Table of Contents

Reproducible titles are in italics.

CHAPTER 3

CHAPTER 4

CHAPTER 5

APPENDIX

Introduction

Teaching primary school students is both demanding and exciting. It involves making numerous daily decisions about curriculum, differentiation, classroom management and assessment. You are perhaps being asked to also accommodate the recommendations of the recently published Australian Curriculum: Science, integrating it with English literacy and learning. As you prepare for this, do you sometimes feel that science teaching is one of your weaker areas, and although you invite your students to dabble in experimentation, are you unsure of how to help them augment their scientific understandings and then argue their positions? As a result of our own work in classrooms, we have realised the need to address these questions in support of our colleagues – educators like you – who are attempting to nurture rather than squelch the scientific curiosity of their students.

Teaching Students to Think like Scientists is a direct response to these questions. Specifically, this book shares ways to integrate science and literacy – ways that draw on many well-known instructional strategies as well as new methods to engage students in the language and practices of scientists. Science, engineering and technology are intimately connected in real-world practices. These areas of study hold the keys to future research and development that will likely maintain and sustain progress on a global level. Cures for diseases, new devices and novel methods for living on and protecting our planet are all dependent on a generation of young people who understand the founding principles of science, engineering and technology. However, our workforce lacks fundamental knowledge in these areas of study.

Although the Australian Curriculum offers year-level science and literacy goals, most teachers and parents will agree that students learn in stages that cannot be precisely associated with a given year level. We do, however, know that when teachers offer students exciting learning challenges coupled with sound instructional practices, they will become agents for their own learning. The classroom scenarios we share in this book provide exemplars of students who, while ready at different times, are creating new science and literacy understandings.

This book is intended to help you use all that you know about literacy from teaching humanities subjects such as English to support your students in learning to read, write and communicate about science. It is intended to help you guide students as they consider critical criteria in written, graphical, oral or digital forms. In the 21st century, people are making decisions every day regarding which mobile phone to invest in for the next couple of years, which food products to consume or which candidate to support when going to vote. They may one day need to know how to evaluate treatments for diabetes or heart disease or to make important decisions about energy use. These issues require that everyday citizens be capable of reading, analysing and evaluating issues in logical, strategic ways. It is through dialogue and oral language that students learn how to use data to discuss and argue an issue and come to mindful conclusions. Informed problem solving rooted in scientific inquiry thinking is the ultimate underpinning of this book.

It's a pivotal time for primary school educators – a time of transformation and change, particularly when it comes to teaching science. Experts in the area of science education agree that science instruction should no longer consist of a series of teacher- or text-delivered facts that students memorise and recite in thought-devoid ways (Bybee, 2011; Minner, Levy & Century, 2010; Reiser, Berland & Kenyon, 2012). Instead, science instruction must present opportunities for students to engage with the science they see and experience in their world. In the lesson scenarios we share, F–6 teachers implement science instruction that helps students to talk, write, read and think like scientists. Throughout, we will note connections to relevant content descriptions and elaborations from the Australian Curriculum: Science and English. (Visit **go.hbe.com.au** to find additional scenarios, download the reproducibles and access the links in this book.)

Reading This Book

Chapter 1 suggests using all you know about teaching English literacy to support classroom science instruction. Chapters 2 through 4, on speaking and listening, writing and reading instruction, offer year-level scenarios that include implementation activities, lesson ideas and instructional practices that fit in with curricular science content.

The F–6 scenarios in chapters 2, 3 and 4, organised as stand-alones, provide virtual opportunities to explore real-world classroom instruction that can be adapted to your own classrooms. We also include in each of the chapters "Questions for Discussion or Reflection" that you can use to individually reflect on teaching and learning or as a way for small professional development groups to debrief and brainstorm ideas for implementation and extension. These three chapters flow from oral language to writing to reading – with the science content and science practices intertwined.

Table I.1 shows the breakdown of the scenarios in these three chapters according to year level and topic covered.

Table I.1. Year Level and Topic of Lesson Scenarios in Chapters 2–4

Chapter	Year	Topic
2	F	Understand that plants need water, minerals and sunlight.
2	1	Discuss the phases of the moon and patterns that result from the position of the sun, Earth and moon.
2	2	Identify forces, motion and types of interaction.
2	3	Understand that some changes caused by heating and cooling can be reversed and some cannot.
2	4	Describe how the process of weathering and erosion affect the surface of the Earth.
2	5	Explain how to solve an animal habitat problem.
2	6	Explain relationships between plate boundaries and earthquakes and volcanoes.
3	F/1	Describe the characteristics of animals, like our pets.
3	1	Explain the cause of sound.
3	2	Describe the life cycle of a frog.
3	3	Understand the places on Earth where water is solid and where it is liquid.
3	4	Comprehend the causes of waves.
3	5	Conduct an inquiry-based investigation in an academic format.
3	6	Explore real-world issues of human impact on the environment.
4	F	Identify how weather changes over time.
4	1	Explain how light moves through different objects.
4	2	Determine the different ways in which people use water.
4	3	Identify common elements of the life cycle of organisms.
4	4	Ask questions about how matter is cycled and how energy flows from living and nonliving organisms through a habitat.
4	5	Design experiments that answer questions about phase changes.
4	6	Design and construct a circuit.

In chapter 5, we identify and discuss effective formative assessment practices based on the scenarios in chapters 2–4. Finally, the appendix contains reproducible pages, which may also be found online (at **go.hbe.com.au)**.

Because primary school educators are already well versed in teaching reading, writing, speaking and listening, and language, we have used these literacy processes as the fundamental elements of this book. We believe that the integration of science and inquiry learning coupled with these literacy processes will seem like a natural, attainable and thoroughly fun way for young people to learn about their world. It is our hope that practising teachers and those preparing to be teachers will implement the ideas in this text as a means to empower their students with the cognitive tools needed to explore, examine, know and explain our natural world; generate and evaluate evidence; understand and construct scientific information; and participate productively in communicating and creating knowledge about our planet. With mental tools like these, young people can move towards a future in which they participate in an imaginative, well-connected, knowledgeable science community.

Core Science Ideas and Practices

One goal of this book is to identify the core ideas and practices that all students should achieve by the time they complete secondary school. This framework defines knowledge and real-world applications that students should amass during their F–12 years in order to be scientifically literate on graduation from secondary school. The identification of core ideas relates to the content or concepts one should know in an area of science, while practices relate to one's *use* of those ideas.

The core ideas or concepts discussed here are drawn from the four areas of science identified in the Australian Curriculum: Science – biological sciences, chemical sciences, Earth and space sciences, and physical sciences – and include the applications or practices of these concepts as they are scaffolded across the years. For example, in the physical sciences, the concepts involving matter and its interactions would be explored through the following eight key activities, which, according to Rodger Bybee (2011), represent an integration of scientific and engineering practices:

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations

4. Analysing and interpreting data
5. Using many resources from maths, technology and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating and communicating findings.

How could these eight practices apply to areas of science? In biological sciences, students making real-world observations of the life cycles of frogs and butterflies could document these observations in the form of field notes and sketches. They could then design an experiment to test the questions they formulated. Another group might conduct internet research to determine what other experts have learned from similar studies. Consider all of the knowledge that students would acquire as they explore scientific ideas through other disciplines, such as geography. And consider the skills based on inquiry that students would develop through such study. Students would likely cultivate problem-solving skills that could extend into other aspects of their lives. They might hone an inquisitive, critical-thinking mindset that propels them to ask questions and seek out answers based on evidence. Along the way, they are building fundamental science knowledge that will help them make personal decisions about their lives, their environment and planet Earth.

In physical sciences, students might spend time observing free fall as they drop various objects (paper, tennis balls, flat pieces of cardboard and so on) from different heights. Using their observational notes, they could work with a partner to come up with an explanation for the varying speeds of falling objects, and just like true scientists, these students could initiate ideas about air resistance and free fall. Their conjectures and wonderings could lead them to research regarding free fall in empty space (a vacuum). Then, mirroring the astronauts of *Apollo* 15, they might try to determine ways to test these ideas (visit **go.hbe.com.au** for a YouTube video of *Apollo* 15 footage). In Earth and space sciences, students learning about fossils might work in groups to correlate rocks and fossil species with geological eras. Using such data, they could forecast Earth events and determine the age of rocks, just like real geologists.

The concept of *inquiry* plays a crucial role in the Australian Curriculum: Science, to the extent that Science Inquiry Skills makes up one of its three interrelated strands.

> Science inquiry involves identifying and posing questions; planning, conducting and reflecting on investigations; processing, analysing and interpreting evidence; and communicating findings. This strand is concerned with evaluating claims, investigating ideas, solving problems, drawing valid conclusions and developing evidence-based arguments. (ACARA, 2013)

Recent research further elaborates on the concept of *inquiry instruction*, recommending that teachers:

- Guide students to learn how to develop scientific investigations that address questions
- Use appropriate investigative steps
- Reflect on how science is done
- Utilise data collection and analyses to change perceptions about the world
- Act in a sceptical manner when assessing science work
- Seek out explanations based on logical understandings of data (NSTA, 2004).

While we all can likely acknowledge that instruction founded on this kind of practice is good science instruction, the means by which to accomplish inquiry thinking and investigation are sometimes elusive. One way to approximate aspects of inquiry instruction is to apply the 5Es: *engage*, *explore*, *explain*, *elaborate* and *evaluate*. With this often-adopted method of teaching science, students begin with an *engage* activity – one that fosters questioning, the articulation of problems to be studied and the use of models. The *explore* phase involves students planning and carrying out investigations. This is followed up by the *explain* part of the process. At this point, students analyse and interpret data. They may use mathematical information, computer technology and computational thinking, and they construct explanations in attempts to design solutions. When they *elaborate*, they extend the discussion of the data and perhaps develop a conclusion or evidence-based argument drawn from the data. Finally, when students *evaluate*, they make informed judgements and communicate their information.

Teachers can introduce students in the early years to scientific concepts using pictures, diagrams and models of animals, flowers, trees, bicycles, cars, aeroplanes, stars and so on. With graduated instruction, teachers can expose upper-year students to models with more mathematical, computational and conceptual sophistication. The expectation for students at all year levels is that they will be able to understand the concepts well enough to analyse and manipulate data in order to formulate explanations, propose solutions and identify new questions to study. The concept of *inquiry instruction* will be woven through this text at all year levels as a means to foster both independent and collaborative critical thinking. These investigations and activities do not necessarily have predetermined outcomes. Rather, in following an investigation, students examine data and draw their own conclusions.

Connecting Science Literacy and English Literacy

Literacy is one of seven general capabilities spanning across all subject areas in the Australian Curriculum, which encourages F–12 students to become literate individuals prepared "to interpret and use language confidently for learning and communicating in and out of school and for participating effectively in society." No longer confined to the humanities alone, literacy is instead recognised as "an essential skill for students in becoming successful learners and as a foundation for success in all learning areas" (ACARA, 2013). This approach has clear implications for the conventional practice of teaching literacy as a subset of the English curriculum, so we suggest some useful pedagogical shifts designed to relate English literacy instruction to literacy in other disciplines.

1. Balancing informational and literary text: For primary school educators, this means a move towards more non-fiction, which has previously been relegated to only a small part of the instructional time in most teachers' classrooms.
2. Building knowledge in the disciplines: This shift emphasises building knowledge about the world through text in content-area studies.
3. Increasing text complexity: This shift underscores the requirement that students read year-appropriate text centred on a *staircase* of instruction, gradually increasing in complexity from beginning to advanced levels. Teachers guide students to accomplish this by providing the support and time needed to focus on close reading.
4. Using text-based answers: This shift underscores the need for students to engage in rich, rigorous conversations rooted in evidence gleaned from text.