Teaching Reading in Mathematics and Science

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Students face special challenges when they encounter reading in mathematics and science, but teachers can use a variety of strategies to help.

Of all the content-area texts that elementary and secondary school students read, mathematics and science are arguably the most difficult. Yet mathematics and science teachers often say that they feel the least prepared to teach students how to read to learn: “I'm a math [science] teacher. I wasn't trained to teach reading.” Helping students with mathematics and science texts, however, is not the same as teaching students to read. Rather, it's helping students make sense of—and learn from—science and mathematics text.

The conceptual density of math and science materials is one of the major reasons for students' difficulties. Schell (cited in Reehm & Long, 1996) maintains that mathematics texts can contain more concepts per line, sentence, and paragraph than any other kind of texts. Science texts can be equally concept-laden. According to Holliday (1991), a high school chemistry text can include 3,000 new vocabulary terms—more than students are expected to learn in foreign language classes.

In addition, reading mathematics and science requires special reading skills—skills that students may not have used in other content areas. For example, in addition to comprehending text passages, students must be able decode and comprehend scores of scientific and mathematical signs, symbols, and graphics. Students also need to read and interpret information presented in unfamiliar ways—not only left to right, but also right to left (number lines), top to bottom (tables), and even diagonally (graphs). Further, students must learn how to read text that is organized differently than that in other core subjects.

Given these challenges, how can teachers help students become more successful at reading and learning from these texts? To begin, teachers can incorporate reading and learning strategies that help students activate prior content knowledge, master vocabulary, and make sense of unfamiliar text styles.

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Activate Prior Content Knowledge

Vacca and Vacca (1999) contend that a student's prior knowledge is “the single most important resource in learning with texts” (p. 25). Reading and learning are constructive processes: Each learner actively draws on prior knowledge and experience to make sense of new information. The more knowledge and skills that students bring to a text, the better they will learn from and remember what they read. Activating students' prior knowledge prepares them to make logical connections, draw conclusions, and assimilate new ideas.

Consider, for example, a science lesson on the phases of the moon. Before students read about this phenomenon, they need certain background knowledge. The teacher can prompt students to recall what they know by asking, “What have you noticed about the appearance of the moon?” Students' responses reveal what they know, misconceptions that they have, and gaps in their understanding. Equipped with this information, the teacher can guide students to confront misconceptions and acquire prerequisite knowledge through hands-on, minds-on activities, such as making observations and collecting data. These *engagement and exploration activities* prepare students to comprehend later reading assignments.

Webbing is another effective strategy for activating prior content knowledge. In a mathematics class that is learning about polygons, for example, the teacher writes the lesson's topic on the board and asks students to volunteer any terms or ideas that this word brings to mind. As students brainstorm their ideas, the teacher begins to construct a web depicting how these ideas relate to the concept of polygons, making mental notes of what students know and what misinformation or gaps in learning the class needs to address. As the web develops, the teacher may add information that students missed but need to know before they tackle the text. Students can refer to this map while they read, making connections with new information (Barton & Heidema, 2002).

Teachers can also activate prior knowledge by developing an anticipation guide (Herber, 1978), a set of teacher-generated questions that can serve as the student's pre/post inventory for a reading selection. Creating an anticipation guide involves

Identifying prior knowledge that students need, common misconceptions students may have about the topic, and key points they will learn as they read; and
Creating four to six statements that challenge or support students' prior knowledge, beliefs, and experiences (see fig. 1).

Figure 1. Anticipation Guide: Matter

Directions: In the column labeled Me, place a check next to any statement with which you agree. After reading the text, compare your opinions about those statements with information contained in the text.

Me	Text	
____________	____________	1. Everything you touch is matter.
____________	____________	2. Iron atoms on Earth are different from iron atoms on Mars.
____________	____________	3. An element is the same thing as a compound.
____________	____________	4. Most everything you see is a compound.

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Before reading, students respond to each statement and prepare to defend their opinions (Barton & Jordan, 2001). When students share their responses in a class discussion, teachers can get a sense of what students know and adjust their prereading instruction accordingly. After reading the assigned text, students once again respond to the anticipation guide statements, noting any changes they have made based on what they have read. Duffelmeyer and Baum (1992) refined this strategy in their extended anticipation guide, which asks students to explain their responses in writing, correct any errors, and find evidence in the text that supports or counters each anticipation guide statement. An advantage of the extended anticipation guide is that it forces students to confront their misconceptions.

Master Vocabulary

Mathematics and science textbooks are often filled with unfamiliar, abstract terminology. Merely asking students to look up terms in a dictionary and memorize their definitions doesn't help learners develop an adequate understanding of these new concepts.

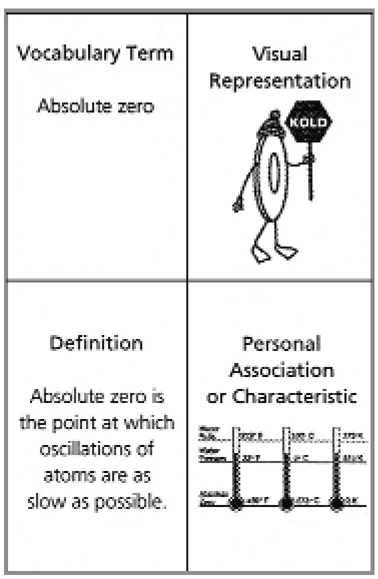
Students need to construct meaning—to grapple with how a concept such as prime numbers is similar to and yet different from other classifications of numbers that they have learned. As Vacca and Vacca (1999) assert,

> Teaching words well means giving students multiple opportunities to learn how words are conceptually related to one another in the material they are studying. (p. 315)

One effective strategy for helping students construct meaning is *semantic feature analysis* (Barton & Heidema, 2002), which involves asking students to complete a chart that identifies the characteristics that concepts have in common (see fig. 2).

Nonlinguistic representations also help students construct meaning, deepen their understanding, and recall knowledge for later use (Marzano, Pickering, & Pollock, 2001). Students can symbolize their personal associations of a term—say, absolute zero—in a graphic that combines verbal and visual word associations (see fig. 2). Monroe and Pendergrass (1997) recommend that educators "teach to the brain's natural capacity for thinking and organizing information" (p. 3). Vocabulary maps, webs, and other graphic organizers give students a chance to manipulate new ideas, see how they are related to familiar concepts, and construct a visual representation of these relationships.

Figure 2.



Make Sense of Text Style

Text style—the organization and presentation of content—affects reading comprehension. Teaching students to recognize a text's style and then use it to aid comprehension can improve student learning.

For a variety of reasons, authors of mathematics and science texts do not always follow the principles of writing that students learn in language arts. For example, main ideas in mathematics and science texts do not necessarily appear in the expected places. In language arts, students have learned that an author's main idea typically appears in a passage's introduction or a paragraph's first sentence. In mathematics, however, the main idea may not appear at the beginning of a word problem. Consider the following example:

> *Jason is sorting red, white, and blue chips into single color piles. He has 58 chips altogether. There are twice as many red chips as white chips, and three more blue chips than red chips. How many chips of each color does Jason have?*

The main idea—"How many chips of each color does Jason have?"—does not appear until the end of the problem. Readers must wade through a host of details before getting to the point of the problem.

Besides pointing out that a word problem's main idea may appear at the end of the problem, teachers can introduce students to the six-step *SQRQCQ* strategy (Fay, 1965) for tackling how the word problem has organized information:

- Survey. Read the problem quickly to get a general understanding of it.
- Question. Ask what information the problem requires.
- Read. Reread the problem to identify relevant information, facts, and details needed to solve it.
- Question. Ask what must be done to solve the problem. "What operations must be performed and in what order?"
- Compute (or construct). Do the computations or construct a solution.
- Question. Ask whether the solution process seems correct and the answer reasonable.

Another reason that students often struggle with mathematics and science texts is that the authors may imply rather than make explicit the hierarchy and relationships among their ideas. Authors in other texts typically use cue words and phrases—*first*, *another*, *for example*, and *moreover*—to show the connections among ideas. These stylistic guideposts appear much less frequently in mathematics and science texts. Without such signal words, readers must infer which sentences contain new ideas, which include supporting examples, and how one set of facts is related to the next. The following passage illustrates this style.

> *The sun is the major external source of the energy, in the form of heat and light, needed*

to make the Earth's processes work. The sun's light provides energy for most life forms. Plants use sunlight, water, and minerals they collect from the soil to form foodstuffs for themselves and for animals. We eat plants and animals for food, ultimately tracing the food energy back to sunlight. The sun's heat on the Earth's surface and atmosphere provides the energy to move the atmosphere and oceans, producing winds, ocean currents, and the water cycle. The sun's heat and light maintain the Earth's temperature. On a global scale, climate is determined by the sun's energy affecting materials such as soil, rocks, and water at and near the Earth's surface. (Mid-continent Research for Education and Learning, n.d.)

When cue words are missing and the hierarchy of ideas is confusing, teachers can provide students with graphic organizers, chapter outlines, and structured overviews before students read the text. Much like a roadmap for tourists, these visual aids help readers navigate text.

Students also have trouble with text style when the authors are content experts who know their subject matter so well that they skip steps or fail to provide the relevant background information or details in their explanations. In a tongue-in-cheek warning about this tendency in mathematics textbooks, one mathematics professor advises his students to read them “as if you are a detective trying to solve a mystery” (Finn, 2002). To help students with their detective work, teachers should try to read the students' textbooks through the eyes of a novice reader instead of a content expert. Novice readers need explanations for the steps in the author's thinking. Do the authors communicate—or merely imply—the necessary information? (Britton, Gulgoz, & Glynn, 1992).

When students have trouble making sense of text, teachers can help by demonstrating the *think-aloud* strategy (Davey, 1983). The teacher selects a sample passage to read aloud to students and models the thinking processes involved in making sense of confusing sections of text. Students see the strategies that effective readers use to grapple with ambiguous passages, identify main ideas, and make logical inferences.

Most students arrive at their science and mathematics teachers' classrooms knowing how to read, but few understand how to use their reading skills to learn science and mathematics content (Santa, Havens, & Harrison, 1996). Fortunately, content-area teachers don't have to be reading specialists. They can help students by sharing strategies that can be easily integrated into an exciting curriculum and that will enhance students' learning of mathematics and science.

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