Supporting Struggling Readers
in Science Education

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Introduction

Science encompasses a broad range of disciplines: mathematics and technology as well the natural and social sciences. Science literacy includes familiarity with the natural world and respect for its unity as well as an awareness of important ways in which science, technology, and mathematics depend on one another. Furthermore, it encompasses the understanding of key concepts and principles of science, the capacity for scientific ways of thinking, the knowledge that the study of science is a human enterprise, and an understanding of what that implies about its limitations. Finally, science literacy requires the ability to use scientific knowledge and ways of thinking for personal and social purposes (American Association for the Advancement of Science, 1989). In this white paper, we will describe unique literacy challenges that science presents for adolescents as well as strategies to support science learning for struggling readers.

Countless reports indicate that most Americans are not science literate and that common approaches to instruction are failing to substantially improve scientific understanding (Glenn, 2000; Programme for International Student Assessment & Organisation for Economic Co-operation and Development, 2001; Schmidt, 2001; Schmidt, McKnight, & Raizen, 1997; Singer, Hilton, & Schweingruber, 2005). Science texts tend to be "an inch deep and a mile wide" (Schmidt, 2001; Schmidt et al., 1997).

Curricula fail to provide a sense of purpose for learning, engage existing conceptions, engage students with relevant phenomena, develop and use scientific ideas, or provide opportunities for self-assessment (American Association for the Advancement of Science, 2000; Kesidou & Roseman, 2002). In addition, the vocabulary load of science textbooks rivals that of foreign language texts (Groves, 1995). Failure to teach science content in depth in high school substantially diminishes success in college science (Schwartz, Sadler, Sonnert, & Tai, 2008). And while these issues are problematic for all learners, lack of proficiency in reading intensifies them.

What unique literacy challenges face adolescents in high school science classes?

Reading science texts and texts about science provides several content-specific challenges:

- The vocabulary load is often high.
- The reading level is often above grade level.
- Conceptually loaded non-technical words are used extensively in science, and many words have both vernacular and specialized scientific meanings.
- Scientific grammar is different from grammar in standard English.
- Science literacy includes the ability to read charts, graphs, tables, and diagrams in addition to text. Some of these can also be highly technical.

The following passage from the most widely used high school biology textbook illustrates several literacy challenges posed by science texts:

> **Eukaryotic Chromosomes** Eukaryotic cells generally have much more DNA than prokaryotes, and therefore contain multiple chromosomes. Fruit flies, for example, have 8 chromosomes per cell, human cells have 46, and carrot cells have 18. Eukaryotic chromosomes contain both DNA and protein, tightly associated to form a substance called **chromatin**. Chromatin consists of DNA tightly coiled around special proteins known as histones. Together, the DNA and histone molecules form beadlike structures called nucleosomes. Nucleosomes pack together to form thick fibers, which condense even further during cell division (Miller & Levine, 2006). (Emphasis in the original)

This passage highlights the high vocabulary loads in some texts. Groves (1995) determined the number of likely new terms in four commonly used textbooks. Values ranged from almost 1,000 to almost 3,000 terms in these texts for yearlong courses. Technical terms are frequently introduced at a rate of four or five per page. If the entire textbook is covered in a 180-day school year, terms would be introduced at rates of between 5 and 15 per day.

Looking more closely at the passage above and comparing it to the content of the *National Science Education Standards (NSES)* (National Research Council, 1996) shows that a single paragraph from the most commonly used high school biology textbook in the United States includes at least six scientific terms (eukaryotic, chromosome, prokaryote, chromatin, histone, and nucleosome) that are, unlike DNA and protein, not included in the *NSES*. The excerpt has a Flesch-Kincaid grade level of 12.0 (and high school biology is typically taught in ninth or tenth grade). Microsoft Word's spell checker does not recognize several of these terms. Moreover, this passage is not remarkably different from others in the text in terms of the challenges described here.

Science texts often have grammatical structures that differ from common English. Both concepts and terms interlock. The passage above makes little sense unless the reader already has a basic understanding of what chromosomes and DNA are. Terms may "pile up" in ways most readers would find difficult to understand (Halliday, 1993). "Moist adiabatic lapse rate" and "dendritic drainage patterns," for example, are both phrasal compounds that act as individual nouns in Earth science texts.

The complexity here is more than just the difficulty of the technical vocabulary, and the problems of these common curricula extend beyond literacy. However, these problems often create issues with literacy. The high vocabulary load, for example, is a symptom of a curriculum that covers a large number of topics briefly rather than focusing in depth on central issues.

How is Apex Learning incorporating research-based best practices into Literacy Advantage course design to address these problems?

Literacy Advantage science courses incorporate features that directly address the special literacy challenges posed by traditional science curriculum. Literacy Advantage courses reframe the introduction of technical vocabulary and explicitly coach students in eight research-based active reading strategies and four vocabulary learning strategies. This section describes the special features that address literacy challenges for science.

Each literacy strategy is helpful in reading science texts. Further, embedded coaching on how to use these strategies supports struggling readers. See *Supporting Struggling Readers in Content Area Learning* for a general discussion of these strategies.

Many of the curriculum features that target literacy difficulties also address other common problems in science instruction. Again, most commonly used American science curricula are "an inch deep and a mile wide," and one way this is manifest in instructional programs is through a high vocabulary load. Because of the strong link between these two problems, addressing one mitigates the other.

In Literacy Advantage science courses, the vocabulary load has been reduced, and the introduction of vocabulary is done in a controlled way. Concepts are introduced prior to the terms that label them, making new terms serve a clear purpose. Instead of introducing several challenging new terms on a single textbook page, new terms are introduced one at a time, and the instructional text surrounding new terms adheres to strict vocabulary controls. This also reduces the piling up of technical vocabulary into phrases that act as nouns. The content and vocabulary are tied to *NSES,* thus reducing the excessive load while still targeting the most important content. Where appropriate, animations are used to demonstrate concepts in ways simply not possible in textbook form. Animation also allows for content in graphs, diagrams, and tables to be layered—adding one component at a time. Thus, the idea of the controlled release of content applies to both verbal and graphical representations of concepts. Definitions with accompanying examples and illustrations for both technical and difficult non-technical terms can be shown with the click of a mouse.

It is important to note that narrowing the content while also deepening it does not represent a watering down of the curriculum. Instead, it increases the likelihood of retention and durable understanding. To illustrate the point, consider again the excerpt from Miller and Levine's *Biology* (2006). Most Americans have been taught this content. Very few of them ever understood it in a meaningful way and fewer still have retained that understanding.

The Literacy Advantage science courses are not easier or shorter versions of other Apex Learning or traditional courses; however, while many of their features would benefit any learner, they are not intended for all students. The courses provide adaptations and support for learners with basic or below-basic literacy levels, and proficient readers may find those features unnecessary or even irritating. For the target audience, however, Literacy Advantage provides rigorous, standards-based science content in ways that support literacy proficiency.

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