TEACHING THE LANGUAGE OF

climate change science

Julie Hayes
&
Bronwyn Parkin

PETAA
PRIMARY ENGLISH TEACHING ASSOCIATION AUSTRALIA
CONTINUAL PROFESSIONAL GROWTH

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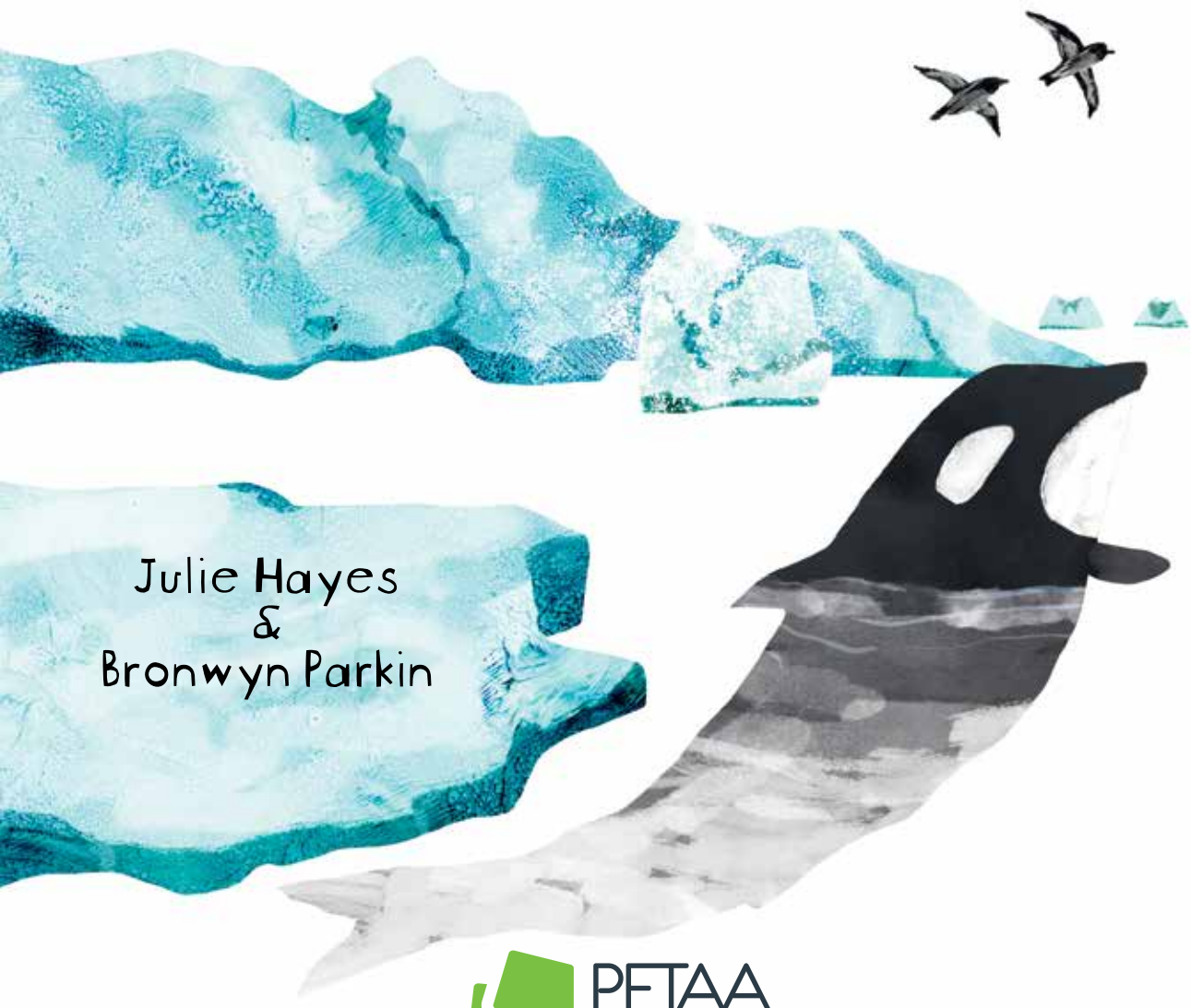

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In the spirit of reconciliation the authors and editor of this book acknowledge the Traditional Custodians of country throughout Australia and their connections to land, sea and community.

We pay our respect to their elders past and present and extend that respect to all Aboriginal and Torres Strait Islander peoples today.

FOREWORD

Climate change education: tackling a multi-generational commitment

We get a glimpse of the deep background that gives this book momentum and significance in this blunt reminder from the peak international climate research group IPCC, directed at policy makers:

> Most aspects of climate change will persist for many centuries even if emissions of CO_2 are stopped. This represents a substantial multi-century climate change commitment created by past, present and future emissions of CO_2. (IPCC 2013:27)

This commitment is aimed at educators as well as policy makers. Each generation needs to become better equipped and coordinated, more focused and dogged than the last. In democracies, policy initiatives grip only with the support of the electorate, so the work of schooling is deeply implicated here. On the question of climate, the knowledge, attitudes and actions of many Australian youngsters over their adult years will be built on the understandings developed with their teachers' and parents' help.

About 40 years before IPCC's observation, participants at a UNESCO workshop on environmental education in Belgrade articulated a 'charter':

> Governments and policy-makers can order changes … but all of these are no more than short-term solutions, unless the youth of the world receives a new kind of education. (UNESCO 1975:2)

A major review of empirical research on educational efforts in climate change, conducted 44 years later, reached a similar conclusion:

> The challenges of climate change education suggest that the type of education we have always done may not be sufficient to engage learners in … how they think and question the justification for their ideas. (Monroe et al. 2019:805)

For the most part, policy responses have been vague, varied, hesitant and, generally, leisurely. Australian environmental educators, however, have developed quality educational resources that support climate-related learning (including professional associations, for example, the Australian Association for Environmental Education, and the Climate Change

Education Network). Australian education bureaus have also responded. Most prominently, at the time of writing, the national curriculum has 'Sustainability' as a cross-curriculum priority, and it is ambitious: students will 'explore the interdependent and dynamic nature of systems that support all life on Earth', address 'a diversity of world views on ecosystems, values and social justice' and build 'the capacities for thinking and acting in ways that are necessary to create a more sustainable future' (all quotations from ACARA 2021).

Every learning area needs to address these aims, but for teachers of English, the aspirations are startling: students will 'develop the skills necessary to investigate, analyse and communicate ideas and information related to sustainability, and to advocate, generate and evaluate actions for sustainable futures' (ACARA 2021).

So aspirations and resources have emerged that could support the Belgrade Charter. Programmatic, actionable curricular responses, however, have been less frequent and less convincing, and it is here that Julie Hayes and Bronwyn Parkin make their case for refitting the early and middle years of schooling. Their working assumption is that it is only via a coherent, cumulative trajectory of learning that policy aspirations and quality resources can be organised into a program.

This book draws on the Literacy component of the national English curriculum to make a distinctive contribution. The authors also build on foundational research by Christie and Derewianka (2008) to map the developing reading and writing demands implicated in the Sustainability priority: from commonsense knowledge expressed in spoken language forms, with statements of personal preference, moving gradually and purposefully towards 'uncommonsense' knowledge expressed in specialised language, abstraction, generalisation, with structured argumentation, judgement and opinion.

This is a language-focused framework for building a nine-year program for a complex, evolving body of knowledge about, and attitudes to, climate change. The attitudes matter here, as the review of research findings by Monroe et al. (2019) showed. The research they reviewed points to optimism and agency as key components of effective teaching and learning – as Hayes and Parkin put it in this book, 'positive attitudes towards the planet: appreciation and respect … and importantly … a sense of responsibility … that lead[s] to action.' The overt progression Hayes and Parkin describe provides a working platform not only for guiding and consolidating learners' understandings, but also for productive cross-curriculum teamwork, and for teacher development.

Hayes and Parkin are exceptionally well placed to take on this complex and contentious task. Together they bring histories of academic expertise in applied linguistics and scientific literacy, the practicalities of teaching in preschools, schools and universities, and the institutional sure-footedness of school leadership and policy advising. Their combined professional track record spans about 65 years, and they have worked with learners from First Nations, migrant, refugee and low socio-economic backgrounds. They have scanned the field of climate studies education – its key scientific claims, its lexical, grammatical and textual conventions, its forms of interpreting and justifying, and its operational practicalities across a range of learners and across the school years.

Around the time I began my studies in education, I read Patrick White's novel *Riders in the chariot*. One of the 'visionaries' in this novel is the taciturn washerwoman Mrs Godbold. She has six daughters, and she 'envisions' them as arrows:

> … she had shot her arrows at the face of darkness, and halted it. And wherever her arrows struck, she saw other arrows breed. And out of those arrows, others still would split off from the straight white shafts (1961/2014:548–9).

Mrs Godbold didn't know where her arrows would strike, or which ones would 'split off,' but her vision reassures her that, over time, those arrows would stop the darkness. It occurred to me, even back then, that 'firing arrows at the face of darkness' is not a bad metaphor for education.

Hayes and Parkin have written a book for this moment, with an actionable theoretical structure that can support its aspirations. Their work reminds us that, to halt the darkness, teachers regularly need to – and can – clarify, replenish and reimagine their resources and, through this process, reassert their decisive role in the multi-generational commitment.

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HOW TO USE THIS BOOK

Icons

Icons are included in the margins throughout the book to flag the following:

This icon indicates a literacy or writing activity.

This icon introduces an activity related to diagrams.

This icon flags a call to action or practical activity.

Online resources

Go to www.petaa.edu.au/Climate-Change-Science-Extras to find digital versions of several supporting documents. You will find the following:

- text analyses (chapters 3–8)
- a reference list with those references that have web links
- diagram: making paper from trees (chapter 5)
- diagram: recycling paper (chapter 5)
- diagram: enhanced greenhouse gas effect (chapter 7)
- diagram: the albedo effect: reflection from different surfaces (chapter 7)
- diagram: how a hydro-powered turbine works (chapter 8)
- understanding paragraphs in factual texts (chapter 8)
- two Year 8 science assessment tasks (chapter 8)
- a list of *Recommended books to support teaching about climate change and sustainability (for Early Years and Primary years students) March 2021* by Vicki Newton

Photo acknowledgements

We thank the many photographers and creators for the use of their photos and diagrams. They are credited in the figure captions. Unless mentioned otherwise in the figure captions, photos are the authors'.

Chapter 1

WHY TEACH ABOUT CLIMATE CHANGE?

Rationale for a climate change progression

Climate change is already impacting Earth, making some places hotter and drier and other places wetter and more likely to experience severe storms. The excess greenhouse gases humans have put into the atmosphere have warmed the oceans, changed weather patterns and caused serious damage to ecosystems such as coral reefs. The poles have warmed disproportionately and, as a consequence, ice is disappearing and vital food chains are disrupted.

As teachers we know this and want to address the issues of climate change in a systematic way with our students. We don't want to alarm students, but knowing the science behind climate change isn't alarming, it's empowering. Only with accurate information about the causes and impacts of climate change can students begin to make evidence-based decisions, and take informed action to reduce their carbon footprint and care for the environment.

The elaborated teaching and learning progression offered in this book aims to support teachers and students in making the links between science and climate change at an appropriate level of understanding for each year level. Particular science descriptors and elaborations from the Australian Curriculum have been selected for their relevance to climate change.

The sequence provides a language-focused, logical and coherent teaching and learning progression in science across the early years and primary years of schooling. The focus is on the language, knowledge, understanding and attitudes that students need to become articulate and active in mitigating the effects of climate change.[1] The teaching and learning progression was developed by educators from the Primary English Teaching Association of Australia (PETAA) in consultation with an advisory group made up of representatives from science teachers' associations and academics from a number of universities (see p. x).

Factors other than climate change – such as overpopulation, land clearing, overfishing, extracting too much water from rivers and aquifers, and misusing pesticides – have led to environmental degradation. These factors are important areas of learning for sustainability. However, the focus in this book is more narrowly on the causes and consequences of

1 The climate change to which this book refers is attributed by scientists to the additional trapping of heat in the atmosphere. The IPCC (2014) concludes a 95% probability that this is due to the emission of greenhouse gases from human activity. It is thus known as 'human-induced climate change'. For the sake of brevity, this has been abbreviated to 'climate change' in most mentions in this book.

climate change. In this way, this book can give time and close attention to developing useful language for teachers to mediate learning.

The progression is not just about developing scientific knowledge. The three pillars of the Sustainability cross-curriculum priority – Systems, World Views and Futures – provide the imperative for two further essential responses. Firstly, the development of positive attitudes towards the planet: appreciation and respect for Earth's ecosystems. Secondly and importantly, this book aims to develop a sense of responsibility, critical thinking and a willingness to make decisions that lead to action. In addition, the book aims to foster respect for and trust in the rigour of the processes used by the scientific community to gather evidence; to provide reliable information; and to explore and discover ways that people can slow down climate change so that the planet and all that is living on it survives and thrives.

The work of scientists is beginning to alert us to the fact that we are highly dependent on the biodiversity of the natural world. Biodiversity helps with nutrient and water cycles, crop pollination, control of diseases, and the production of medicines, food and fibres. Climate change threatens the biodiversity on our planet.

The progression begins at Preschool level and continues to Year 8. It supports the development of informed, articulate and active citizens, who recognise the Earth as their home, recognise the interdependence of all living things, and have the will and means to help create a sustainable future.

Why the need for this book?

An abundance of resources, both print and web-based, is available to use in teaching about climate change. However, it is sometimes difficult for primary teachers to work out which activities to use for which year levels, and the activities are often not linked to the Australian Curriculum: Science and to the Sustainability cross-curriculum priority. It is time-consuming for teachers to work out which science descriptor has implications for climate change, to find relevant resources, to choose relevant activities, and then to decide which actions for sustainability are appropriate. This book fills that gap.

While sustainability has been identified as a priority in the Australian Curriculum, it is often left to teachers to work out the links between the science curriculum, climate change and the impact of human activity at a level appropriate for their class. Although climate is not explicitly mentioned in the science curriculum content descriptions until Year 10, a deep understanding of how our actions and use of Earth's resources affect the environment and living things can be developed through all the science strands. This book shows teachers how science topics can be taught with a systematic emphasis on developing stewardship, responsibility and care for our planet and the environment.

Why PETAA?

For almost 50 years, PETAA has provided books and professional learning that offer practical help to classroom teachers. Knowing that learning is mediated and developed through oral and written language, this PETAA publication includes model science texts, which we call focus texts, that exemplify the language students need to use in order to talk and write like scientists. The language, of course, holds the scientific concepts, and the concepts are developed through language.

The focus texts are both the starting point and the end point of this approach to science teaching. They guide the kinds of activities students could be involved in to understand the topics. The activities allow the teacher to share scientific knowledge using the language of the texts. The end point is for students to gain control over the language suggested in the focus texts. Chapter 2 outlines the approach in more detail, and is an important read before proceeding to the year-level activities in subsequent chapters.

PETAA, with its strong basis in literacy theory and research is well placed to support teachers in the literacy of science. The advisory group of academics and science teachers has verified the accuracy of the science content and sequence. PETAA continues to work in partnerships with others to provide practical help to primary teachers across Australia.

Who is this book for?

Any teacher of science

This book is for Preschool, primary and middle-year teachers of the Australian Curriculum: Science. It is intended for non-specialist classroom teachers as well as specialist science teachers.

Whole school

The book will help schools that want a whole-school approach to teaching about climate change or already have a whole-school approach to sustainability.

Language-focused teachers

The book supports teachers who understand or are willing to explore the power of language in learning, and who want to support their students in becoming advocates and agents for the planet.

How the book is structured

The teaching and learning progression outlined in this book is not a substitute for the mandated science program – it is part of it. The most benefit will be derived from schools wishing to address climate change by using the progression at every year level.

Chapter 2 has two purposes. Firstly, it supports teachers in understanding the role of language in learning, specifically scientific language. However, knowing what we want students to say and write isn't sufficient so, secondly, the chapter provides useful, sequential pedagogic strategies for supporting students in the development of scientific language.

Chapters 3 to 8 are all year-level focused. Each chapter is structured in the following order:

- A brief introduction to the concepts and language intended for climate change science in this year level or levels.
- The relevant achievement standards.
- The science descriptors and topics relevant to climate change science, and the implications for sustainability, divided into the subsections of biological science, Earth science, chemical science and physical science.
- For each topic, a focus text that summarises the conceptual and language learning intended, in the order intended.
- For each topic, key messages relevant to climate change that we need to convey and that students begin to own.
- For each topic, suggested orienting activities and an inquiry, sequenced in a consistent way that can lead to student language development.

Science as a human endeavour has been embedded in the texts and activities as they repeatedly confirm the ongoing contributions of scientists to our understanding of how the world works. Students are encouraged to trust the evidence that a rigorous, scientific process provides, and to use reliable sources for their science information.

(The scientific method is systematically developed throughout the Australian Curriculum: Science. This book does not repeat that detail. Teachers already have the information at hand in the Australian Curriculum and state syllabi.)

Chapter 9 is a call for action. Without students taking personal action to mitigate climate change, there is no point to this book. The aim is for student actions to be backed up by their scientific knowledge. This book does not want to duplicate the plethora of sustainable action resources already available. Instead, the suggested sustainability actions logically follow from scientific study and are appropriate to the age group. This means that actions that begin in the Early Years as socially motivated become increasingly backed by scientific understanding. Students deepen their sense of responsibility to influence others, and the spheres of influence become wider as the year levels progress, moving from the personal to the political.

Action as antidote for anxiety

Feeling powerless and overwhelmed is not helpful in the face of our changing climate (Ojala 2016). The advisory group and the authors of this book have been mindful of setting learning and action goals appropriate for each year level, and not concentrating on issues that are outside the students' sphere of action. By taking the actions for sustainability suggested, following each of the topics, students are encouraged to take control of the things that are within their power.

Key messages

For citizens to understand climate change and its impact on living things, the following are the key messages that gradually unfold across the year levels through the science curriculum.

Biological sciences

- All living things are interdependent. We rely on each other. When habitats are affected, species die and food chains are interrupted. This affects us all. Humans are only one species of animal, but our overuse of the Earth's resources makes us the biggest danger to all other living things.
- Our key responses to climate change are mitigation (reducing the severity of climate change) and adaptation. In the 2015 Paris Agreement, 196 countries agreed to limit the temperature increase below 1.5 degrees, in order that living things could continue to not only survive but thrive.
- Adaptation occurs over generations and, for many living things, may not happen quickly enough to keep up with the changing climate. Humans have the capacity to adapt using technologies that are continually being developed.
- Climate change is one of the factors threatening biodiversity on our planet. Biodiversity plays a vital role in sustaining ecosystems around the globe. We depend on these ecosystems to provide our food, water, clothing, medicine and materials needed to build and make things.

Earth sciences

- We live on one planet, made up of land, oceans and the atmosphere. We share the one atmosphere and the one ocean.
- The Earth system is very sensitive to the amount of heat energy we put into the atmosphere and ocean, with far-reaching impacts on living systems.
- Human activities are producing carbon dioxide (CO_2), other greenhouse gases and atmospheric pollution. The greenhouse gases are accumulating in the atmosphere and act as a blanket to trap energy that heats up the planet (DAWE 2020).
- The use of fossil fuels – coal, gas and oil – is the main cause of this heating (NASA 2020a). We have to find cleaner ways of producing goods and services with energy sources that don't heat up the planet. There are solutions but it will take effort to change our habits.
- The polar regions influence the Earth's weather patterns and act as 'canaries in the coal mine' for our warming planet (Borgå 2019).
- The oceans have absorbed about 90% of the heat from the enhanced greenhouse effect and this is changing weather, habitats, ocean currents and sea levels. Even if we stop putting greenhouse gases into the atmosphere now, the oceans will continue to release the accumulated heat over coming generations (Gray 2017).

Chemical sciences

- All objects are made of materials, which are finite resources of our planet, whether they come from living or non-living things. We need to respect and look after them.
- Some materials come from renewable sources and some come from non-renewable sources. A material familiar to students – and something they can act on – is plastics, which are made from oil. Some materials are recyclable and others are not, ending up in landfill or in the oceans. The most important action is to reduce our use of materials, followed by re-use and finally recycle.
- The transfer of additional heat around the planet from the use of fossil fuels is leading to changes in weather and climate, including increased heat, increased cold in some places and extreme weather events, which affect all parts of the globe (NASA 2020a).
- Greenhouse gases are created by chemical reactions that occur in the environment (when soil microbes in rotting vegetation release gases) and within animals (during gut fermentation in cattle).

Physical sciences

- Almost all of the Earth's energy comes from the sun. The energy system is a closed system.
- The greenhouse effect is a natural phenomenon that has kept Earth at a habitable temperature for a very long time.
- When fossil fuels are unearthed and burnt to make electricity and fuel, the additional greenhouse gases that are released trap heat in our atmosphere and upset the system that has existed for thousands of years.
- We have to find ways of generating energy that are sustainable and do not pollute or produce greenhouse gases.

Science as a human endeavour

- Scientists have been observing changes in climate over decades and there is a clear consensus that these changes are life-threatening phenomena.
- We can trust that scientists are always adding to and modifying their understanding of climate change and are working hard to mitigate, manage and adapt to a changing climate.
- Our role as citizens is to act in ways that mitigate climate change: to change our own habits of energy use and consumption, and to convince those around us to do the same.

Sources of information

A number of teacher information sources are recommended to provide reliable information about climate change.

- NASA (NASA 2020a) has a seemingly inexhaustible list of resources that are well written and easily accessible. Their images are amazing and, because of a US federal agreement, they are available for everyone worldwide to use.
- The Intergovernmental Panel on Climate Change (IPCC; UN 2020) offers data to inform governmental policy decisions. It arguably presents the most peer-reviewed, authoritative position on climate change. Their reports are hard to read so an alternative is to read reputable journals that use IPCC data and recommendations.
- The highly regarded Australian institution CSIRO is a good source for information on how climate change is affecting Australia specifically. *State of the climate 2020* (BOM and CSIRO 2020) is recommended.
- For weather information and predictions, the Bureau of Meteorology (BOM) is the best local source.

Reliable student-level resources are also sometimes difficult to find. This book has used the following as much as possible:

- The **Australian Museum** (Australian Museum 2021) 'Climate change resources' page has many articles and links relevant to topics in this book.
- *Climate Kids* (NASA 2020b).
- *National Geographic Kids* (NGS 2020) has great images and text about climate change topics.
- *Primary Connections* (AAS 2007) offers a sequence of carefully thought-through science topics.
- *YouTube* has thousands of videos on the topics in this book. They can be a great resource and effectively demonstrate concepts. Be aware that many are class projects developed by students or by teachers during COVID-19 lockdown. Many videos are of dubious reliability and are not referenced. These videos have been used with caution, and information cross-checked against more reliable sources. Often, turning off the sound is recommended, just using the visuals. In this way, teachers can provide the targeted language they want, at the pace they want.

Figure 1.1 Antarctica. Photo: Ralph, Adobe Stock

What teachers think about this way of teaching

Students are concerned about climate change, and giving them the language gives them the knowledge to talk about it in an informed manner.

The science can be technical and overwhelming, so teaching it in a systematic way keeps the scientific language accurate but accessible.

The teaching sequence enables students to make the connections from abstract to concrete more readily so the learning is meaningful.

You can never underestimate the value of modelling to students how to note take from a scientific source (e.g. video/diagram/demonstration) and use those notes to create their own original text.

The climate change science project supported me to create a cohesive teaching and learning sequence. I systematically used the context to teach powerful language choices, and the language to teach the content. It also highlighted the power of imitation in learning.

I learned that the curriculum intentions are realised through the interrelationship of language and activity.

It was wonderful! I use the approach all the time now.

I have really found it useful to take notes and reconstruct sentences from the notes. The notes record the most important thing and that's often the way to start a sentence. Using the notes helps me to jointly construct text and help students to write extended texts.

Using a focus text and a set teaching sequence helps refine and organise key elements of the science curriculum so that planning, teaching and learning are deep and meaningful.

Using a focus text and this teaching sequence gives students the opportunity to move from the concrete to more technical scientific language by giving them many opportunities to understand and use these terms.

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