1 The Role of Language in Science

Teaching science is exciting. Sharing the biological, physical, and social world with students is a wonderful experience. Students love to learn about themselves and their world and are often thrilled with lab experiences and other hands-on learning opportunities provided to them in the science classroom.

A look inside a classroom confirms this. Andrew sits excitedly at a lab bench. His class has been studying human systems, and they've finally gotten to the nervous system, which Andrew has been waiting for all year. His biology teacher has told the students that they get to dissect sheep brains and examine the structures of the sheep's central nervous system.

Andrew and his lab partners glove up, ready to begin. They weigh the brain and then they separate the two hemispheres and measure them. They find the corpus callosum and then begin labeling the lobes. They find the cranial nerves. The lab progresses for several days while students investigate the structures in the sheep brain. Andrew is in heaven. He loves this work and can't wait to get back to class each day.

Labs are exciting and powerful ways for students to learn science. However, our purpose here is not to provide science lab instruction. There are a number of excellent resources available related to designing science labs (e.g., Shevick, 1998). But in this book, we want to explore the reading and writing components of science that prepare students for the inquiry work they do in labs.

In the case of Andrew's very exciting experience, his teacher did a significant amount of work so that students would be prepared for the lab. Andrew's teacher, Mr. Jeffers, read to the class daily from texts about the nervous system, and he had students read books about the nervous system on their own. Mr. Jeffers has a collection of books and allows students to choose from that collection for their independent reading.

Andrew chose *Another Day in the Frontal Lobe: A Brain Surgeon Exposes Life on the Inside* (Firlik, 2006) and regularly shares passages with his peers. For example, he read aloud the following lines to a classmate, Jessica, during free choice reading time in their English class: "We can thank, or blame, our frontal lobes for much of what we consider to be our personality and intelligence. Damage to the frontal lobes can be subtle, including changes in insight, mood, and higher-level judgment" (Firlik, 2006, p. 7).

In addition, Mr. Jeffers provided his students with vocabulary useful for discussing the central nervous system and, more specifically, the brain. He started with words used to describe locations: anterior, posterior, dorsal, ventral, rostral, caudal, coronal, saggital, and axial. He then moved to specialized and technical language including gyrus, sulcus, fissure, nerve, track, and ventricle.

Students kept journals and completed a number of writing tasks in preparation for the lab. For example, at the end of one of the class meetings, Mr. Jeffers asked students to identify questions they had about the central nervous system. He then collected these as an exit slip as students left class that day. He used these written responses to determine if students needed more information from him and to assess their developing inquiry into the nervous system.

In preparation for the lab, Mr. Jeffers showed his students a virtual lab of a sheep brain dissection (see www.academic.scranton.edu/department/psych/sheep/framerow.html). For each slide, he shared his thinking. This think-aloud provided his students with an opportunity to understand how expert scientists think as they work. For example, when he displayed the first slide, he thought aloud about the physical orientation. As he said, "I can tell that this is the right hemisphere as I can see the rostral portion of the brain and I notice that the cerebellum is to the left. So, as I think about this image, I see that this part (points to top) is dorsal or toward the top. I see that this is ventral or toward the bottom. I also see that this is a saggital view, as if an arrow were shot from the back to the front and we were seeing that slice."

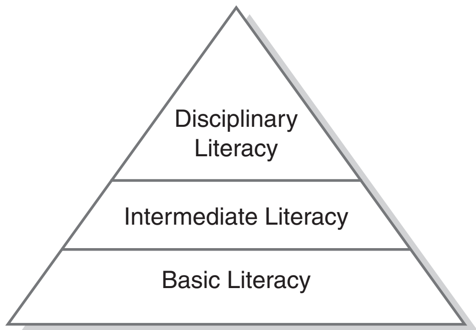
LEARNING IS BASED IN LANGUAGE

High-quality science instruction requires that students learn to read and write like a scientist. The discipline of science, and reading and writing in science, is different from history, English, mathematics, art, or nutrition. Science teachers guide their apprentices, students, in this discipline through reading and writing. That's not to say that science teachers should become reading teachers. In fact, we argue that not all teachers are teachers of reading (Fisher & Ivey, 2005). Instead, we understand that humans learn through language. As such, we have to ensure that students in our classrooms have opportunities to read, write, speak, listen, and view. This may sound like a semantic difference, but we think it's much more conceptual than that.

We understand that there are students who need access to reading instruction, even in high school. There are experts in reading who should provide that instruction, often in the English department. However, the job of the science teacher is a bit different. The science teacher has to provide students with opportunities to use language for learning content. Along the way, students will become better readers and writers. They will also develop a much deeper understanding of science when they are immersed in the language of science. They will begin to think, read, and write like scientists. Of course, most scientists in the "real world" read and write daily as part of their jobs. They write grants, reports, and articles. They take notes and organize information. They read the work of others and they read their own work. In fact, scientists read widely. We don't know a single bench scientist who reads from a single source. Scientists like to be informed, which requires that they read from a variety of sources in their discipline. Unfortunately, in many middle and high school classrooms, students only read from a single source and that source is most often the textbook. That's not to say that the textbook is bad. It's a great resource with tons of information and support. And, as we see in Chapter 5, there are ways to help students read from this type of text. We're just saying that it should not be the only text a student reads. Remember Andrew and his motivation to read widely such that he read from a popular press book about neurology? That's what we'd like all of our students to do.

Toward this goal of getting our science students to incorporate literacy as a scientist might, we acknowledge that educators must have an understanding of the various forms of literacy attainment. Shanahan and Shanahan (2008) have examined how literacy development progresses and conclude that there are three stages of growth that can be represented graphically in a pyramid form (see Figure 1.1). These stages are basic literacy, intermediate literacy, and disciplinary literacy. Basic literacy, the base of the pyramid of literacy development, represents the foundational and generalizable skills that are needed for all reading tasks—decoding skills, comprehension of print and literacy conventions, recognition of high-frequency words, and usual fluency routines. Additionally, students at this stage learn to recognize common ways to organize texts (e.g., story formats, list structures). These are basic literacy skills.

Figure 1.1 The Increasing Specialization of Literacy Development



Basic Literacy: Literacy skills such as decoding and knowledge of high-frequency words that underlie virtully all reading tasks.

Intermediate Literacy: Literacy skills common to many tasks, including generic comprehension strategies, common word meaning, and basic fluency.

Disciplinary Literacy: Literacy skills specialized to history, science, mathematics, literature, or other subject matter.

As students progress beyond this stage—usually in upper primary grades—they move into intermediate literacy. This stage involves the development of skills that allow readers to facilely decode multisyllabic words, automatically respond to terms that are not classified as high frequency, understand the use of punctuation that is less common, and have a working knowledge of a larger body of vocabulary. At this point, students are better able to employ various comprehension strategies and can utilize "fix-up" procedures to mediate weaknesses in comprehension. Additionally, they are able to interpret more complex forms of text structure (e.g., cause and effect, problem-solution, parallel plots).

Beyond this stage, we move into an area in which content teachers are required to play a bigger role. This is the stage of literacy that we are most concerned with for science students at the secondary level. Shanahan and Shanahan (2008) call it disciplinary literacy. The skills involved in this stage are usually not formally taught and are difficult to learn due to the abstract nature of many discipline-specific texts. Moreover, disciplinary literacy is more constrained in terms of its applicability to a wide range of reading materials. Specifically, an English teacher who is proficient in teaching literacy skills related to reading classic and contemporary novels may not be so skilled at guiding students to comprehend a technical biology article from a current journal.

Consider disciplinary literacy in science. Content in science often requires reading between the lines, visualization, the interpretation of graphs and charts, and knowledge of inquiry methods of study. It is a process that differs greatly from that of reading *The Great Gatsby* or reviewing a primary source document like a speech written by Frederick Douglass. The progressive narrowing of Shanahan and Shanahan's pyramid represents the constricted and specialized nature of more advanced literacy skills—skills that are increasingly less generalizable to other areas of reading and more focused on the needs and skills of a particular discipline, like science.

USING LANGUAGE IN SCIENCE

By now you're probably asking yourself this: "How can I go beyond my current effort as I work to integrate language and disciplinary literacy into the science classroom?" This is what the rest of this book is about. Based on our experiences with hundreds and hundreds of students, we have some ideas about what works. To make our point, we'd like to invite you to read a brief excerpt from the U.S. Department of Labor, Occupational Safety & Health Administration technical manual related to Oil Well Derrick Stability.

> Supplemental footing shall be provided to distribute the concentrated loads from the mast and rig support points. The manufacturer's load distribution diagram will indicate these locations. In the absence of a manufacturer's diagram, the supplemental footing shall be designed to carry the maximum anticipated hook load, the gross weight of the mast, the mast mount, the traveling equipment, and the vertical component of guywire tension under operational loading conditions. These footings must also support the mast and mast weight during mast erection. (www.osha.gov/dts/osta/otm/otm_iv/otm_iv_1.html)

Conventional wisdom in many reading circles would suggest that the reader should deploy comprehension strategies to understand this passage. But we ask you, would making a prediction help you understand what the author wanted you to know? If not, how about summarizing or questioning or inferring or making personal connections?

This is our point in writing this book. Students often need more than simple comprehension strategies to learn. What would have helped you? More background knowledge is what you needed. As a result, our first content chapter, the one that follows this one, focuses on background knowledge. When you know something about oil wells, this passage becomes infinitely more readable.

Second, you might have had some difficulty with the vocabulary in this passage. You could probably read all of the words, but their specific usage might have confused you. For example, you probably know the word *mast* and you may have made a connection with a sailboat. However, the authors of this piece of text were using that word to mean a very specific part of the oil well. Thinking about sailboats wouldn't really help you make sense of the passage. In other words, you need vocabulary instruction, and not just a list of words to memorize, but rather meaningful interactions with words as they are used in the discipline. Importantly, we think of vocabulary as the expression of background and prior knowledge. Vocabulary is critical if students are to develop their understanding of science. In fact, it has been estimated that students are required to learn on average 3,000 new words each year in science. As a comparison, a Spanish I class introduces students to about 1,500 words. Science is a vocabulary dense subject area and we have devoted an entire chapter to this topic.

Once the reader has developed or activated background knowledge and has a sense of the words used in the discipline, reading and writing become much easier and more meaningful. Once background knowledge and vocabulary understanding have been developed, teachers can focus on reading and writing. We have chapters on both reading and writing in science that provide you with examples of instructional routines useful for students in learning content.

We conclude this book with a discussion of assessments. As teachers, we have to regularly assess student learning to make decisions about next steps instruction. The final chapter provides you with a number of ideas about formative assessments and using language to determine what students know and what they still need to know. As such, these assessment tools are part of the language system we use to improve student learning.

As we have noted, scientists read and write regularly. They have extensive background knowledge in their specific discipline and deep knowledge of the words used in their content areas. As science teachers, we can use these same processes with our students, apprentices in science, so that they learn at higher levels. Having said that, we're not suggesting that science become a reading and writing class. Students in science need to experience, ask questions, and interact. We're just suggesting that they do so armed with information useful in helping them inquire.