Science Literacy Is > Strategies

DOUGLAS FISHER, MARIA GRANT, and NANCY FREY

Abstract: Comprehension strategies, while helpful, are not sufficient to produce student achievement at high levels. The authors examine the role of background knowledge and vocabulary in developing understanding and facilitating achievement. Through purposeful instruction in vocabulary and by building and activating background knowledge, teachers can help students absorb content.

Keywords: background knowledge, teaching approaches, vocabulary

In many schools, science achievement is too low. Eighty-two percent of our nation's twelfth graders performed below the proficient level on the 2000 National Assessment of Educational Progress (NAEP) science test. And according to the U.S. Department of Education, "The longer students stay in the current system the worse they do. According to the 1995 Third International Mathematics and Science Study, U.S. fourth graders ranked second. By twelfth grade, they fell to 16th, behind nearly every industrialized rival and ahead of only Cyprus and South Africa" (U.S. Department of Education).

It's time to question why students are not doing well and are losing ground as they progress through school. These problems might occur because science instruction is neglected in favor of the tested subjects of math and reading/language arts (McMurrer 2008) or because inquiry approaches to science are often neglected (Jeanpierre 2006). Or they might result from a mismatch between the current focus on reading-strategy instruction and the actual requirements for understanding science reading.

Although all three reasons likely contribute to the lack of robust achievement in science, we wish to explore the final one further.

As literacy educators and peer coaches ourselves, we have often suggested that teachers focus on "strategies" for helping students understand what they read. Most commonly, these strategies include cognitive processes like predicting, inferring, connecting, summarizing, visualizing, and questioning (Harvey and Goudvis 2007). Unfortunately, in some classrooms these methods have been implemented in ways that force students to read science texts while completing a "predicting" or "questioning" worksheet. Does this approach produce the outcomes we desire: students reading to answer the questions they have about the biological and physical world? We do not think so.

Consider the following sentence from a popular neuroanatomy book:

> Cells of the mesoderm cannot penetrate the contact of the ectoderm and endoderm at the prochordal plate, but they can migrate around this region of adhesion, and some mesoderm cells will be located anterior to this structure. (Patestas and Gartner 2007, 12)

Which of the commonly recommended reading strategies would help you understand this sentence? Making a prediction? How about summarizing, making connections to other texts, or reading between the lines (inferencing)? In fact, none of these comprehension strategies would result in greater understanding of the content.

If you did understand the sentence, why is that? Our experience suggests that understanding is largely based on background knowledge and vocabulary. Researchers have understood the importance of background

Douglas Fisher, PhD, and Nancy Frey, PhD, are professors of teacher education at San Diego State University, San Diego, CA, and teachers at Health Sciences High and Middle College, San Diego, CA. Maria Grant, EdD, is an assistant professor of secondary education at California State University–Fullerton, Fullerton, CA.

or prior knowledge for decades (Grierson et al. 2007; Johnson 1982). When readers have sufficient background knowledge and vocabulary, they can use the cognitive strategies outlined above to clarify understanding (Applegate, Quinn, and Applegate 2006). Unfortunately, the current push for strategy instruction has resulted in significantly less attention to background knowledge and vocabulary.

Building and Activating Background Knowledge

Comprehensive literacy efforts in science demand attention to background knowledge. To neglect this foundation is to reduce science to a collection of facts to be memorized, rather than to present science as a range of processes that validate and extend real-world understandings.

One of the easiest, most effective ways to build background is through wide reading (Marzano 2004). Students need a specific time every day to read manageable texts about the topics under investigation. This time is not for free, voluntary reading, but for students to read from a variety of topic-related texts that have been selected by the teacher. The selected texts must span a wide range of difficulty, because students cannot learn much from books they cannot read (Allington 2002). Each new reading encounter allows students to incorporate their previous reading experiences. As a result, they have more background knowledge for each text and thus will be able to read increasingly difficult texts. Reading in this manner provokes students to ask content-related questions that can be answered by further reading.

When Mr. Bautista's seventh-grade students study adaptation, Mr. Bautista has them read each day from texts he has assembled (see the appendix for a sample of the books). In his classroom, students rotate through a series of twenty-minute stations. While one group watches a short DVD with headphones, another group reads independently, a third undertakes an inquiry lab, and a fourth group meets with him for guided instruction. Even a quick conversation with students reveals the importance of the wide-reading component of literacy instruction. In one instance, Mr. Bautista's student Tino first acknowledged his limited understanding of animal adaptation, then focused on what he learned while reading:

> The first book I read talked about the different things animals have, like claws and long tails. Or maybe the stink of a skunk. It was kinda interesting, but I already knew all of that. Then I read more about the claws and how different animals use them because of where they live. That's called the habitat. The animals have to fit in, you know, where they live. Then I wanted to know more about the lizard that squirts blood from the eye. I read on the Internet that's how it protects itself. I saw the YouTube video about it. It really can squirt blood.

Although Tino has learned much, he still has material to learn. Amanda had a different take on animal adaptation and displayed the understanding she has gained in this way:

> Sometimes the environment changes too fast and the animals can't adapt in time, so they all die. When they are extinct, they are gone forever. Like maybe this is what happened to the dinosaurs. But lots of animals are extinct. What they had special, like thick fur or really good eyes, the adaptations, didn't always help them. But sometimes it did and they kept changing and are alive now. I think that is what happened to the zebra, but I don't know for sure.

The students' reading experiences introduced them to the concepts of habitats, survival, growth, reproduction, and extinction. Wide reading also provided them with numerous examples of animal adaptation that they used to understand other classroom experiences. These reading experiences prompted new questions. With time and practice, students can begin to read, write, and think like scientists (Fisher, Lapp, and Grant 2007).

Learning Words Inside and Out

In addition to wide reading, solid science literacy instruction requires attention to vocabulary. Of course, attention to vocabulary does not mean assigning a list of words that students need to memorize. Instead of thinking about vocabulary as a list of words that need to be taught, we have found it helpful to think about vocabulary as an initiative with five components. Research on these five components suggests that together they result in significantly greater word knowledge, which generalizes to reading-comprehension skills (Fisher and Frey 2008).

Make It Intentional

Given the limited amount of time we usually have for vocabulary, every word selected for instruction must matter. In general, three types of words can be considered. Beck, McKeown, and Kucan (2002) identify these as Tier 1, Tier 2, and Tier 3 words. Tier 1 words are basic for reading. These words are typically part of the spoken vocabulary of most students and rarely need to be taught. Tier 2 words are specialized, high-utility terms that often change meaning in different contexts. For example, *process* has a specific use in terms of photosynthesis, but students may know the word in other contexts. Or consider the term *hybrid*. This word no longer relates specifically to genetics; many students today think of a hybrid as a car. Finally, Tier 3 words are technical terms, bound to a specific discipline. The terms *tundra*, *forests*, *grasslands*, and *wetlands* are examples. To ensure that the selected words matter, we created a list of categories and questions that teachers can use to determine which words are worth teaching (see table 1). Planning instruction around specific words ensures that vocabulary instruction is intentional.

TABLE 1. Considerations for Selecting Vocabulary Words

Topic	Questions to ask
Representative	• Is the word representative of a family of words that students should know? • Is the concept represented by the word critical to understanding the text? • Is the word a label for an idea that students need to know? • Does the word represent an idea that is essential for understanding another concept?
Repeatability	• Will the word be used again in this text? If so, does the word occur often enough to be redundant? • Will the word be used again during the school year?
Transportable	• Will the word be used in group discussions? • Will the word be used in writing tasks? • Will the word be used in other content or subject areas?
Contextual analysis	• Can students use context clues to determine the correct or intended meaning of the word without instruction?
Structural analysis	• Can students use structural analysis to determine the correct or intended meaning of the word without instruction?
Cognitive load	• Have I identified too many words for students to successfully integrate?

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Make It Transparent

One way that students learn is through teacher modeling. Our vocabulary initiative uses teacher modeling to teach students ways to determine word meanings. Being transparent does not mean telling students definitions. Instead, transparent word solving occurs through the use of context clues; word parts such as prefixes, suffixes, roots, or cognates; or outside resources, including people and dictionaries. For example, while reading aloud, a biology colleague came to the word *carnivore* and used word parts to figure out the meaning of the word: "I'm not sure what the carnivore eats. I do know that *carne* means meat, because I eat *carne asado* burritos. Perhaps the carnivore is the meat eater." An earth science colleague used context clues, including illustrations and examples embedded into sentences, to figure out the word *plates* while reading about tectonic plates and earthquakes.

Make It Usable

Students need to use the words they are learning in peer conversations and writing. They cannot just listen to words; they must be encouraged to incorporate target words into their daily language use. A number of excellent instructional routines exist to do this, such as jigsaw, reciprocal teaching, and word mapping (Brassell 2008), all of which involve students' use of vocabulary with peers. For instance, a middle school science teacher we observed extended the conversation the class was having about nocturnal animals by saying, "Turn to your partner and explain the advantages nocturnal animals have over diurnal animals. Be sure to use both those terms in your discussion." These prompts lower the risk for some learners who are reluctant to speak in front of the entire class, including some adolescent English-language learners who may feel self-conscious about their language skills.

Make It Personal

Independent learning is a critical but often neglected aspect of word learning. Teachers must provide students with tasks that allow them to apply what they have learned to new situations. Students also need to learn to notice new words, even ones that are not formally taught. Over time, with intentional instruction, they will personalize their word learning and develop sophisticated vocabularies, allowing them to read for information. The most common way teachers implement this strategy is through generative sentences in which students are given a specific word, a position for the word in a sentence, and an expected length of the sentence. In their earth science class, for example, one of the sentences students were asked to generate placed *thrust faults* in the third and fourth position of a sentence of at least eight words. Jessica wrote, "There are thrust faults in Los Angeles because the San Andreas Fault bends to the west," and Corima wrote, "A geological thrust fault is caused by compression forces and results in an angle equal to or less than 45°." Both students clearly understood the term and the associated background knowledge. In addition to

generative sentences, word sorts, journals, and mnemonics are particularly helpful in independent word-learning routines. It is important that these individual tasks be connected with the other components of a vocabulary initiative.

Make It a Priority

The fifth and final component of our intentional vocabulary initiative requires that daily instructional time be devoted to word learning. Like building background knowledge, vocabulary must be a priority if students are to read for information. Teachers can meet in course groups to determine which words to teach and how best to teach them. When entire schools focus on vocabulary, achievement increases—and not just literacy achievement, but achievement in the content areas (Fisher 2007).

Why Not Strategies?

Strategies are not much help without background knowledge and vocabulary. That is not to say that students will not benefit from quality reading comprehension–strategy instruction. However, a limited focus on strategies in isolation from background knowledge and vocabulary will not result in students who read more and better. If we are to improve scientific understanding and science achievement, we must recognize the role that background knowledge and vocabulary play in a literacy-rich science curriculum.

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APPENDIX
Books about Adaptation

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