Anticipation Guides: Reading for Understanding

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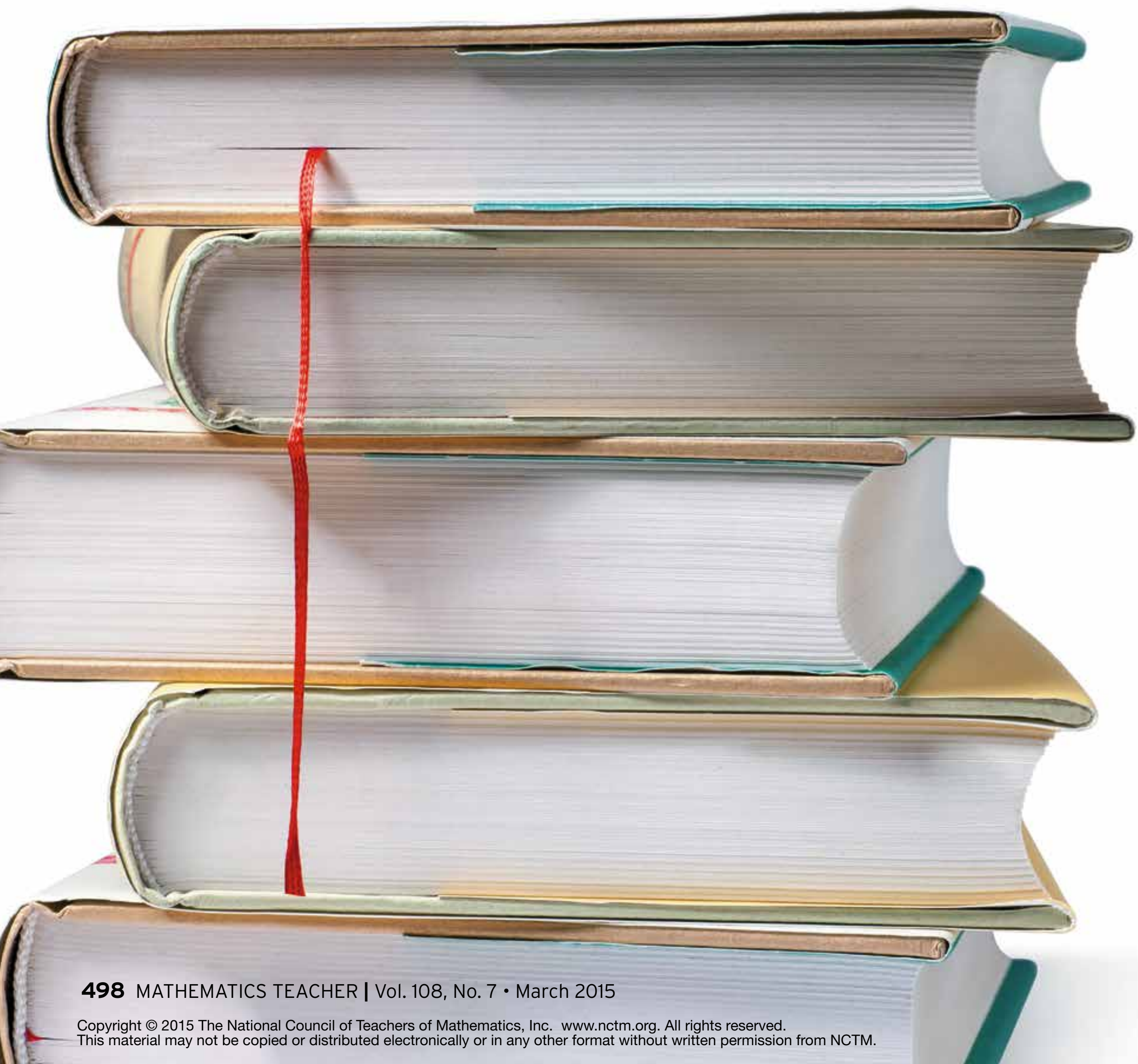

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Mathematics

Help students develop skills to support comprehension of concepts and terminology.

With the acceptance by many states of the Common Core State Standards for Mathematics, new emphasis is being placed on students' ability to engage in mathematical practices such as understanding problems (including word problems), reading and critiquing arguments, and making explicit use of definitions (CCSSI 2010). Engaging students in mathematics through reading and discussing mathematical ideas is an important means of developing these mathematical practices and the skills needed to be successful in such tasks. Reading is a fundamental skill for learning in all disciplines, including mathematics. Independent readers can gain new knowledge and understanding from reading a variety of mathematics-focused texts. Students' reading abilities also influence their performance on mathematics assessments.

In this article, we describe benefits and specific considerations for supporting reading comprehension in mathematics and discuss the use of anticipation guides as tools to actively and critically engage students in reading, mathematical reasoning, and comprehension of mathematics text. Our discussion is based on our work with mathematics teachers using literacy strategies in the Literacy Instruction in Math and Science for Secondary Teachers (LIMSST) project. During this four-year project, we observed mathematics lessons, collected lesson plans, and interviewed teachers about their use of literacy strategies.

READING AND MATHEMATICS LEARNING

American students do little reading of published mathematics texts, either in or out of class. Students may be reluctant to read mathematics texts because of the complexity of comprehending technical text. Yet the ability to read such texts can deepen understanding of concepts, support independent learning of mathematics, and prepare students for advanced study. Students who lack skill in comprehending mathematics text are perpetually reliant on a more knowledgeable other, frequently a teacher, to explain the information contained in their textbook or in mathematics problems that they are asked to solve (Wade and Moje 2000).

Mathematics is particularly difficult content to read, presenting demands in higher-level thinking and comprehension skills. Many students may not easily comprehend mathematics texts, even when they are able to decode print materials (Cantrell, Burns, and Callaway 2009). Mathematics texts make heavy use of precise symbols and unfamiliar vocabulary; use longer and more complex sentence structure; contain more words, symbols, and concepts per paragraph than other texts; and have little redundancy to help with interpretation (Schell 1982). Further, mathematics texts are often written above the grade level of intended students (Barton and Heidema 2002; Reehm and Long 1996). Concepts critical for understanding may be hidden, implied, or left unstated. In reading mathematics text, readers need to analyze and expand

GRAPHING LINEAR INEQUALITIES IN TWO VARIABLES

Before reading
Decide whether the statements below are true, false, or sometimes true. In the Before column, place a T (true), an F (false), or an S (sometimes true). You must make a decision. Do not leave any blank.

After reading
Review your responses and place a T (true), F (false), or S (sometimes true) in the After column for each statement. Underneath each statement, provide *evidence from the text* that supports your thinking. Reference ideas from the text with the page number and section where the information was found. There may be more than one source in the text for each statement. When you have entered an S, describe the situations for which the statement is true or false.

Before **After**

___T___ ___T___ 1. A graph of an inequality shows all the points that satisfy the inequality.
p. 102, middle section: "Every point in the shaded region satisfies the inequality," and a solid line shows points on the line that satisfy the inequality.

___T___ ___S___ 2. The solution to a linear inequality in two variables includes the points on the line of the related linear equality.
p. 102, middle section: T: When the inequality is $\leq$ or $\geq$, points on the line are included in the solution, and the line is drawn as solid.
F: When the inequality is $<$ or $>$, the points on the line are not included, and the line is drawn as dashed.

___T___ ___F___ 3. When solving linear inequalities in two variables, test points should be on the boundary line.
p. 102, bottom section: Test points should not be on the boundary line. Test points off the line indicate which side of the line to shade. If the test point makes the inequality true, shade the side of the line that includes the test point. If the test point makes the inequality false, shade the opposite side of the line.

___F___ ___F___ 4. The point (3, 1) is included in the graph of the solution for the linear inequality $4x - 3y < 7$.
p. 102, bottom section: This shows a similar example. When (3, 1) is substituted, $4(3) - 3(1) > 7$. This makes the original inequality false. This point should not be included in the graph of the inequality. The opposite side of the line should be shaded.

___F___ ___S___ 5. The region containing the test point should not be shaded.
F: p. 103, part a: *If the test point makes the inequality true, shade the side of the line that includes the test point.*
T: p. 102, bottom section: If the test point makes the inequality false, shade the opposite side of the line.

___T___ ___T___ 6. Solving linear inequalities could be used to find a solution to a problem when the solution cannot be above or below a certain amount.
p. 103: This shows an example using an inequality to find the number of employees that can be assigned to each department when 20 employees are available.

Source: Holliday et al., *Glencoe Algebra 2* (2008, pp. 102–3)

Fig. 1 An anticipation guide shows sample answers (in blue) that provide text references.

meaning rather than condense ideas (Fuentes 1998; Shanahan and Shanahan 2008).

Mathematics teachers may be unaware that the Common Core State Standards for English Language Arts, Science, and Technical Subjects require students by the end of grade 8 to read and comprehend technical grade-level texts (including mathematics) independently and proficiently (CCSSI 2010). To comprehend mathematics text, most students require explicit instruction in the specialized structure, language conventions, and interpretive processes used in these texts (Shanahan and Shanahan 2012). Some might think that such instruction should be provided by a reading or an English teacher, but there is good reason for mathematics teachers to accept responsibility for developing these reading skills in their students. Mathematicians and mathematics teachers are skilled readers of mathematics text, in contrast to traditionally trained reading teachers, who have likely focused their learning and teaching on reading fiction and prose (Reehm and Long 1996).

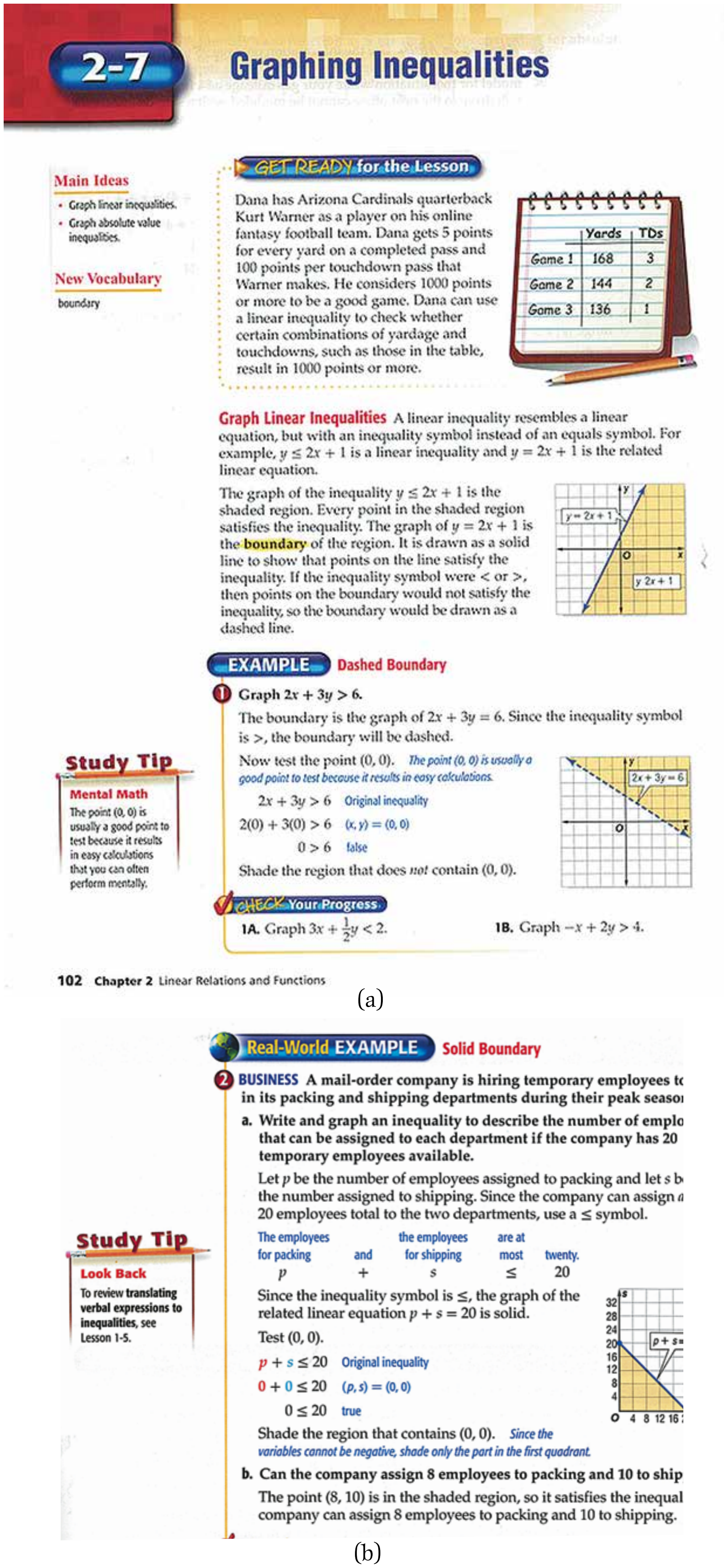
ANTICIPATION GUIDES: A TOOL FOR SCAFFOLDING MATHEMATICS READING

Many students benefit from scaffolding mathematical thought, both when solving problems and "when reading about mathematical concepts and relationships" (Buehl 2011, p. 65). Anticipation guides are reading comprehension tools designed to scaffold text comprehension. In using anticipation guides, students are presented with statements, related to concepts in the reading, that are used to elicit prior knowledge, focus reading, and construct mathematical arguments (Duffelmeyer and Baum 1992; Kozen, Murray, and Windell 2006).

Students learn to read mathematics by applying higher-level thinking processes to text (Forget 2004). Anticipation guides support students in developing skills in justifying findings and supporting ideas with evidence, skills also used in mathematical justification and proof. Constructing viable arguments and evaluating others' reasoning are core mathematics practices in which students "justify their conclusions, communicate them to others, and respond to the arguments of others" (CCSSI 2010, pp. 6–7). Skill in making and justifying claims can be developed in mathematical investigation, but reading and discussing the nuances of mathematical text provides an additional context in which to develop reasoning and justification skills. When using anticipation guides, students construct arguments that relate to both incorrect and correct ideas and thus have the opportunity to address misconceptions and engage in debate from various viewpoints and interpretations.

The project teachers were provided a single experience in reading with an anticipation guide and then asked to design one or more guides for use in their own classes. These mathematics teachers found anticipation guides to be valuable tools that promoted justification and helped students delve into meanings of various concepts and terms. Some of their suggestions for designing and using anticipation guides effectively in mathematics are found in **figures 1** and **2**. **Figure 1** shows a sample anticipation guide with sample responses for a high school mathematics class; **figure 2** provides the mathematics text to be used with the guide.

When first introducing anticipation guides, explain the differences between an anticipation guide and a typical reading guide, for which answers are often stated directly in the text. Model a few examples for students to demonstrate the thinking process needed to read for evidence and make inferences from the text. This process may be new to students, and they may become frustrated if


2-7 Graphing Inequalities

Main Ideas
- Graph linear inequalities.
- Graph absolute value inequalities.

New Vocabulary
boundary

GET READY for the Lesson

Dana has Arizona Cardinals quarterback Kurt Warner as a player on his online fantasy football team. Dana gets 5 points for every yard on a completed pass and 100 points per touchdown pass that Warner makes. He considers 1000 points or more to be a good game. Dana can use a linear inequality to check whether certain combinations of yardage and touchdowns, such as those in the table, result in 1000 points or more.

	Yards	TDs
Game 1	168	3
Game 2	144	2
Game 3	136	1

Graph Linear Inequalities A linear inequality resembles a linear equation, but with an inequality symbol instead of an equals symbol. For example, $y \le 2x + 1$ is a linear inequality and $y = 2x + 1$ is the related linear equation.

The graph of the inequality $y \le 2x + 1$ is the shaded region. Every point in the shaded region satisfies the inequality. The graph of $y = 2x + 1$ is the **boundary** of the region. It is drawn as a solid line to show that points on the line satisfy the inequality. If the inequality symbol were < or >, then points on the boundary would not satisfy the inequality, so the boundary would be drawn as a dashed line.

EXAMPLE Dashed Boundary

1 Graph $2x + 3y > 6$.

The boundary is the graph of $2x + 3y = 6$. Since the inequality symbol is >, the boundary will be dashed.

Now test the point (0, 0). *The point (0, 0) is usually a good point to test because it results in easy calculations.*

$2x + 3y > 6$ Original inequality

$2(0) + 3(0) > 6$ $(x, y) = (0, 0)$

$0 > 6$ false

Shade the region that does *not* contain (0, 0).

Study Tip
Mental Math
The point (0, 0) is usually a good point to test because it results in easy calculations that you can often perform mentally.

CHECK Your Progress

1A. Graph $3x + \frac{1}{2}y < 2$.

1B. Graph $-x + 2y > 4$.

102 Chapter 2 Linear Relations and Functions

(a)

Real-World EXAMPLE Solid Boundary

2 **BUSINESS A mail-order company is hiring temporary employees t in its packing and shipping departments during their peak seaso**

a. Write and graph an inequality to describe the number of emplo that can be assigned to each department if the company has 20 temporary employees available.

Let p be the number of employees assigned to packing and let s b the number assigned to shipping. Since the company can assign a 20 employees total to the two departments, use a ≤ symbol.

The employees for packing	and	the employees for shipping	are at most	twenty.
p	+	s	≤	20

Since the inequality symbol is ≤, the graph of the related linear equation $p + s = 20$ is solid.

Test (0, 0).

$p + s \le 20$ Original inequality

$0 + 0 \le 20$ $(p, s) = (0, 0)$

$0 \le 20$ true

Shade the region that contains (0, 0). *Since the variables cannot be negative, shade only the part in the first quadrant.*

Study Tip
Look Back
To review translating verbal expressions to inequalities, see Lesson 1-5.

b. Can the company assign 8 employees to packing and 10 to ship

The point (8, 10) is in the shaded region, so it satisfies the inequal company can assign 8 employees to packing and 10 to shipping.

(b)

Source: Holliday et al., *Glencoe Algebra 2*. c 2008. The McGraw-Hill Companies, Inc.

Fig. 2 Some textbook examples are shown.

they do not quickly see a clear answer.

Successful reading of mathematics text requires readers to draw heavily on prior knowledge of mathematics concepts and relationships as they interpret the meaning of the text. When using anticipation guides, direct students to carefully consider each statement before reading; doing so activates and assesses their prior knowledge. Have them determine whether or not each statement is true; then have them discuss their decisions with a partner and defend decisions on statements on which they did not agree. This discussion helps encourage the students to read with a purpose, seeking information to justify their position.

In writing anticipation guide statements, focus on important concepts, potential misconceptions, and facts or concepts that may not be well understood by students.

Encourage students to read the text interactively, comparing current knowledge with information in the text while looking for confirming evidence. During the reading phase, ask students to read thoughtfully, record evidence supporting their thinking along with the text location where the evidence was found, and prepare to justify their interpretation using support from the reading (Duffelmeyer and Baum 1992). A valid justification must explain why a statement is true, false, or sometimes true.

Before beginning this phase, talk with students about what constitutes adequate evidence and justification. The components of an adequate justification will depend on what is being justified. When the justification refers to a mathematical convention, such as placing the independent variable on the horizontal axis when constructing a graph, it is enough to cite the page in the text that presents that convention. However, in most cases, students must justify their interpretation of the meaning inherent in the mathematical ideas. A successful justification of this type explains why a statement is true "by providing insight into underlying relationships that hold in every instance" (Lannin, Ellis, and Elliott 2011, p. 35). Remind students to read all parts of the text—margins, text, pictures, captions, graphs, and figures. If the anticipation guide includes, as our example does, statements that are sometimes true and sometimes false, emphasize that students are to describe the conditions under which statements are true or false.

After students have read the text, have them discuss and defend their interpretations of each anticipation guide statement, using evidence from the text, and listen to other students' conceptions. They can "try out" their interpretations in a small group before joining a whole-class discussion. Such discussions engage students in analyzing and expanding the meaning of densely written text. Through discussion, students use mathematical terminology, build conceptual knowledge, and refine their own understanding. For students with limited topic and vocabulary knowledge to draw on in making sense of complex text, discussion scaffolds reading comprehension skill and strengthens their background knowledge for use in future reading. The individual writing and class discussion that occur during anticipation guide lessons also provide opportunities for teachers to gain insight into students' sense making, reasoning, and understanding.

When moderating discussions, maintain focus on supporting claims with evidence, not on whether an answer is correct. After students defend their decisions with supporting evidence, ask other groups for additional evidence in support of a particular decision. Finally, have students reflect on changes in their understanding that resulted from reading and discussion. Reflection and whole-group discussion help students synthesize ideas and address misconceptions related to the statements.

It is important to allow ample time for reading, interpretation, and discussion. Reading complex text with thought and interpretation takes time, and discussions that probe deeply into ideas through debate take more time than responding to simple questions of knowledge. If only limited time is provided, students will be tempted to make quick, simple responses, thereby losing opportunities to engage in sense making and justification that they would have made with extended available time.

Teachers in our project found that reading information in text form, discussing it, and then writing it helped deepen students' understanding as well as develop reading skills. They described how anticipation guides encouraged students to think about their prior learning and to confirm or change their thinking, rather than just recording others' ideas. Students love to argue "why" they have the correct answer, and anticipation guides require them to support their reasoning to get others to change their minds. Teachers noted that when students first thought and then discussed their thoughts in pairs or small groups, they were more confident and more likely to contribute to whole-class discussions.

DESIGNING STATEMENTS FOR STUDENT RESPONSE

In designing an anticipation guide, begin by selecting a reading and the key understandings you want students to gain from the reading. Choose short selections to allow ample time for careful reading and discussion. In determining readings and key ideas to include, refer to standards documents and research on common misconceptions. Identify what students may already know about the topic that the reading may challenge or affirm. Then use this information to plan specific statements that students will respond to. In writing statements, focus on important concepts, potential misconceptions, and facts or concepts that may not be well understood by students. If a particular statement does not produce the results you desire, consider rewording the statement for future use.

Effective anticipation guides include several types of statements, each with a different purpose. The anticipation guide (see **fig. 1**) on graphing linear inequalities illustrates statements included for these different purposes.

• *The answer is similar to one found in the text*. Statement 1 involves a slight rewording of information that is stated clearly in the text. Although the wording does not exactly match the text, the statement is easy to confirm and presents a situation that is familiar to students from their experience with class worksheets on various topics. Beginning with such statements eases students into the anticipation guide process. The different wording requires students to think about the meaning of the text and examine information found in the figure outside the main text to determine whether the statement on the guide has the same meaning.

• *The answer requires interpretation*. Statement 3 illustrates this form of statement. The text demonstrates testing the point (0, 0), which is a point not on the boundary line $2x + 3y = 6$. However, it is left to students to realize that a test point not on the boundary line will help determine which side of the line should be shaded and that a test point on the line will help determine whether the line itself should be solid (indicating that all points on the line make the inequality true) or dashed (indicating that points on the line do not make the inequality true). Such statements will encourage students to read and interpret the ideas in the text, not simply find and copy matching words. This example also demonstrates how mathematics texts may include specific examples of worked problems or use of symbols without fully explaining underlying rules or conventions for these examples.

• *The statement gets at nuances of meaning that some students may not consider on their own*. This occurs when the idea itself is challenging—because the related text did not explicitly discuss such nuances or because it relates to a common student misconception. Statements 2 and 5 on the sample anticipation guide describe situations that are sometimes true and sometimes false. Because responses of true and false can both be supported with evidence from the text, these statements will lead to a discussion of the conditions under which the statement will be true or false. Such statements provide opportunity for discussion of the idea or meaning beyond the information presented in the text.

A conclusive answer need not be found in the text because the resulting discussions will lead students to clarify their understanding of concepts and relationships. For example, in one class that we observed, use of the statement "3.14 is an irrational number" prompted a lengthy discussion as students distinguished π from its common approximation.

Even for cases in which a statement in the text is not completely accurate, the anticipation guide provides an opportunity to discuss the nuances of the text and develop a more complete understanding. Note that the accompanying text states, "The graph of the inequality $y \leq 2x + 1$ is the shaded region"; it should instead state that the graph is the shaded region and the boundary line. Statement 2 in the guide allows students to consider and discuss this issue.

• *The statement requires students to interpret the information in examples and apply it to a new situation.* In statement 4 in the guide, students determine whether a specific point is part of the solution for the given equation. The point serves as a test point, similar to an example in the text. To answer, students must determine whether the coordinates in the point make the inequality true and then determine whether the result means that it is part of the graph of the inequality. In another example, students were given the statement, "The coefficient for x in $13x^3 + 9x^2 - 10 = 15$ is 13." In this example, there is no visible x-term because the coefficient is 0. The example in the text stated that the coefficient of the xy-term is 1 but did not specifically address what happens when the coefficient is 0 (Holliday et al. 2008). Asking students to consider and justify their thinking about a statement in which the x-term had "disappeared" because the coefficient was zero provoked a lively debate regarding whether there is an x-term and why the term is not visible when a coefficient is 0.

In designing an anticipation guide, use a small number of statements (seven or fewer). Using fewer statements will allow students to take the time needed to read and interpret thoughtfully and to locate evidence supporting their positions. Well-designed response sheets should also provide space for students to indicate their response to each statement both before and after reading. Requiring students to write prereading decisions in a different color from postreading decisions will make changes in thinking based on reading or discussion evident. Be sure to provide ample space for students to record their reasons and supporting evidence and its location in the text for each statement.

READING AND THINKING IN A MATHEMATICALLY MEANINGFUL WAY

The Common Core State Standards place an increasing emphasis on the development of literacy skills for informational texts as well as on mathematical sense making and problem solving (CCSSI 2010). It is imperative that teachers create opportunities to support students in developing skill in reading complex mathematics texts. By engaging students in reading critically, interpreting text, and supporting and defending claims with evidence, anticipation guides develop reading comprehension skills and position students for advanced study in mathematics. Anticipation guides take practice to implement successfully, but they spur students to read, think, write, and discuss mathematical content meaningfully. They provide another tool for fostering a culture of reasoning and justification, creating habits of mind that motivate students to consider essential content ideas, develop meaningful and precise language, and deepen conceptual understanding.

As one teacher stated: "Anticipation guides . . . will draw out misconceptions and initiate debate. They take practice to implement successfully, but I truly believe they are fantastic tools that allow students to think, write, and discuss mathematical content in a meaningful way."

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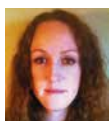

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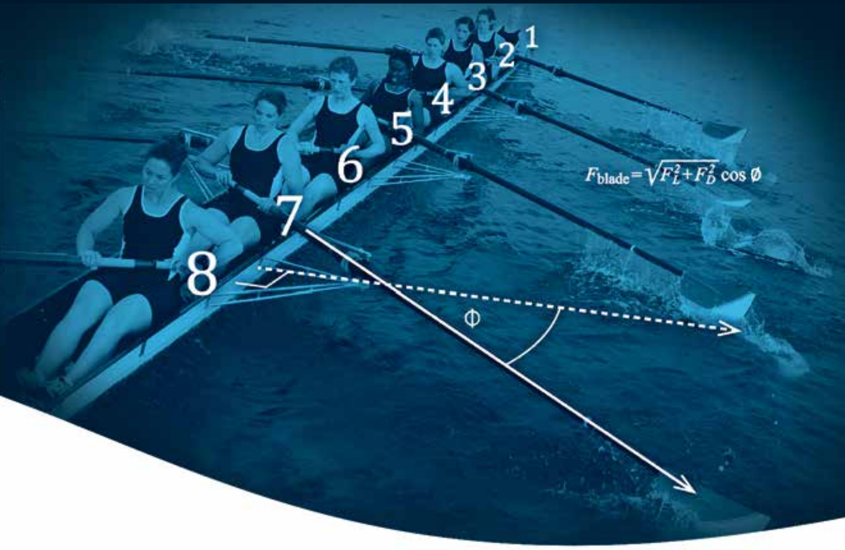

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