READING science

Practical Strategies for Integrating Instruction

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361 Hanover Street
Portsmouth, NH 03801–3912
www.heinemann.com

Offices and agents throughout the world

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Figure 5.1 Parts of an Atom, Figure 5.2 Life Cycle of an Apple Tree, and Figure 5.3 Decibel Levels of Various Sounds from *Science Magnifier* (2010). Published by Carolina Biological Supply Company. Reprinted with permission from the publisher, www.carolina.com.

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Cataloging-in-Publication data is on file at the Library of Congress.
ISBN: 978-0-325-06258-7

Editor: Katherine Bryant
Production: Victoria Merecki
Cover design: Suzanne Heiser
Interior design: Shawn Girsberger
Typesetter: Shawn Girsberger
Manufacturing: Steve Bernier

Printed in the United States of America on acid-free paper
20 19 18 17 16 PPC 1 2 3 4 5

To Ashu

and the teachers
who will encourage
his scientific interest and passion

Contents

Acknowledgments

This section is always the most difficult part of a book to write. How can I thank every person who has impacted and influenced my thinking on this text? I am convinced we learn more by listening than by speaking, and I know many wonderful teachers who have given me a great deal of food for thought since I started writing this book.

I want to begin by thanking the teachers who took time out of their already packed schedules to try out ideas and listen to my thoughts. Those teachers and their students played a significant role in the creation of this text, and without them it wouldn't exist. Thanks especially to Lisa Carp, Andrea Continanzi, Marissa Hoff, Mary Lee, Jennifer Roberson, and Amanda Snow. Also, discussions I had with teachers I met through recent presentations at the Arkansas Reading Association Conference, the International Reading Association Conference, and the Reading Council of Greater Winnipeg have taught me a great deal.

In addition, I learn daily from my students and value their thoughts and feedback. Amanda Kane, J. William Lee, and Lisa Kuan have been especially helpful with their scientific knowledge, and I know their future and the future of our children are bright when educators such as these are guiding learning.

Thanks as well to Katherine Bryant for all of her hard work. She gave me a chance to write this book, and for that I will always be grateful. Her feedback was specific, fast, and brilliant. Her fantastic suggestions moved me from my initial idea for the text to a book that will help many science teachers in the classroom.

Colleagues both past and present, including Dan Ouzts, Lane Roy Gauthier, John Beach, Della Dekay, and others, helped me to keep my sanity as I navigated speaking and writing deadlines. Their sense of humor and friendship are always greatly appreciated.

Also, I thank my son, Ashenafi. Many hours were spent working on this project instead of watching *Sid the Science Kid*, conducting science experiments, and visiting the children's museum. A book is not created in isolation, and I know it takes away quality time from those close to us to get things done.

Finally, I thank the readers of this book. My hope is that by asking questions, engaging with ideas, and thinking about information contained within the pages of this book, we can continue to facilitate and strengthen connections between science and literacy. Please take the time to let me know your thoughts and suggestions on ideas shared in this book. In that way we can all continue to learn.

Introduction

With the large amount of scientific information we expect our students to learn today, we already struggle to find enough minutes in the classroom to develop that knowledge. Then just when we feel like we don't have an extra minute to spare, we have the additional pressure to include literacy skills. But the truth is, literacy skills aren't add-ons to the science class, put there because others expect us to include reading and writing in the classroom because of standards or curriculum frameworks. Instead, these skills are critical parts of science instruction. By enabling our students to comprehend a variety of scientific texts and communicate scientific understanding, we open doors for them. We know that career opportunities are plentiful in STEM (science, technology, engineering, and mathematics) fields, but beyond that, we want all students to grasp scientific content in order to better understand the world around them. Although there is no way we can teach students all of the scientific content they must know, we can teach them how to access that content so that they can continue to learn long after they walk out the doors of our classrooms.

I hope that you view this book as an invitation to reflect on how science and literacy can connect in your classroom. Whether you are just beginning your teaching journey or have many years of teaching experience, the ideas, suggestions, and activities within the pages you will read are meant to serve as the foundation upon which you can create important connections between science and literacy. These connections, which help students to think, read, and write like scientists, are the disciplinary literacy skills necessary to strengthen their

scientific knowledge. Science requires specialized literacy demands, and these demands serve as the basis for this book.

About This Book

Throughout the book, you'll find brief "Think About It" and "Take Action" sections that will encourage you to reflect on your own teaching and try some new ideas. If you're reading the text alone, these sections will provide opportunities to gather your thoughts and apply ideas found within the text. They can also serve as good discussion starters if you're reading the book as part of a study group or book club.

The five chapters of this book include student examples from various grade levels and practical activities that you can use and modify to meet the needs of your students. You will also find that many of the activities involve collaboration among students. This type of collaboration reflects the learning that takes place in real life. Seldom do scientists work in isolation as they seek answers to scientific questions and find ways to effectively communicate their findings. Therefore, we need to encourage this type of collaboration in our classrooms.

Chapter 1 starts by answering the question, Why do we need to teach literacy skills in our science classes? It then lays out eight challenges we face in the science classroom, what those challenges mean for our teaching, and how they also give rise to important opportunities to engage students as scientific thinkers.

Chapter 2 takes a closer look at the texts we use in our classrooms. The most widely used text in the science classroom is the science textbook, but there are many other forms of text that we can integrate into our classrooms to strengthen scientific understanding. While the emphasis in education is clearly on informational text, these texts range from trade books to electronic texts and even to local texts. This chapter not only examines the types of text we might use but also looks at suggestions for locating and selecting the texts.

Developing vocabulary knowledge is the focus of Chapter 3. Vocabulary is important so that students can not only comprehend text that they hear or read but also accurately communicate scientific information. The chapter begins with ideas for determining the science terms students need to learn. Obviously our students encounter many unknown words, so we have to know how to

determine which of those words deserve our time and focus. Not all terms are best taught in the same manner, so this chapter also takes a look at a variety of practical ideas for developing various types of vocabulary, and how we can engage students by giving them choice in the vocabulary they learn and broadening their exposure to a wide range of scientific terms.

Reading scientific text does our students no good if they can't comprehend it, so I've dedicated all of Chapter 4 to building comprehension skills. In order for comprehension to occur, our students must develop what I refer to as *text flexibility*: the ability to recognize that different types of text need different approaches. Students must be taught the best way to approach scientific text as opposed to other types of text with which they may be more familiar. Informational text has many unique features, and before students can focus on the content of a scientific text, they must learn to navigate those features. Our students must not only understand a text's content but also synthesize information they read in multiple sources, support their opinions with specific textual references, and realize the important role the author's purpose plays in a text's creation.

As students learn to comprehend scientific text, we can't forget about the importance of images. Images play a very important role in scientific text, so these images are the focus of Chapter 5. While many of our students may *see* images, do they really *look* at them? Can they shift between reading text and viewing images and synthesize the information both provide? Without truly analyzing and understanding images, our students may not understand scientific content. This chapter provides a close examination of various types of images students encounter in science.

Final Thoughts

Although this book is divided neatly into five chapters, we all know that literacy skills and life in general are messy. The content from every chapter spills out into other chapters. We need to use the understanding of diverse texts we develop in Chapter 2 as we read and reflect on the content in Chapters 3 through 5. Also, knowledge of images, as discussed in Chapter 5, is an integral part of students' comprehension of scientific text, detailed in Chapter 4. We must continually remember that our overall goal is to develop students who can access scientific content.

My greatest hope is to hear from teachers who write and highlight all over their copies of this text. That is when I will really feel like I am providing some assistance in the important process of connecting science and literacy. Grab a marker or highlighter, or turn on your e-book reader, and start reading this text. Even better, grab a few other colleagues and have a book club where you can share ideas that you try and discuss how you can modify some of the suggestions in this text to better fit your students' needs. We must look at literacy skills not as a time stealer that uses up precious minutes during the teaching of science but rather as something that complements the science curriculum. We need both literacy and science skills to create scientists in our classrooms and to prepare our students for the future challenges they will meet. Now, it's time to get started.

1

Making the Science-Literacy Connection

Has there ever been a better time to teach science? While the job is far from easy because of increasing district expectations, changing standards, and the feeling that there is never enough time in the day, it's an exciting and challenging time for teachers who dedicate their lives to helping students strengthen their scientific knowledge. Right now, you can open almost any educational journal or newspaper, turn on your computer, or watch the feeds in social media and realize that more and more attention is being drawn to the field of science and the methods through which the content is taught.

Nobody can deny that teachers of science are passionate about their content. This passion led you to choose to become science teachers so that you can pass on your love of science to your students. Your challenge is taking your

passion and knowledge and using it to create students who are passionate and knowledgeable about the field of science. It isn't easy, and there are many challenges you face in developing your students' scientific knowledge. However, there is one common link that can help you meet these challenges: literacy.

Rethinking the Science-Literacy Relationship

In order to gain scientific knowledge, our students must be able to understand scientific material. This requires our students to possess the literacy skills necessary to read, view, and articulate scientific thoughts. Most of us are familiar with the phrase *content area literacy*. Many of us took a content literacy course in order to become a teacher. Often the content in a class such as this focuses on specific strategies that can help students understand content area material. Whether planning to teach math, science, or social studies, everyone sits together to learn how to use SQ3R (Robinson 1946), KWL (Ogle 1986), and other popular content area strategies with future students. Then future teachers walk out of the classroom with notebook pages or word documents full of strategies to use in lessons.

If you are like me, and took a class similar to this, the confidence didn't last long. In fact, by the time I could locate the well-worn notebooks during my first year of teaching or find the file folders containing the notes or locate electronic files that were lost in computer crashes or moves, it was apparent that the information from that class was not helping my teaching of science as much as I was hoping. We get frustrated because we work long hours each day to help our students access scientific material, and yet many of our students continue to struggle with the scientific texts we want them to read.

We Must Focus on Scientific Literacy Skills

Instead of looking at everything with a broad lens, we need to look more closely at the materials, demands, and requirements for our own content area. Research by Shanahan and Shanahan (2008) emphasizes that each content area has unique literacy demands, known as disciplinary literacy skills, and it is through the development of these important skills that our students learn to read, write, and think like historians, scientists, and mathematicians. In particular, Shanahan and Shanahan list these literacy skills specific to scientists:

- Scientists must be able to read and comprehend a wide variety of texts, and often they must also be able to examine and compare information from multiple sources on the same topic.
- Scientists must not only possess a large scientific vocabulary but also know how to determine the meaning of new words they encounter in scientific text.
- Scientists must be able to not only understand images but also shift their attention from printed text to images and back to printed text in order to comprehend text.

Of course even if our students do not choose to pursue scientific fields, they still need to develop these disciplinary literacy skills in science so that they will be able to make educated decisions and be contributing members of society. As adults, we often have to make decisions regarding the type of medical treatment we or a loved one might need. We also need to be advocates for practices that can positively influence our neighborhoods and families. We debate whether fluoride should be added to water or whether a factory might be impacting cancer rates in our communities. The only way we can read about, research, and intelligently respond to these issues is through the development of these disciplinary literacy skills. These skills are important to all of our students.

Why Is This Our Job? Why Are We Perfect for the Job?

As teachers of science, we are ideal for teaching the literacy skills our students need to understand science. We aren't teaching students to read for the sake of learning to read but rather helping them to develop the specific types of literacy skills they need to not only learn scientific information but also be

THINK ABOUT Life as a Scientist

What types of text must a scientist read as part of a scientific career?

Can you think of any distinct differences between the types of reading scientists do and those of historians or mathematicians? Are the types of text a scientist encounters present in your classroom? How does your science classroom prepare students to think, read, and write like scientists?

able to ultimately think and read about science topics independently. It seems more appropriate to look at ourselves as *disciplinary literacy experts*. We must know the specific literacy skills necessary for students to comprehend scientific information and articulate their understanding. For us, that means we need to continually think about the skills necessary to create scientists in our classroom and know how we can best develop those skills.

As science teachers, our goal is to develop students who can understand and evaluate sources of scientific information. Not only must students be able to comprehend what the author is stating in the scientific text, but they must also be able to realize that all text is not created equal, and not all information they read is accurate. They must be aware of the importance of examining multiple sources of information on a scientific topic and understand that an author may have had a reason for presenting information in the way that it is shared. Our students must use their knowledge of images and vocabulary in order to gain meaning from the text.

We also want our students to develop the skills and strategies necessary to ultimately be able to increase and deepen their scientific knowledge independently. This requires putting the appropriate scaffolds in place to enable our students to develop these literacy skills. Therefore, this teaching must occur while students are learning scientific information. The integration of literacy and science is a necessary part of our classrooms.

The Standards Actually Support Our Goal

I'm sure you have heard a lot about the English Language Arts Common Core State Standards (ELA CCSS) and the Next Generation Science Standards (NGSS). The ELA CCSS for grades 6–12 include an entire section of standards specifically relating to science and technical subjects. These standards emphasize developing academic vocabulary, citing evidence from text, and using content-rich nonfiction. The NGSS also expect students to use literacy skills as they compare and contrast multiple texts, develop argumentation skills, analyze and interpret data, and evaluate information and communicate it.

While these standards may feel overwhelming when we add them to our already full plates, these literacy-focused standards actually will help us to strengthen our students' scientific knowledge. Obviously, hands-on experiences must continue to play a central role in our classrooms as students develop

THINK ABOUT Addressing Our Challenges

What do you believe are the most challenging aspects of scientific knowledge that may be addressed through literacy instruction? Are students struggling with scientific vocabulary, images, overall comprehension of information? What have you tried in the past to help students deal with the challenges? How did those strategies work?

scientific knowledge. However, at the same time we realize that when students struggle with scientific text or vocabulary demands, it can negatively impact the amount of scientific learning they gain from these experiences. How can our students synthesize the results of their scientific experiments with other written research if they don't have access to scientific text because of a lack of disciplinary literacy skills? What if our students cannot articulate their findings to others because of an inability to visually represent their findings or unfamiliarity with specific vocabulary terms? Our students need these literacy skills to support the knowledge they gain through engaging science experiences we provide for them, and the current standards support the need for that knowledge.

Embracing the Challenges and Opportunities of Science and Literacy

Integrating science and literacy is challenging, but challenges often strengthen learning by the opportunities they provide. Let's take a look at some of the challenges we may face in our science classrooms and see what each of these challenges means for us as science teachers. As you look at each of these challenges, you can also think about the opportunities each of them provides you as a science educator. While I discuss the challenges briefly below, the rest of this book will help you to not only meet these challenges but also take advantage of the opportunities they provide.

Students' Science Background

To begin with, we have to think about what students know and understand about science when they walk through our classroom doors. Unfortunately,

there are a lot of grim statistics regarding the amount of time that students actually engage with science in elementary classrooms. In some classrooms it is no more than sixteen minutes per day (Winters Keegan 2006). That is less than the amount of time most students spend in elementary classrooms listening to announcements or transitioning from content area to content area during each week of school. It clearly isn't enough time to focus on science.

While we'd love to see this change, and see elementary teachers spend more time on science, the reality is that our middle school students may not have the scientific background we expect them to have when they walk through our classroom doors. If they aren't passionate about science, it may not be from a lack of interest but merely from minimal exposure. Therefore, the experiences we provide for our students are pivotal in influencing their views of the scientific field.

What Does This Mean for You?

We can't assume our students have an adequate scientific background to use the classroom textbook and to understand the vocabulary we use in our science classrooms, so we need to help build that background. We can do this by incorporating a wide variety of texts, such as online texts, articles, and trade books, into our lessons. If we're required to use a textbook, we can supplement it with other texts to help those students who may need to increase their background knowledge so that they can understand the science topics we teach. By recognizing this need, we can successfully build our students' interest in and passion for science. This interest is the necessary foundation for supporting and strengthening their scientific knowledge base. By taking into consideration our students' level of scientific knowledge and expanding the texts and strategies with which we approach our students' learning, we can develop scientifically knowledgeable students.

Diverse Needs

Our science classrooms are becoming more ethnically and culturally diverse. Students bring to our classrooms unique experiences, perspectives, and backgrounds. Our challenge is meeting all of their needs. Diversity is a good thing.

There is no doubt about that. However, this diversity is also a challenge because we want all of our students to be successful in strengthening their level of scientific knowledge.

What Does This Mean for You?

To reach all of our students, we need to familiarize ourselves with a wide range of strategies so that not just high-achieving students develop scientific skills. We must modify strategies and activities so that all students can reach their potential, including ELL students and those who struggle with reading or have other learning challenges. We can encourage our students to both develop and represent their knowledge through a variety of ways. Reading multimodal texts, working with peers, and using images can help students understand the science content. Our ultimate goal is for all students to be able to independently use a variety of strategies to gain scientific knowledge from texts and other sources, drawing on their unique backgrounds and strengths as they do so.

Prior Reading Experiences

Many of our students may not be reading a wide variety of informational texts either inside or outside of school. Outside of school, they may read about favorite television shows, fictional stories, and even graphic novels. Inside the English language arts classroom, the focus is often on fictional stories or hybrid texts (those stories that weave fiction and fact). Therefore, our students may not have the experience necessary to understand the informational science texts we present them.

What Does This Mean for You?

We must understand informational texts and the unique demands they present. While we will look more closely at informational texts in Chapter 2, let's briefly look at how informational texts differ from other types of text with which our students may be more familiar: the use of informational text features (e.g., headings, table of content, fonts), the amount of content presented, and the fact that students must read informational texts primarily to gain information rather than read for pleasure, as they often do when reading narrative text. We have

to help students recognize the organizational structure of the diverse texts and develop their ability to read, write, and interact with a wide range of tools and media. Even students whom we may typically classify as *good* readers can have difficulty understanding scientific material if they are unfamiliar with a specific type of text. By focusing our efforts on helping students understand the unique demands of a wide variety of scientific texts, we are providing opportunities for them to critically read and understand texts they will encounter in science—skills that are imperative if they are to independently engage with information they encounter in scientific texts.

Active Involvement

We all know that research supports less rote memorization of science facts and the creation of more student knowledge through inquiry-based approaches (Conderman and Woods 2008). This inquiry learning requires students to be actively engaged with scientific material. As teachers of science, we thrive on providing students with hands-on experiments. So why is the expectation of active involvement in science instruction a challenge? Well, let's think about the amount of time our students spend outside of school watching YouTube videos, chatting on social media, or playing games. In fact, the amount of screen time students have outside of class is a constant source of discussion. These types of experiences often are passive. Students don't have to spend a great deal of time thinking about what they are doing. However, today's students need to be actively playing a part in their learning and constantly thinking about what is occurring in the science classroom. While our students may appear to be actively participating in science experiments and reading, are they thinking about what is occurring and why, or are they passive spectators?

What Does This Mean for You?

We can actively engage our students with scientific information by making connections between their personal and prior experiences and what is occurring in the science classroom. We can also involve them with selecting vocabulary terms to learn and choosing scientific texts they want to examine. When they seek out diverse texts on the topic to see what others say about the topic, they are actively engaged with the content. Scientific knowledge is dynamic and

requires investigation. We must require that our students scrutinize information, consider sources, and question how information on a topic is changing or may change as they gain more information.

Our students must challenge each other and ask questions about scientific information they are processing. Through reading both traditional and digital text, articulating their opinions on the topics and text, and creating questions, students realize that their opinions and views play a role in the classroom, and they can also challenge their own and other students' thinking instead of assuming all information they read is factual.

While our students may spend quite a bit of time outside our classrooms passively participating in life experiences, we need to ensure that our science classrooms are student-centered and less teacher-driven. Since students actively contribute in a student-centered classroom, this type of climate also requires much more group interaction. While we already have our students complete experiments in groups or through hands-on activities, we have to encourage active student engagement in *all* aspects of the science classroom.

Science Textbooks

As teachers of science, many of us are required to use a particular textbook. These textbooks are mass-produced to cover certain scientific content regardless of students' needs. Frequently they are difficult for students to read and understand.

What Does This Mean for You?

We don't have to abandon our textbooks, but we definitely want to see them as only one source of information. Diverse texts include both print and digital texts, such as science journals, instructions for science experiments, research articles, and other types of print. Our science classrooms provide an opportunity to introduce our students to these many different types of scientific writing, which they will continue to encounter throughout their lives whether they become scientists or not, and to different perspectives about scientific issues.

Vocabulary Demands

When I ask teachers what makes science content challenging, vocabulary is often one of the first things they mention. According to Fang (2004), science

is more lexically dense than many content areas. In fact, the ratio of content words to general words is higher in science than in social studies or math. When we add this lexical density to some of the prior challenges, such as diverse student backgrounds and limited experience with science content, vocabulary can present a huge issue in our classrooms and keep our students from becoming knowledgeable about science.

What Does This Mean for You?

Many of the new science terms our students encounter are technical words they do not see in other content areas. We have to help our students build that academic vocabulary. Many other vocabulary words our students encounter in our science classrooms are multi-meaning terms and may have a different meaning in science than in everyday speech. These multi-meaning terms create confusion for our students, especially for ELLs. Also, some terms are not science specific but play a key role in accessing science content, such as *synthesize*, *replicate*, and *evaluate*. Mastering both the scientific vocabulary and strategies for figuring out unfamiliar terms will serve students well in our classes and in their future learning.

Extensive Use of Images

Given that many of our students spend a great deal of their hours outside of class on screen time, they are undoubtedly exposed to a lot of images. But they may be passive consumers of images; they may not actually think about what they are viewing in the way that they must think about images they encounter in science. The challenge isn't the number of images our students will encounter in our science classrooms but rather how we expect them to engage with the images.

What Does This Mean for You?

Often science texts contain graphs, video links, diagrams, and other types of images. In order to understand science content, students must move back and forth between images and words to gain the text's meaning. Therefore, we must guide our students in understanding the important role images play in science

FIND OUT HOW STUDENTS VIEW SCIENCE AND SCIENCE TEXT

Have students brainstorm their thoughts on their experiences with science and science classes. Is there anything that makes science really difficult for them? What activities are often part of science class? Are there specific experiences that stand out? What do they especially like or dislike about science class? How do they gain scientific information outside of class?

Collect and read through students' thoughts, looking for patterns within the class responses. What type of texts do they discuss, if any? Is science a topic to experience or facts to memorize? Do students mention vocabulary or difficult words in science? Do they talk about graphs, charts, or other images?

This brief activity can reveal student perceptions and misconceptions about science. Perhaps they see the textbook or any text as *the* source of information. Our students may see questions or discussion merely as a way to find out if they know a specific answer instead of a way to further their scientific understanding. Do any of them mention the importance of science to the world outside the classroom? Perhaps many of our students struggle with new words they encounter in science.

After reading through student comments, discuss the results with students and talk about goals for the class. After trying some of the ideas in this book, ask students to write their beliefs about science again and see if anything has changed in their responses. ✱

text and then assist them in navigating images so that they can use the information they gain from the images to strengthen their scientific knowledge. Students must also critically examine images just as they do the printed word. We can provide them the opportunities to practice these crucial skills.

Overwhelming Amount of Scientific Information

With the click of a computer key, our students can view an overwhelming amount of scientific information, but there is no guarantee that they are critical consumers of the information they encounter. We may find that our students

merely soak in what they find on the Internet without giving a lot of thought to whether the information is accurate or not.

What Does This Mean for You?

We must teach students to question what they read now more than ever before. While the Internet requires additional literacy skills that are not necessary with reading traditional text, such as the ability to search and navigate websites, a lot of the literacy skills necessary for students to comprehend digital resources are basic literacy skills we all need to focus on with our students. Some in the educational field raise the concern that we often don't ask students to question the information they encounter in text, *period* (Thompson 2011). So while technology helps to remind us that students must be critical of what they read, this is an important skill for all scientific information students encounter, regardless of the source.

Before Moving On

As you think about the eight challenges in this chapter, you'll see a common thread that ties the challenges together. That thread is literacy. As teachers of science, we must use literacy skills to help meet our students' diverse needs and to deepen their scientific understanding. Our students will be able to better access science information if we engage them with diverse texts, work on building scientific vocabulary, focus on comprehension, and provide them with the knowledge necessary to intelligently engage with images in the science classroom. The standards we strive to meet acknowledge that thread and support our mission for strengthening our students' science knowledge through addressing literacy skills. The remaining chapters in this book will help you to meet these challenges and use literacy skills to strengthen your students' science knowledge. We'll begin in Chapter 2 by looking at the scientific texts we use.