DeltaScience Content Readers™

Delta Science Content Readers:

Embedding Literacy in Science

Executive Summary

Research has shown that scientific understanding must be built over multiple years through instruction that develops and deepens students' understanding of core science content. High-quality curriculum is the foundation for any such effort to meet the goals of science education. Teachers need high-quality materials that align with an effective curriculum and clear, reliable sources of information that they can share with their students.

Science learning requires students to read scientific explanations of the natural world. Reading proficiency, like scientific literacy, develops over a long period of time, involving a complex set of skills that students only master with extended instruction, support, and practice. The Delta Science Content Readers *program meets current goals for science education by delivering an effective, standards-based curriculum. The program also accommodates the variations in reading proficiency that are one of the everyday challenges of real classrooms.*

The Delta Science Content Readers *were planned and written to deliver the same core science content in two editions at two reading levels: the Red Edition at a grade 3–4 reading level and the Purple Edition at a grade 4–5 reading level. Text in both editions is structured to conform to the principles of "considerate text" (Armbruster, 1984; Tyree, Fiore, and Cook, 1994). The* Delta Science Content Readers *also harness the instructional power of embedding literacy instruction in the exploration of engaging, real-world concepts. Comprehension skills and strategies are taught and applied as an integral part of learning compelling science content. In the student reader, a short lesson teaches a featured skill or strategy before each major section. Students then apply that skill or strategy as they read the section.*

As students talk about science, they make the connections and discover the patterns that support their learning. Using language also leads students to think more critically and analytically about their ideas. The clear, "considerate" instructional design of the Delta Science Content Readers *provides students with numerous opportunities for practice in recognizing text structures and using nonfiction text features.*

School Specialty Science

Delta Education

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Introduction

Meeting Goals for Science Education

There is widespread agreement about the value of science education. As the authors of the 2009 NAEP Framework write: "The nation's future depends on scientifically literate citizens who can participate as informed members of society and a highly skilled scientific work force, well prepared to address challenging issues at the local, national, and global level" (WestEd and the Council of Chief State School Officers, 2008, p. v). In addition to the value science education holds to our nation's future, it is also highly valuable to the future of individual students. Science helps students understand and appreciate the world they live in:

> *The eventual goal of science education is to produce individuals capable of understanding and evaluating information that is, or purports to be, scientific in nature and of making decisions that incorporate that information appropriately, and, furthermore, to produce a sufficient number and diversity of skilled and motivated future scientists, engineers, and other science-based professionals (Duschl, Schweingruber, and Shouse, 2006, p. 34).*

Research has shown, however, that scientific understanding must be built over multiple years, with instruction that develops and deepens students' understanding of core science content (Michaels, Shouse, and Schweingruber, 2008).

Teaching the *National Science Education Standards*

High-quality curriculum is the foundation for any effort to meet the goals of science education: "The program of study in science for all students should be developmentally appropriate, interesting, and relevant to students' lives; emphasize student understanding through inquiry; and be connected with other school subjects" (National Research Council, 1996). The *National Science Education Standards* were written to guide the creation and revision of state science standards.

Teachers also need high-quality materials that align with an effective curriculum. These materials are necessary to support teachers' own understanding. As the authors of *Ready, Set, Science!* write: "There is a growing body of evidence that what a teacher knows about science influences the quality of instruction and has a powerful effect on the success and type of discussions that teachers can engage in and sustain with students" (Michaels, Shouse, and Schweingruber, 2008, p. 153). Most importantly, teachers need clear, reliable sources of information that they can share with their students.

Recent research has emphasized the effectiveness of a form of science instruction known as "science practice." This approach, which includes scientific inquiry, integrates learning into four strands of scientific proficiency (Duschl, Schweingruber, and Shouse, 2006, p. 36).

Four Strands of Science Learning

1. Know, use, and interpret scientific explanations of the natural world
2. Generate and evaluate scientific evidence and explanations
3. Understand the nature and development of scientific knowledge
4. Participate productively in scientific practices and discourse

Acquiring these skills requires engagement; students must participate in science. They must ask questions and think critically while reading, talking, and writing about science. They must use evidence to construct arguments and defend theories. They must use scientific language, scientific representations, and scientific tools. "In addition to engaging in direct investigation of scientific phenomena, students make meaning by writing science, talking science, and reading science" (Douglas, Klentschy, Worth, and Binder, 2006, p. xi).

Supporting Reading Proficiency

Science learning requires students to read scientific explanations of the natural world. Reading proficiency, like scientific literacy, develops over a long period of time. It involves a complex set of skills that students only master with extended instruction, support, and practice. Research has shown that students often take the longest to master the skills they need for content-area reading (McGee, 1982; Armbruster, Anderson, and Meyer, 1992; Carlisle and Rice, 2002). As any classroom teacher knows, different students are able to process different levels of complex text (Chall, 1984; Fountas and Pinnell, 2001).

Thus, good reading instruction supports science instruction. Scientific explanations often involve difficult vocabulary and challenging concepts. They can pose acute problems to readers of all ages—but particularly to students reading at elementary school levels. The more students advance in reading proficiency, the more access they have to scientific explanations.

The inverse is also true. Good science instruction supports reading instruction. Reading researchers have identified the limitations of isolated skill instruction. Although this instruction remains important, researchers now emphasize the value of embedding literacy instruction in the exploration of engaging, real-world concepts (Snow, 2008). Researchers in science education have also recognized the reciprocal relationship between reading instruction and science instruction. The editors of *Linking Science and Literacy* write, ". . . students improve their skills in many areas of literacy when those skills are practiced in engaging contexts" (Douglas, Klentschy, Worth, and Binder, 2006, p. xi).

Delta Science Content Readers: Embedding Literacy in Science

The *Delta Science Content Readers* are designed to support teachers in their efforts to achieve the goals of the *National Science Education Standards*:

> *Understanding science requires that an individual integrate a complex structure of many types of knowledge, including the ideas of science, relationships between ideas, reasons for these relationships, ways to use the ideas to explain and predict other natural phenomena, and ways to apply them to many events (National Research Council, 1996).*

Spanning physical science, life science, and earth science, the program covers all the *National Science Education Standards*. The *Delta Science Content Readers* also incorporate state standards and the following additional national standards and frameworks: *McREL Compendium of Standards and Benchmarks, Project 2061 Benchmarks,* and the *Science Framework for the 2009 National Assessment of Educational Progress*. Planned and written as small, modular books, the *Delta Science Content Readers* support these standards while allowing teachers and administrators to make decisions about the best use of available resources.

The *Delta Science Content Readers* meet current goals for science education by delivering an effective, standards-based curriculum. The program also accommodates the variations in reading proficiency that are one of the everyday challenges of real classrooms. The *Delta Science Content Readers* were planned and written to deliver the same core science content at two reading levels. Each title is available in a Red Edition targeted at a grade 3–4 reading level and a Purple Edition targeted at a grade 4–5 reading level. Text in both editions is structured to conform to the principles of "considerate text" (Armbruster, 1984; Tyree, Fiore, and Cook, 1994).

Differentiating Reading Levels in *Delta Science Content Readers*

Red Edition	Purple Edition
• Reading level: grade 3–4 • One-column format • Fewer words per page than the Purple Edition • Shorter, simpler sentences • Fewer, but larger, photos than the Purple Edition	• Reading level: grade 4–5 • Two-column format • More words per page than the Red Edition • Longer, more complex sentences • More, but smaller, photos than the Red Edition

The *Delta Science Content Readers* also harness the instructional power of embedding literacy instruction in the exploration of engaging, real-world concepts. Comprehension skills and strategies are taught and applied as an integral part of learning compelling science content. In the student reader, a short lesson teaches a featured skill or strategy before each major section. Students then apply that skill or strategy as they read the section. The teacher's guide provides additional instruction for each skill or strategy, as well as prompts, discussion questions, and additional information designed to guide students' comprehension of each section. Throughout each reader, students gain practice with standard nonfiction text features such as tables of contents, headings, captions, labels, diagrams, charts, and glossaries. Consumable student booklets called *Skillbuilders* provide additional practice in four key literacy areas—comprehension, writing, grammar, and vocabulary—aligned with the content of the corresponding student reader.

Developing Science Understanding

Brain Research and Science Learning

During the second half of the twentieth century, theories of stage development argued that there were sharp limits on the scientific knowledge that children could acquire. Based on the work of Jean Piaget, these theories maintained that children's development progresses in stages from concrete to abstract modes of thinking. Recent research into cognitive development has called these theories into question. Even young children are driven to investigate and explain the natural world, and they acquire more science knowledge and more reasoning skills than previously thought (Metz, 1995; Gelman and Kalish, 2005). The authors of *Taking Science to School* conclude: "In contrast to the commonly held and outmoded view that young children are concrete and simplistic thinkers, the research evidence now shows that their thinking is surprisingly sophisticated. Important building blocks for learning science are in place before they enter school" (Duschl, Schweingruber, and Shouse, 2006, p. 53).

Critical to children's conceptual development is how instruction builds on this prior knowledge (Donovan, Bransford, and Pellegrin, 2000). Some prior knowledge can involve misconceptions about science. Rather than being an obstacle to learning, these misconceptions can be a starting point for the development of more accurate knowledge: "It is thus critical that children's prior knowledge is taken into account in designing instruction that capitalizes on the leverage points and adequately addresses potential areas of misunderstanding" (Duschl, Schweingruber, and Shouse, 2006, p. 3).

Brain research has emphasized the power of patterning. Making connections engages students, and they are more likely to understand and remember new learning that they can connect to prior knowledge (Donovan, Bransford, and Pellegrin, 2000; Sousa, 2000; Erlauer, 2003; Caine and Caine, 2005; Tileston, 2006). Building on these patterns is part of the purposeful instructional development of prior knowledge: "To understand science, children . . . need to view facts in broader contexts of meaning. They need to reposition the ideas they bring with them to school within a larger network of ideas" (Michaels, Shouse, and Schweingruber, 2008, p. 41).

Another conclusion from brain research is the social component of effective learning. As Laura Erlauer writes, "The human brain is a social brain." (2003). Our minds engage more quickly and deeply in the concepts that we explore as part of a group (Donovan, Bransford, and Pellegrin, 2000; Sousa, 2000; Caine and Caine, 2005; Tileston, 2006). Teaching children to work together within a community of learners not only supports their learning of science content but also helps them understand the social structure of the scientific enterprise in general (American Association for the Advancement of Science, 2008).

Language is a critical component of science learning. The authors of *Linking science and literacy in the K–8 classroom* write: "At the root of deep understanding of science concepts and scientific processes is the ability to use language to form ideas, theorize, reflect, share and debate with others, and ultimately, communicate clearly to different audiences" (Douglas, Klentschy, Worth, and Binder, 2006, p. xi). As students talk about science, they make the connections and discover the patterns that support their learning. Using language also leads students to think more critically and analytically about their ideas. Finally, using language supports the development of metacognition. Critical to science learning, metacognition is children's ability to reflect on their own thinking (Donovan, Bransford, and Pellegrin, 2000). To scaffold the collaborative talking and thinking that promote deeper science understanding, researchers recommend that teachers foster open-ended discussion in their classrooms (Michaels, Shouse, and Schweingruber, 2008). Students also benefit when they explain their understanding of science concepts through writing. Science notebooks are an effective tool for encouraging students to write about science (Young, 2003).

The *Delta Science Content Readers* were planned and written so both teachers and students would benefit from the conclusions of cognitive research. The chart on the following page lists some of the research-based features in the student readers that support science learning.

How *Delta Science Content Readers* Support Science Learning	
Program Feature	**Aligned with Research**
Science Statement	• Prompts open-ended discussion • Activates knowledge, interest, and experience • Connects existing knowledge and new learning
Make a Connection	• Prompts open-ended discussion • Allows teachers to start instruction with the knowledge students bring to school • Connects existing knowledge and new learning • Encourages collaborative learning
Checkpoint	• Supports self-assessments, as well as informal assessments, of science learning • Encourages collaborative discussions of science learning • Provides prompts for writing in science notebooks
Apply Science Concepts	• Applies scientific language and scientific representations • Asks students to generate and evaluate scientific explanations • Guides students to recognize patterns among concepts • Provides prompts for writing in science notebooks
Let's Review	• Applies scientific language and scientific representations • Asks students to generate and evaluate scientific explanations • Guides students to recognize patterns among concepts • Provides prompts for writing in science notebooks

Developing Content-Area Literacy

Supporting Comprehension of Content-Area Texts

Comprehension is a process through which a reader draws meaning out of a text (Carlisle and Rice, 2002). Researchers have identified three components in the process of comprehending content-area texts (Mayer 1984):

- **Selecting Information** Identifying the most important information and focusing on it
- **Organizing Information** Assembling the selected information into a coherent concept
- **Integrating Information** Making connections between this new concept and information the reader already knows

Research has shown that students in late elementary school and middle school (grades 4–9) have the most difficulty with these three subprocesses, and their difficulties are most acute when reading content-area texts (Armbruster, Anderson, and Meyer, 1992).

The way a text is structured supports a reader's effort to select, organize, and integrate information, so understanding text structure is a critical component of comprehension. Most students are familiar with the narrative text structure used in fiction. Narrative features such as plot, setting, and character are typical of the oral stories students hear from friends and family; they are also an integral part of children's movies and television shows. Nonfiction text structures vary more and involve logical structures that are often not immediately apparent to children. As a result, readers can fail to recognize the framework the author chose and thus fail to select, organize, and integrate the information in the text (Carlisle and Rice, 2002; Tyree, Fiore, and Cook, 1994).

In the words of *Put Reading First*, "text comprehension can be improved by instruction that helps readers use specific comprehension strategies" (Center for the Improvement of Early Reading Achievement, 2003, p. 49). In the *Delta Science Content Readers*, Build Reading Skills lessons provide explicit instruction in skills and strategies for comprehending the following text structures:

- Main Idea and Details
- Compare and Contrast
- Cause and Effect
- Sequence

Students also benefit from explicit instruction in skills and strategies for using nonfiction text features such as tables of contents, headings, captions, labels, diagrams, charts, and glossaries. In the *Delta Science Content Readers*, the following Build Reading Skills lessons support students' use of nonfiction text features:

- Preview the Book
- How to Read Diagrams
- How to Read Charts

The clear, "considerate" instructional design of the *Delta Science Content Readers* provides students with numerous opportunities for practice in recognizing text structures and using nonfiction text features (Armbruster, 1984; Tyree, Fiore, and Cook, 1994).

Teaching students to represent text visually can help them select, organize, and integrate information (Armbruster, Anderson, and Meyer, 1992; Hyerle, 2000; Marzano, 2003). *Put Reading First* identifies the following benefits of teaching students how to use graphic organizers (Center for the Improvement of Early Reading Achievement, 2003, p. 51):

Benefits of Teaching with Graphic Organizers

- Graphic organizers guide students to recognize and understand text structures.
- Graphic organizers clarify relationships between information in the text.
- Graphic organizers prepare students to summarize what they have read.

In the *Delta Science Content Readers*, students are consistently guided to use graphic organizers. Lessons in the student readers and in the teacher's guides model the use of graphic organizers, including K-W-L charts. Practice opportunities, including Reflect on Reading activities and the *Skillbuilders* booklets, are often structured around graphic organizers.

There is widespread agreement among reading researchers that effective comprehension instruction is direct and explicit (National Reading Panel, 2000). The steps of explicit instruction typically follow this sequence (Center for the Improvement of Early Reading Achievement, 2003):

- **Teach** Students hear or read a direct explanation of the skill or strategy.
- **Model** The teacher demonstrates how and when to apply the skill or strategy.
- **Guided Practice** The teacher guides students as they apply the skill or strategy.
- **Application** Students practice the skill or strategy independently.

Another popular way of phrasing how instruction should proceed, after a direct explanation is offered, is "I do it" (model), "We do it" (guided practice), and "You do it" (application). Many reading researchers recommend the use of Think Alouds for modeling reading skills and strategies (Wilhelm, 2001; Lipson, 2007). The following chart shows the structure of comprehension instruction in the *Delta Science Content Readers*:

Comprehension Instruction in *Delta Science Content Readers*

Research-Based Step	Program Feature
Teach	• Build Reading Skills lessons in student reader • Instructional support in teacher's guide for each Build Reading Skills lesson
Model ("I do it")	• Think Aloud in teacher's guide for each Build Reading Skills lesson
Guided Practice ("We do it")	• Suggested in teacher's guide support for each Build Reading Skills lesson
Apply ("You do it")	• Reflect on Reading activities in student reader • Comprehension worksheets in *Skillbuilders*

Reading researchers also recommend that students receive support before, during, and after reading (National Reading Panel, 2000; Harvey, 2000; Vaughn and Linan-Thompson, 2004; Lipson, 2007). The chart on the following page shows how these recommendations have been incorporated in the *Delta Science Content Readers*.

Reading Support in *Delta Science Content Readers*	
Research-Based Step	**Program Feature**
Before Reading	• Make a Connection questions engage students and activate prior knowledge. • Find Out About statements set a purpose for reading. • Vocabulary box previews key science vocabulary. • Build Reading Skills lesson introduces a target comprehension skill or strategy.
During Reading	• Checkpoint questions allow teachers to assess comprehension. • Questions and prompts in the teacher's guide provide additional support for guiding comprehension.
After Reading	• Reflect on Reading activity guides students to apply target skill or strategy to science content. • Apply Science Concepts offers additional opportunities for student engagement with the content of each section. • Let's Review questions guide students to respond to the content of the student reader.

Teaching Content-Area Vocabulary

Recent research has emphasized the important role that vocabulary plays in reading comprehension (Beck, McKeown, and Kucan, 2002; Marzano, 2004; Hiebert and Kamil, 2005; Stahl and Nagy, 2005; Graves, 2006). As researchers have explored how students understand and remember word meanings, they have rethought what constitutes the most effective approach to vocabulary instruction. Many researchers have stressed the importance of carefully choosing which words to teach (Biemiller, 1999; Biemiller and Slonim, 2001; Hiebert and Kamil, 2005; Beck, McKeown, and Kucan, 2002). However, the challenges of selecting words to teach and identifying the most effective methods of instruction are different in the content areas than they are in traditional reading lessons.

Science vocabulary is what Beck, McKeown, and Kucan (2002) have labeled "Tier 3 words." These are words that don't appear often in text outside a particular content area. The characteristics of content-area vocabulary are different from the more literary vocabulary found in fictional narratives. Armbruster and Nagy (1992) have offered a clear description of these different characteristics, which are summarized in the chart below.

Two Kinds of Vocabulary	
Vocabulary in Fictional Narratives	• Learning new vocabulary often involves learning a new label for a familiar concept (*miniscule* for "very small"). • Readers can often understand a fictional narrative if they don't know or don't fully understand a key vocabulary word. • Reading vocabulary is often discrete. Words are not related and not mutually reinforcing.
Vocabulary in Content-Area Texts	• New vocabulary often represents new concepts that can be complex and difficult to understand. • Vocabulary often represents the very concepts that students are expected to learn. • Readers cannot understand a content-area lesson if they don't know or don't fully understand a key vocabulary word. • Vocabulary words in content-area lessons are often related in meaning. If a student doesn't understand *temperature*, for example, it is hard to understand *thermal energy*.

In addition to these differences, in science "words are often given specific meanings that may be different from or more precise than their everyday meanings" (Michaels, Shouse, and Schweingruber, 2008, p. 4).

Because content-area vocabulary differs from vocabulary in fictional narratives, it requires a different instructional approach. Marzano (2004) emphasizes the importance of building background and developing conceptual understanding for this kind of vocabulary. While preteaching vocabulary is a popular approach in reading lessons, Armbruster and Nagy recommend that teachers do not preteach key content-area vocabulary. Instead, they recommend that teachers embed instruction for content-area vocabulary into the work of understanding the rich and difficult concepts these words represent. These approaches are reflected in the teacher's guides for the *Delta Science Content Readers*:

- Students preview science vocabulary before reading. The teacher reads each word aloud so students have a phonological representation of the word.
- Teachers are prompted to display vocabulary words in a graphic organizer during reading. The graphic organizer supports class discussions of the relationship between vocabulary and the concept each word represents.
- Questions are provided during reading so teachers can reinforce and extend understanding of the relationships between concepts and vocabulary.
- After Reading activities deepen and extend understanding of vocabulary.

Reaching English Learners

Among English learners, there are significant differences in terms of the amount and degree of formal schooling, level of literacy in the native language, age of arrival in the United States, and age of enrollment in school (Francis, Rivera, Lesaux, Kieffer, and Rivera, 2006). Like native speakers of English, English learners experience a wide range of language proficiency. Levels of language proficiency generally proceed from Beginning to Advanced, building on preceding levels, and are distributed across the domains of listening, speaking, reading, and writing. Individual English learners may experience accelerated or slower growth, as well as reversals of progress or unparallel development within the separate domains.

Research supports the use of certain instructional approaches for both native English speakers and English learners. As with native speakers, English learners benefit from direct, explicit instruction in reading comprehension. Instruction in the use and application of comprehension strategies, combined with careful teacher modeling and scaffolded instruction, are important approaches (Gersten, Baker, Shanahan, Linan-Thomson, Collins, and Scarcella, 2007). Similarly, the lack of proficiency in vocabulary impedes the acquisition of content in academic areas for English learners, as it does for native speakers. Effective vocabulary instruction for English learners must also be explicit, systematic, and intensive (Linan-Thompson and Vaughn, 2007).

Research also supports the use of certain distinct instructional strategies with English learners. Some of these distinct, research-based approaches are reflected in the *Delta Science Content Readers*. In the teacher's guide for each title, Supporting English Learners provides teachers with a specific strategy to help English learners access the content in that reader. These strategies include: Set Objectives, Activate Prior Knowledge, Use Photographs and Other Visuals, Teach Academic English, and Develop Vocabulary.

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