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Research-Based Curriculum

Science Readers: Content and Literacy in Science

Fostering Content-Area Literacy

Reading Across the Content Areas

It is usually regarded as the task of the English or language arts teacher to guide students through the effective use of comprehension strategies as they read. Although students read in almost every subject area they study, some teachers may overlook the need for guiding students through their textbook-based and trade book-based tasks. Comprehension strategies best serve students when they are employed across the curricula and in the context of their actual learning. It is only then that students can independently use the strategies successfully while reading. Students will spend the majority of their adulthood reading nonfiction expository writing. With this in mind, teachers at all levels must actively pursue ways to enhance their students' ability to understand reading material.

Science Reading

The goal of literacy in science is to develop students' curiosity about the world around them in order to promote a knowledgeable population in an ever-changing technological world. Studying the natural world helps students understand how and why things work. Another important goal of literacy in science is to introduce students to the idea of looking at the world and current issues through a critical and scientific lens. To accomplish these goals, students must learn how to question, explore, and analyze natural phenomena. With these skills well in hand, students understand the complexity of available information and are empowered to become independent learners and to consider data that they might otherwise overlook.

21st-Century Literacy Demands

The literacy demands of the 21st century are tremendous. Literacy was defined a century ago by a person's ability to write his or her own name. In the 1940s, one needed to be able to read at the eighth-grade level to function adequately in the factory setting. To be considered fully literate today, one needs to be able to read at the 11th- or 12th-grade level (and often beyond) as a part of workplace duties, leisure activities, and civic duties.

We have entered a new era in education—one that is deeply tied to the technological advances that permeate our modern lives. Today, some children can use a cell phone to take a picture before they can speak. Students in school can use the Internet and online libraries to access information from remote locations. Now more than ever, it is the content-area teacher's responsibility to prepare students for the reading demands of our technological age. In order

to become effective and efficient readers, students must utilize comprehension strategies automatically and independently. Students need teacher guidance to help them become independent readers and learners so that they not only understand what they read but also question it and explore beyond it.

The Reading Process

Teachers can easily optimize reading materials with students by utilizing the three-part framework of the reading process to facilitate science learning. Break reading assignments into three comprehension-building steps: before reading, during reading, and after reading. What teachers do during each stage of the reading process is crucial to their students' learning.

Before Reading

Prior to beginning a reading activity, teachers can set the stage for learning by generating interest in the topic, activating and building prior knowledge, and setting the purpose for reading. Teachers should also take the time to introduce key concepts and vocabulary, thereby providing a critical foundation for conceptual understanding.

During Reading

During reading, students actively read text aloud. In this stage of the reading process, students are engaged in answering questions (either self-generated or teacher-generated), monitoring their comprehension of the text, clarifying the purpose for reading, visualizing the information, and making connections.

After Reading

Students expand their understanding of the material after reading the text. During the final stage of the reading process, students build connections among the bits of information they have read, enabling themselves to deepen their understanding and reflect on what they have learned.

Effective Reading Strategies

Before Reading

- scan visual aids
- preview the text
- skim the text
- brainstorm related ideas
- make predictions about the text
- generate questions about the text

During Reading

- reread for clarity
- seek answers to questions about the text
- observe and discuss text structure
- make connections between ideas
- visualize content
- generalize about specific content

After Reading

- reread to review and locate specific information
- confirm predictions
- clarify meaning
- relate the reading to the reader
- synthesize new information
- summarize what was read
- generate new questions

Research to Practice

Reading activities in *Science Readers* are organized in a three-part framework: Before Reading, During Reading, and After Reading. Each lesson focuses on specific reading comprehension strategies and includes multiple opportunities to foster curiosity and reflect on new learning.

Writing Across the Curriculum

Teachers may wonder where writing fits within the science curriculum. What do run-on sentences have to do with sound waves and volcanoes? Writing is the means through which students are able to articulate complex terms and synthesize concepts. Writing is a tool that students can use to understand and investigate the subject of science. Writing allows students to translate complex ideas into words and language that they understand. Scientists frequently write articles, publish research, and record data and observations.

Research studies (Gere 1985; Barr and Healy 1988) suggest that writing in the content areas does make a difference. Barr and Healy (1988) state that "schools succeed when the emphasis by both teachers and students is on writing and thinking about relevant and significant ideas within the subject areas." The encouragement of writing across the curriculum leads to higher-order thinking skills (Gere 1985). Shifts in students' attitudes have also been documented and show a great benefit to writing across the curriculum (Winchester School District 1987).

Effective Writing Strategies

Writing to Learn

- observation journals
- recording data
- observation reports
- topic analyses
- diagrams
- charts

Writing to Apply

- research reports and projects
- expository writing
- presenting data
- proposals
- hypotheses
- synthesis of data
- conclusions
- questions

Research to Practice

Each lesson in *Science Readers* features activities that encourage students to use what they have learned and apply it through writing.

The Reading/Writing Connection

Reading and writing are interactive processes that use similar strategies. When taught together, they reinforce each set of skills and can improve achievement. Together, reading and writing create an atmosphere of communication in which thinking is a critical part of the process. Teachers who promote higher-level thinking with both reading and writing processes will help develop better thinkers.

Readers and writers engage in similar processes for comprehension. Readers have a purpose for reading, and writers have a purpose for writing. Just as readers use prior knowledge to make connections to a particular topic, writers use prior knowledge in order to write about a topic. Readers can change comprehension strategies while reading, similar to the way writers can change and develop meaning while writing. Both strategies require rereading to check comprehension. These are just some of the similarities in processes for reading and writing.

In the article "Success of Children at Risk in a Program That Combines Writing and Reading," Gay Su Pinnell writes, "As children read and write, they make the connections that form their basic understandings about both. Learning in one area enhances learning in the other. There is ample evidence to suggest that the processes are inseparable and that we should examine pedagogy in the light of these interrelationships. Hence, the two activities should be integrated in instructional settings. Teachers need to create supportive situations in which children have opportunities to explore the whole range of literacy learning, and they need to design instruction that helps children make connections between reading and writing" (1988).

Writing is the expression of ideas and thoughts gathered while reading. Science texts are often heavily loaded with difficult vocabulary words and complex concepts that are challenging for students to understand. Encouraging students to both read and write helps them process the information presented. When students read content without writing about it, they miss a crucial step in the process of comprehending the information.

Writing helps create the bridge between content knowledge and understanding. A wide variety of writing assignments and activities can help students become actively engaged in science. Additionally, writing activities promote active learning, encourage discussion, engage all students, and develop thinking.

Research to Practice

Each lesson in *Science Readers* incorporates writing and promotes the reading and writing connection, thus increasing overall comprehension and concept development.

Developing Academic Vocabulary

Decades of research have consistently found a deep connection between vocabulary knowledge, reading comprehension, and academic success (Baumann, Kame'enui, and Ash 2003).

Students with wide vocabularies find it easier to comprehend more of what they read than do students with limited vocabularies. The type of reading students encounter in school can be highly specialized, and the words they need to learn can be challenging. This type of academic vocabulary is often not encountered in everyday life or in everyday reading. Therefore, all students need opportunities to be introduced to, interact with, and apply new vocabulary words.

Vocabulary knowledge is essential for success in reading. However, its influence does not stop with reading. Students' knowledge of words impacts their achievement in all areas of the curriculum because words are necessary for communicating the content (Lehr, Osborn, and Hiebert 2004). As classroom teachers know, students have difficulty understanding and expressing the concepts and principles of the content areas if they do not know the specialized vocabulary that represent those concepts and principles.

Indeed, Marzano (2004) maintains that there is a strong relationship between vocabulary knowledge and background knowledge. Therefore, by building students' vocabulary, we can increase their background knowledge and thereby provide more opportunities for learning new concepts.

Vocabulary teaching is critical for helping students increase their oral vocabulary, enhance their reading comprehension, and extend their writing skills. Yet in order for students to benefit from their word knowledge, it is not enough for teachers to introduce new vocabulary and share definitions. In short, the quality of a vocabulary program matters.

Components of Effective Vocabulary Programs

Research shows that there are several components of an effective vocabulary program:

- regular opportunities to develop oral language (Nagy 2005)
- a culture of promoting word consciousness (Nagy and Scott 2000)
- dynamic, explicit instruction of key words (Beck, McKeown, and Kucan 2002)
- guidance in independent word-learning strategies (Graves 2000)
- daily structured contexts for academic word use in speaking, writing, and assessment (Beck, McKeown, and Kucan 2002)
- students' fluent reading of varied texts (Cunningham and Stanovich 1998)

Research to Practice

Each lesson in *Science Readers* incorporates vocabulary development so that students have experiences with learning the key words and concepts before they encounter them in the text.

Value of Informational Text

What if I were to ask you to close your eyes and imagine a scientist working away in their lab? What images would your mind conjure? Would you imagine someone in a white lab coat surrounded by beakers of bubbling liquid? Or perhaps would you imagine groups of people building complicated pieces of equipment? Chances are that you would not immediately think of a scientist reading research on the Internet or reading an article from a science journal. However, these actions are every bit as important to science as conducting experiments or building new technologies. Scientists read and write to communicate their findings and share ideas with others in the science community.

Science and literacy learning may seem like an unlikely dynamic duo, but they are the perfect team. Science learning gives literacy an authentic context. Studies have shown that students learn science concepts and comprehend text best while engaging in authentic inquiry experiences combined with reading, writing, and verbal communication (Michaels, Shouse, and Schweingruber 2008). Students who read, write, and talk about science are

better prepared to go beyond what is presented in class. The use of informational texts that are relevant to student inquiries is inherently interesting to most students, motivates further reading, and enables students to build background knowledge.

Research suggests that science textbooks can be overwhelming for many children, especially those who have difficulty reading. Ansberry and Morgan (2010) point out that textbooks often contain unfamiliar vocabulary and cover a broad range of topics. However, informational children's literature tends to focus on fewer topics and give more in-depth coverage of the concepts. Hapgood and Pallinscar (2007) found that reading to explore science topics, combined with firsthand investigation and discussions, can help students acquire reading strategies even better than direct instruction in those strategies can.

Students cannot learn or be fully engaged in the practices of science merely by reading. Providing students with opportunities to read informational text and write about their experiences in science reinforces the fact that scientific evidence can be based on both firsthand information and text-based resources.

Research to Practice

The *Science Readers* series provides students with access to high-quality informational text partnered with scientific investigations. Teachers model a variety of literacy strategies while teaching science content in a meaningful context.

Science in the 21st Century

Next Generation Science Standards

The Next Generation Science Standards (NGSS) were developed to establish learning goals in science that afford students the skills and knowledge they need to become informed citizens, college-ready, and prepared for careers in science, technology, engineering, and mathematics (STEM). The NGSS were developed from the *Framework for K–12 Science Education* (National Research Council 2012). The *Framework* provides a sound, evidence-based foundation for standards by drawing on current scientific research—including research about the ways students learn science effectively—and identifies the science all K–12 students should know.

The developers of the NGSS recognized that deep understanding of science concepts requires more than rote memorization of key ideas and science facts. There is a critical need for students to understand the relationships among concepts and how to apply what they have learned to find solutions to new challenges. To this end, the standards integrate three important dimensions of learning—Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas.

While change can be unsettling at times, the developers of the NGSS assure educators that the standards are not a radical change to science education. Rather, they are a carefully crafted update and revision of what students have been learning for years. Students will continue to learn about rocks and soils, forces and motion, and chemical and physical changes. However, now teachers will emphasize the relationships between these concepts. These new standards aim to help educators cultivate students' natural curiosity, push their creative boundaries, and get kids excited about science and technology.

NGSS Dimensions

- The **Science and Engineering Practices** describe behaviors that scientists engage in as they investigate and build models and theories about the natural world. They include the practices that engineers use as they design and build models and systems.
- **Crosscutting Concepts** have application across all domains of science. As such, they are a way of linking the different domains of science.
- The **Disciplinary Core Ideas** describe—at each grade from kindergarten through high school—what each student should know in physical science, life science, earth and space science, engineering, technology, and applications of science.

Research to Practice

To meet the needs of students and teachers, many lessons in *Science Readers* are aligned with the Next Generation Science Standards.

STEM Education

STEM education is a powerful approach to learning that is gaining momentum across the nation. As with many education initiatives, STEM means different things to different people. Most agree that STEM is the integration of science, technology, engineering, and mathematics to design solutions for real-world problems. The most essential component of STEM education is the engineering design process. This process is an articulated approach to problem solving, in which students are guided through the cyclical process of solving a problem and refining that solution to achieve the best possible outcome.

The application of STEM practices in the classroom affords teachers the opportunity to challenge students to apply new knowledge. Even kindergartners can design and build structures, improve existing products, and test innovative solutions to real-world problems. STEM instruction can be as simple as using recycled materials to design a habitat for caterpillars discovered on the playground, and as challenging as designing a solution to provide clean water to developing countries. The possibilities are endless.

STEM is a tool educators can use to help students become technologically, scientifically, and mathematically literate. Students engaged in STEM are able to develop important 21st century skills along with creativity, collaboration, critical thinking, and communication. Students who become STEM proficient are prepared to answer complex questions, investigate global issues, and develop solutions for real-world challenges. STEM is a strong component of a balanced instructional approach ensuring students are college- and career-ready.

Research to Practice

Many of the activities in *Science Readers* support STEM education. These activities have been marked for easy identification.

Using the 5Es in a Classroom

The 5Es Instructional Model describes five phases of learning that follow the constructivist learning theory. In this theory, new knowledge is built upon existing knowledge and experiences.

The 5Es include *engage*, *explore*, *explain*, *elaborate*, and *evaluate*. Each of these phases of learning helps to focus students on learning objectives while connecting these objectives to prior knowledge and alternate applications of new knowledge.

Engage

At this stage, teachers introduce a topic or concept with an intriguing, fascinating, or challenging question or demonstration designed to capture students' interest, curiosity, and attention. At this stage, teachers do not seek a "right answer." Rather, they prompt students to talk about what they already know about the topic (or think they may know), and discuss what else students would like to know.

Explore

During exploration, students conduct various hands-on or problem-solving activities and experiments designed to help them explore the topic and make connections to related concepts, often within groups or teams. During this stage, students share common experiences while the teacher acts as a facilitator, providing materials as needed and guiding the students' focus.

Explain

In this stage, teachers help students observe patterns, analyze results, and/or draw conclusions based on their activities and investigations. Teachers also define relevant vocabulary.

Elaborate

In this stage, students build upon the concepts or ideas they have learned and make connections to other related concepts and new situations.

Evaluate

In the final stage, teachers evaluate, or assess, students' understanding of the topic studied. This evaluation can be formal or informal but should demonstrate a clear understanding of what students have learned throughout the course of the lesson.

References Cited

Ansberry, Karen and Emily Morgan. 2010. *Picture Perfect Science Lessons: Expanded 2nd Edition: Using Children's Literature Books to Guide Inquiry*. 3–6. Arlington, VA: NSTA Press.

Barr, Mary A., and Mary K. Healy. 1988. "School and University Articulation: Different Contexts for Writing Across the Curriculum." *New Directions for Teaching and Learning* 36 (Winter): 43–53.

Baumann, James, Edward Kame'emui, and Gwynne Ash. 2003. "Research on Vocabulary Instruction: Voltaire Redux." In *Handbook of Research on Teaching the English Language Arts*, edited by James Flood, Dianne Lapp, James Squire, and Julie M. Jensen, 52–85. Mahwah, NJ: Lawrence Erlbaum.

Beck, Isabel L., Margaret G. McKeown, and Linda Kucan. 2002. *Bringing Words to Life: Robust Vocabulary Instruction*. New York: Guilford Press.

Bybee, Rodger W., Joseph A. Taylor, April Gardner, Pamela Van Scotter, Janet Carlson Powell, Anne Westbrook, and Nancy Landes. 2006. *The BSCS 5E Instructional Model: Origin and Effectiveness*. Colorado Springs, CO: BSCS.

Cunningham, Anne E., and Keith E. Stanovich. 1998. "What Reading Does for the Mind." *American Educator* 22 (1–2): 8–15.

Douglas, Rowena, edited by Michael P. Klentschy, Karen Worth, and Wendy Binder. 2006. *Linking Science and Literacy in the K–8 Classroom*. Arlington, VA: NSTA Press.

Gere, Anne R., ed. 1985. *Roots in the Sawdust: Writing to Learn Across the Disciplines*. Urbana, IL: National Council of Teachers of English.

Graves, Michael F. 2000. "A Vocabulary Program to Complement and Bolster a Middle Grade Comprehension Program." In *Reading for Meaning: Fostering Comprehension in the Middle Grades*, edited by Barbara M. Taylor, Michael F. Graves, and Paulus Willem van den Broek, 116–135. Newark, DE: International Reading Association.

Hapgood, Susana and Annemarie Sullivan Pallincsar. 2007. "Where Literacy and Science Intersect." *Education Leadership* 64 (4): 56–60.

Lapp, Diane, Maria Grant, Barbara Moss, and Kelly Johnson. 2013. "Students Close Reading of Science Texts." *The Reading Teacher* 67 (2): 109–19.

Lehr, Fran, Jean Osborn, and Elfrieda H. Hiebert. 2004. *A Focus on Vocabulary*. Honolulu, HI: Pacific Resources for Education and Learning.

Marzano, Robert J. 2004. *Building Background Knowledge for Academic Achievement*. Alexandria, VA: Association for Supervision and Curriculum Development.

Michaels, Sarah, Andrew W. Shouse, and Heidi A. Schweingruber. 2008. *Ready, Set, Science! Putting Research to Work in K–8 Classrooms*. Washington, DC: The National Academies Press.

Nagy, William E. 2005. "Why Vocabulary Instruction Needs to Be Long-Term and Comprehensive." In *Teaching and Learning Vocabulary: Bringing Research to Practice*, edited by Elfrieda H. Heibert and Michael L. Kamil, 27–44. Mahwah, NJ: Lawrence Erlbaum.

Nagy, William E., and Judith A. Scott. 2000. "Vocabulary Processes." In *Handbook of Reading Research* vol. 3, edited by Michael L. Kamil, Peter B. Mosenthal, P. David Pearson, and Rebecca Barr, 269–84. Mahwah, NJ: Lawrence Erlbaum.

National Research Council. 2012. *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Committee on a Conceptual Framework for New K–12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Partnership for 21st Century Skills. 2009. Framework for 21st Century Learning: Tuscon, AZ: Partnership for 21st Century Skills.

Pinnell, Gay S. 1988. "Success of Children at Risk in a Program That Combines Writing and Reading." Technical Report No. 417. Reading and Writing Connections.

Winchester School District, MA. 1987. "Winchester High School Excellence in Education Grant: Reading and Writing Across the Curriculum." Final Report. Washington, DC: Office of Educational Research and Improvement. ED 305 589.