Using QARs with charts and graphs

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"Well, they know the content, but they can't answer the questions," Emily (pseudonym) explained one day after school. Having worked steadily

The key features and uses of graphic types

Graphic type	Key features	Uses
Table (Sample A)	Grid format with cells Numerical values in each cell Labels across the top and bottom	• Communicates numerical values for different categories
Chart (Sample B)	Boxes and arrows or Boxes connected to each other	• Shows the relationship between parts of a group • Shows a sequence or process
Picture (Sample C)	Illustration or photograph Labels pointing to parts of the illustration	• Gives a realistic representation so that the item can be recognized • Identifies important parts
Line graph (Sample D)	X and Y axes Numeric units on each axis Matrix Lines connecting data points	• Communicates the relationship between two numeric variables • Shows trends
Bar graph (Sample E)	X and Y axes A categorical value on one axis and a numerical axis on the other	• Communicates the number or percentage of units in a certain category • Quickly summarizes numerical data • Makes comparisons between categories

for a year to help prepare her fifth-grade students for the impending statewide science assessment, Emily was understandably apprehensive about their performance. As we talked, she continued to describe how her students could explain detailed scientific processes, but when asked a multiple-choice question they often produced the wrong answer. She was concerned that her students' learning would not be evident from the assessment. After lamenting the sad state of affairs with high-stakes assessments and our own philosophical contentions with them, Emily and I (Heidi) decided that we were obligated to help her students. We put our heads together in a problem-solving session and decided to try using question-and-answer relationships (QARs) to help her students identify the purposes of various multiple-choice questions.

Educators devised the QAR strategy to assist readers as they answer comprehension questions in text (Raphael, 1986). Generally readers use a taxonomy of four question types to help them think about how to answer questions. The questions fall into two broad categories (in the text and in your head) with two question types in each category: (a) in the text—Right There and Think and Search; (b) in your head—The Author and You and On Your Own. Right There questions are literal and can be answered by looking for explicitly stated information at one place in the text. Think and Search questions require the reader to draw a conclusion by integrating text information from different parts of the passage. The Author and You questions require readers to think about the passage and then make some inference based on their own knowledge and the text information. On Your Own questions are related to the text and topic but require readers to draw solely on their own experiences.

In this article we will share how we taught fifth-grade students to use the QAR framework as they attacked charts, tables, figures, and other graphics. The first section of the article will describe why we decided to use QARs in this way, the next section will detail the sequence of our instruction, and the final section will describe the success that we had using QARs in this way.

Why we used QARs

We began to use the QAR framework with expository passages and standalone multiple-choice questions. During this time we asked students to answer questions and explain how they obtained their answers. This is when we first learned that Emily's students were having significant problems interpreting graphics. Often students could not explain how they chose their answers. They simply went to the graphic, superficially located some number matching the answer choices, and moved on. As we thought about this task, we realized that answering questions with graphics requires a complex, multistep process. Students must first read a related question, then read and analyze the graphic, determine the answer, locate the answer within a list of options, and record the selection on an answer sheet. To make matters more complicated, students are frequently required to shift among many different types of graphics in a short time. Because this multistep process is so sophisticated, we immediately recognized that the test was assessing not only students' science knowledge but also their ability to analyze graphics. We found five major problems with the way that students approached questions involving graphics.

1. Perceptions of graphics. Graphics are succinct and usually do not contain blocks of text-like passages. For this reason, students often believe that answering a question involving a graphic requires nothing more than looking at it

Sample A—Table

Temperature and precipitation for four cities on January 4, 1999

City	Chicago	Pittsburgh	Dallas	Baltimore
Degrees Celsius	0°	9°	18°	–2°
Precipitation amount in cms	1	2	5	0

Question: Which city received the most snow?
a. Dallas
b. Pittsburgh
c. Chicago
d. Baltimore

Answer: c. Chicago

QAR: The Author and You

Explanation: To answer this question students have to know that 0° Celsius is freezing. They also have to know that precipitation can be snow, sleet, rain, hail, or freezing rain. Thus, the answer requires that students not only use information provided but also integrate their own knowledge with the data.

and locating a specific number. We found that students became really confused if the answer options consisted of words or if the numerical choices did not match the specific numbers represented in the graphic. In other words, students were treating all graphic questions as Right There types, when many were Think and Search questions, and a few were the in-your-head category. Take the question "How many more inches did it rain in Michigan than Texas?" Even this very simple question requires students to retrieve two piece of information, perform a process, and then obtain an answer.

2. Inattention to the details of graphics. Often students could not explain exactly what a graphic was telling. When asked, they might respond, "There are 10 things in this group and 5 here." They often read neither the units corresponding with numbers nor the titles, labels, or captions accompanying the graphic. In Sample E on p. 27, a bar graph (see the Key Features and Uses of Graphic Types Table), students must pay attention to the fact that the units increase by two and that the Y-axis is telling the number of animals per square mile.

3. Irrelevant data. Students treated all data as relevant to the question when at times entire sections, columns, or labeled portions were not relevant. Sometimes a graphic was included that contributed nothing to answering the question. In these situations, the question was an On Your Own question, but students treated it as a Right There question. Sample C on p. 25 is a good example of this situation. The picture actually does not help students answer the question. Instead they must use information that they know to help them.

4. Inattention to questions. Students did not carefully read the questions before attending to the graphics. They would spend all their time looking at the graphic without understanding the information for which they were searching.

5. Not using prior knowledge. Students did not integrate their prior knowledge with the information in the graphic. They did not understand that they might be expected to draw on scientific knowledge they already had as they analyzed a graphic. For example, in Sample A students must know that 0° Celsius is the freezing point of water if they are to make judgments about how much snow each city received. They must also know that the term *precipitation* can refer to either snow or rain.

Instructional sequence: Three-step plan

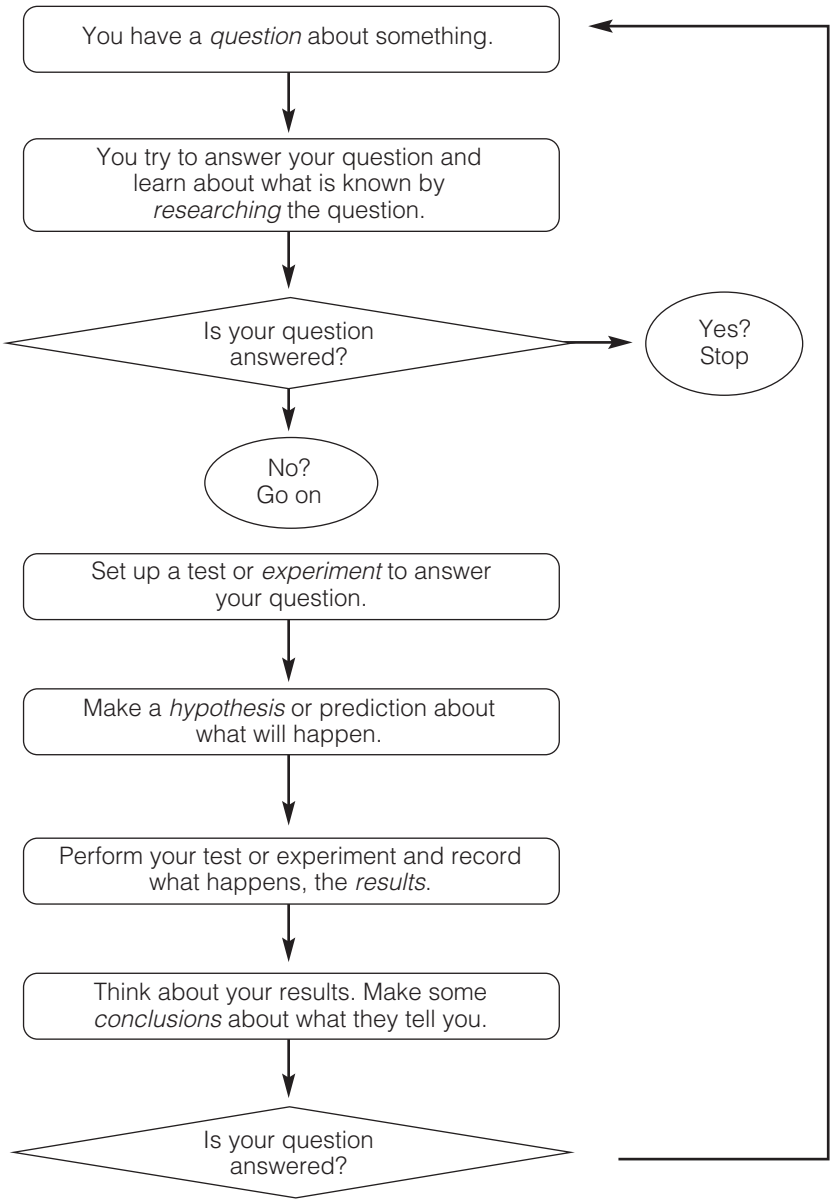
As we watched students, it became clear to us that many questions with accompanying graphics could be classified using the QAR taxonomy. We had seen QARs work with other questions, and we felt that they would be helpful as students analyzed graphics. Our teaching process had the following three steps, the first two of which served as building blocks for using QARs: (a) identifying the type of graphic, (b) understanding the relationships in graphics, and (c) using QARs with questions and graphics.

Identifying the type of graphic. Ultimately we wanted students to understand how to use graphics to answer questions, but we had to start with understanding the different types of graphics. Students did not differentiate between a table, a chart, a figure, and a graph, which prevented them from understanding the relationships between data. In the first part of the strategy we clarified the differences between five graphic types. We chose the five we did because we had seen them on many tests and believed that they were developmentally appropriate for fifth graders.

The Table details the differences between the five types and has a coordinating example of each one. To start this segment of the instruction we labeled samples of each graphic type—table, chart, picture, line graph, and bar graph. We asked students to contrast the various graphic types. For example, when we showed them the table we

Sample B—Chart

The scientific process



Question:	What would you do if you conducted research and found that your question had been answered? a. Continue to research b. Stop the process c. Set up an experiment d. None of the above
Answer:	b. Stop the process
QAR:	Right There
Explanation:	The information to answer the question is explicitly stated in the graphic and can be found in one place. The students need only to read the graphic and use the supplied information to find the correct answer.

asked them how it differed from the chart, picture, line graph, and bar graph. The students quickly observed that the main part of the table (the data) included numbers—not bars, lines, or pictures. They also noted that the table had boxes (cells) and that the labels for the numbers were on the top and left side (column header and row header). As they identified the key attributes of each graphic, we illustrated the graphics on chart paper and labeled their parts. We also constructed a graphic like the Key Features Table, which, at this stage, contained only the columns for "Graphic" and "Features." We then practiced identifying graphic types by showing students examples and having the group decide what type of graphic each one was. Finally, students went on a graphics hunt. In groups, they used sticky notes to label graphics they found in nonfiction trade books, encyclopedias, newspapers, magazines, and content area texts. Students went home and looked for more graphics, and after several days we convened to share results.

As students shared graphics, many interesting questions arose. They quickly discovered that many graphics have features of several different types (e.g., data table with numbers accompanying a line graph). Students also found graphic types that we had not identified—scatter plots, pie charts, color-coded maps. For enrichment, students learned about these, but we stayed focused on our five. Students began to have questions about why various graphic types were chosen for various purposes. We helped them to see how data could be manipulated by the graphic type. For example, if an author wanted to minimize the differences between the per pupil expenditures in two counties on a bar graph, she or he could increase the scale for dollar amounts from increments of 10 to increments of 50. In this way, the physical space represented by the bars on the graph would be minimized and the differences between the counties smaller. The reflection session led nicely into the next instructional sequence, teaching students the relationships depicted in graphics.

Understanding the relationships in graphics. While crucial to our strategy, this part of our instruction was tricky because it required the students to think

abstractly and to make inferences. We started by taking each type of graphic and asking students to more fully analyze the contents. We ordered the graphics from the simplest to the most complex in the following way: pictures, tables, bar graphs, charts, line graphs. We concentrated on each graphic type for two days, asking students to answer questions and to talk about the graphic in pairs. We carefully orchestrated these pairs so that stronger students worked with weaker students. After students worked with their partners, we discussed each particular graphic and the relationships between the different elements.

We started our discussions by asking general questions like these: "What does this graphic tell you? What type of data do you see—words, numbers, or pictures? How are the data organized? Are the data shown in ways other than numbers and words?" Then we asked students why they thought that the particular graphic was set up the way that it was by asking questions like "What are the advantages and disadvantages of this particular graphic type?"

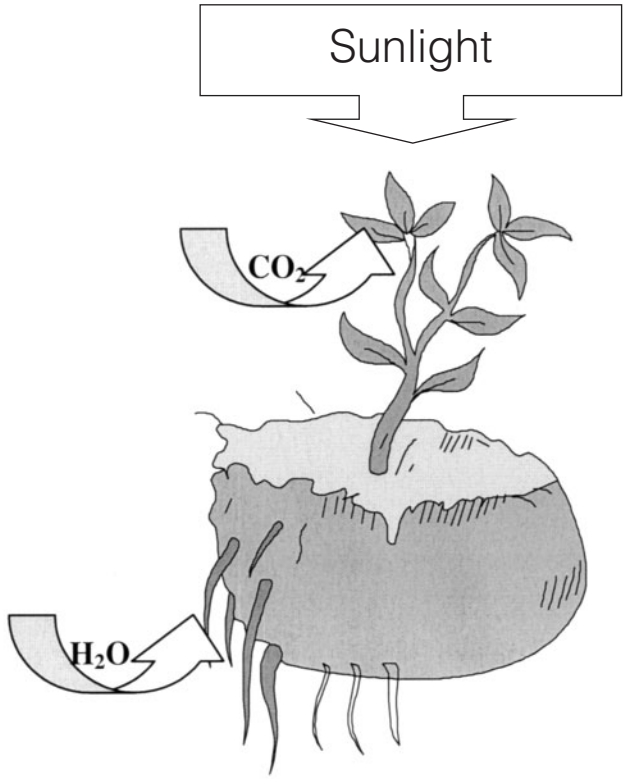
Our discussions were enlightening to the students. For example, when we started talking about the bar graph students quickly identified that it was showing the number of animals in a park. They recognized that the bars represented the animals, but most students did not immediately note that the scale on the Y-axis was actually showing the number of animals per square mile. We pointed out that estimating the number of animals in the park would require knowing how many square miles the park covered. Students realized that the bar graph was a good way to eyeball the data. They could quickly understand which animals were the most populous and which were the least. They also recognized that a reader could obtain a close numerical report but that this was not the best use of this graphic, which was best suited to quick summary information. At this point we added the last column, "Uses," to our Table and completed it with the students' help.

During this time we were laying important groundwork for using the QARs with graphics. If students could identify the best uses of each graphic type, then they were more likely to know what kinds of questions would relate to each. For instance, the fact that tables communicate data in specific numbers indicates Right There or Think and Search types. Line graphs, on the other hand, are used to communicate trends and the relationship of one set of variables to another. So questions are not likely to be Right There types. Instead Think and Search or The Author and You questions are more likely to match these graphics.

Using QARs with questions and graphics. Once students fully understood graphic types and the relationships each communicated, we were ready for them to use the QARs. Essentially we followed the same steps that we had when we used QARs with expository

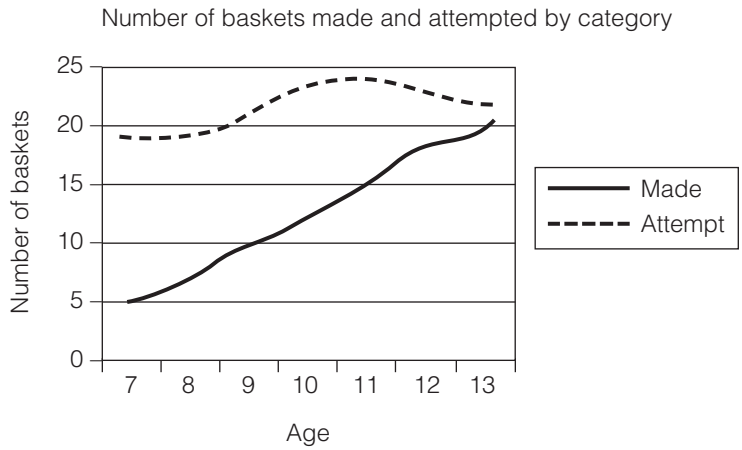
Sample C—Picture

The ingredients of photosynthesis



Question:	What chemical that is used in photosynthesis do *only* plants have? a. H_2O b. Chlorophyll c. Sugar d. CO_2
Answer:	c. Chlorophyll
QAR:	On My Own
Explanation:	Although a picture is provided, nothing in this picture assists students in answering the question. In fact, the information in the picture could mislead or distract them. Students must be able to figure out that their own knowledge is needed to answer the question and must know that CO_2 and H_2O are common to many different organisms.

Sample D—Line graph on basketball



Question:	According to this graph, which of the following is true about the relationship between the number of baskets made and attempted? a. Older players make fewer baskets. b. Players attempt more baskets than they make. c. As students get older the number of baskets made gets closer to the number of baskets attempted. d. b and c
Answer:	d. b and c
QAR:	Think and Search
Explanation:	Students have all the information required to answer this question in the graphic. However, they must pay careful attention to multiple pieces of data. First they have to note the relationship between age and the baskets. As age increases so do the numbers of baskets made and attempted. Then students have to differentiate between the lines representing the number of baskets made and those attempted. They must understand that players always attempt more baskets than they make. Finally, students must deduce the relationship between age, number of baskets made, and number of baskets attempted. They must see that these two lines get closer together and must understand that this means that as players get older the ratio of made to attempted baskets gets smaller.

passages, allowing for a few modifications. There were roughly four stages of our instruction.

Stage 1. We extended the QARs to questions with graphics. We gave them the different graphics with questions and answers. (See examples accompanying Samples A–E.) Students read each question, studied the graphic, and verified the answer supplied. Earlier, students had been given cards labeled with each type of question and a description. As we looked at each question and graphic, the students held up a card to match their choice of QARs.

Stage 2. We gave students the same information but asked them to work in groups of four to decide the QAR. Even though we provided the answer, students had to thoroughly understand the process by which that answer was selected. At this point we noticed in-depth conversations about why the answer given was correct and the process for arriving at that answer. This analysis was much deeper than discussions that we had observed earlier in the year.

Stage 3. We gave students individual sheets with questions, answers, and graphics and asked them to assign QARs to these questions independently. We told the students that in order to correctly determine the QAR they had to look at both the question and the graphic. This was different from their previous use of QARs because students could not simply rely on the cues in the questions to help them determine the QARs. Some questions could seem like one type but, after students looked over the graphic, could actually be another question type. Only when students combined their knowledge of the question with their understanding of the graphic could they correctly deduce the QAR.

Stage 4. We showed students how to use the QAR strategy to locate the correct answers. We followed our earlier teaching sequence, large-group practice, small-group guided practice, individual practice, and large-group reflection. We gave students the following six-step process: Read the question, review the graphic, reread the question, assign a QAR, answer the question, and locate the answer in the answer choices. We put this process on laminated bookmarks to help the students remember the steps. We did not want them to try to memorize the process or to have it detract from comprehension of the actual material.

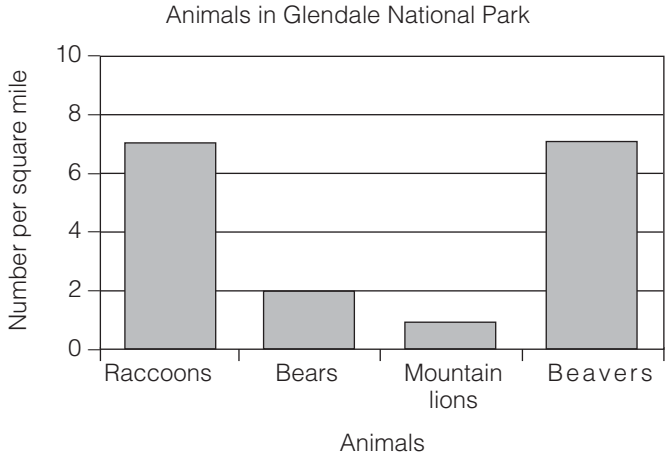
We stressed that students read the questions and *not* the answer choices before they did anything else. Reading the question is an age-old test-taking strategy that helps the learners focus on important information as they read. We told students not to read the answers because when they did they would become distracted by the choices. In these instances they would quickly cross-reference the choices with the data in the graphic and gravitate to any matches that they noted, even when the choices did not answer the question. In Sample C, for instance, the choices that match the labels in the picture do not correctly answer the question.

To review the graphic students read the title, labels, and units and thought about the graphic type. Then we asked students to reread the question to remind themselves of its focus. We added this step after we realized that students often forgot the question when they spent time reading the graphic. We also found that reading the question twice ensured that students would focus on the specific information requested. At

the fourth step students determined the QAR.

At the fifth and sixth steps the students first answered the question using the graphic and then located the answer in the answer choices. We encountered two problems at this point. The first was skipping the fifth step—answering the question without relying on the answer choices. Students often wanted to simply go straight to the answers and make a choice, and in so doing they were often not truly answering the question. When they first had to answer the question on their own without relying on the choices, their thinking was more analytical and they were usually more prepared to deal with the second problem—what to do when their answer was not one of the choices. When this happened we told them to "troubleshoot" the graphic making sure that they understood the units and increments being shown and that they were answering the actual question. If they did this and still were unsuccessful, we told them to make a choice closest to their answer but to come back to that question when they had finished the others.

Sample E—Bar graph



Question:	About how many bears would you encounter in 10 square miles of Glendale National Park? a. 1 b. 2 c. 20 d. same as the number of mountain lions
Answer:	c. 20
QAR:	Think and Search
Explanation:	All of the information necessary to answer this question is provided in the graphic. However, the students must carefully read the units on the Y-axis. The increments represent the number of animals in each square mile. The question asks for the number of bears in 10 square miles. The students must determine how many bears are in 1 square mile (2) and then multiply this by the number of square miles (10).

Why our strategy worked

As teachers, we often thought that we were bombarding the students with test preparation. We also felt philosophically torn between quality instruction and temporary test coaching. We liked this strategy because we believed that we were not only giving students solid instruction for life, but also addressing the skills they would need to be good test takers. We would have changed very little of this strategy had we not been pressured by the test. The major reason this process worked was that it cued students to slow down and pay attention to graphics. Previously their approach had been superficial and impulsive. This process forced us as teachers to take a closer look at the task demands of graphics and to move away from assumptive teaching. We assumed that students simply needed to look at a chart or table and retrieve an answer. We assumed that answering these kinds of questions did not involve integrating prior knowledge. We assumed that students understood the differences between graphics as well as the relationships depicted. Teaching students to analyze each graphic type forced us to be explicit about graphic information in ways that we had not been before. The framework of QARs helped us to see how sophisticated graphics can be.

Finally we saw the QAR strategy as an excellent vehicle for metacognitive instruction. The process of categorizing graphics, discussing how answers are obtained and why an answer is correct, assisted readers in thinking about their own processes. Once they began thinking about these issues, they were on the way to deeper analysis. We do caution teachers, however, that teaching these processes could be distracting. The instructional focus could be more on the steps and classifications than on the material being analyzed. To avoid this, we tried to make sure that students spent more instructional time *using* the strategy than learning it. We also gave students cards and bookmarks with reminders so that they did not have to memorize. Gradually they began to internalize the information without setting out to learn it.

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Reference

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