–227. Reproduced with permission from *Mathematics Teaching in the Middle School*. Copyright © 1997 by the National Council of Teachers of Mathematics. All rights reserved.