CHAPTER FOUR

CONTEMPORARY SCIENCE CURRICULA IN AUSTRALIAN SCHOOLS

GOALS

The goals for this chapter are to support you to:

- Understand the importance of school science education in Australia and the role curriculum can play in this vision;
- Understand the purpose of science curriculum documents and how they can inform practice at a planning level; and
- Be familiar with the rationale, scope and sequence of the Australian curriculum in science including the opportunities afforded science education by the general capabilities and cross-curriculum priorities.

Australian Professional Standards for Teachers – Graduate level

- Standard 2: Know the content and how to teach it (Focus areas 2.1, 2.3, 2.5, 2.6)
- Standard 3: Plan for and implement effective teaching and learning (Focus area 3.2)

INTRODUCTION

A quality education in science is a crucial outcome of schooling. All young people need a deep understanding of how the practice of science enables humans to make sense of the world around them. The knowledge produced by science allows us to solve problems and make informed, evidence-based judgements to improve our lives and that of others. For example, our understanding of science allows us to develop drugs to treat diseases, build telescopes to search the outermost parts of the Universe, predict weather patterns and explain why certain chemicals react with each other in predictable ways. Many of the global problems facing humanity (e.g., climate change, food and energy shortages) require science and technology-based solutions.

There are two key purposes of school science education in Australia. The first is to provide future scientists with a firm grounding in scientific concepts, skills and attitudes so that they have the background to continue with science study beyond the compulsory years of schooling. The second and arguably the most important purpose is to develop scientific literacy in all young people. Science teaching should promote the development of scientific literacy and assist students in the process of actively making informed decisions about science-based issues impacting on them at a public and on personal levels (Millar, 2006)

If we consider that our young people will need to tackle a range of future issues at local, national and global levels, then it is crucial that the school science curriculum includes the necessary understandings, skills and values and be implemented in an engaging and inclusive way to enable their development as scientifically aware and literate citizens. This chapter starts by unpacking what curriculum is before examining the science curriculum specifically and how it can be used to inform science learning and teaching practices. The intention of this chapter is to provide you with details and insights into curriculum in general and the Australian science curriculum, in particular, to assist you in being able to navigate these documents effectively. Ultimately, the intention is to support you in the development and implementation of meaningful science learning experiences for your students.

WHAT IS CURRICULUM?

The type of learning offered to students is dictated through curriculum documents. Before considering Australian science curriculum documents, the term, *curriculum*, is defined and explained. A simple definition coined by Decker Walker, Emeritus Professor of Education at Harvard University is that, "the curriculum refers to the *content* and *purpose* of an educational program together with their *organisation*" (Walker, 2003, p.5). The *content* of a curriculum refers to the components or topics. In science there are typically knowledge and understanding aspects (e.g., physics, chemistry, biology, earth science and astronomy concepts), process skills (e.g., posing questions, collecting and analysing data, constructing arguments) and affective factors (e.g., valuing living organisms and scepticism). The *purpose* of the curriculum refers to the aims or objectives and is usually linked to an overarching goal of preparing the next generation of young people to achieve their full potential, live fulfilling lives and to participate fully in society. The *organisation* refers to the structure (e.g., simple to complex understandings), scope (breadth of content) and sequence (order and timing of content). The purpose, organisation and content of the Australian curriculum in science will be described in detail later in this chapter.

There are different forms of curriculum depending on the audience (Corrigan & Marangio, 2018). For example, and in brief, there is the *ideal* curriculum (underlying philosophy of the curriculum), the *formal* curriculum (mandated curriculum documents or frameworks), the *perceived* curriculum (curriculum as interpreted by teachers), the *enacted* curriculum (the teaching strategies used by teachers in the classroom), the *experiential* curriculum (learning activities experienced by students) and finally the *attained* curriculum (the actual learning by the students). Alignment across these various levels of curriculum is not always evident as the things that students actually learn can be quite different to the ideal curriculum. It is important for teachers to keep this factor in mind as they are the key people responsible for interpreting and enacting the curriculum in ways that make sense for their students as well as how it was intended.

USING SCIENCE CURRICULUM DOCUMENTS

When you commence your first job as a beginning teacher, a question uppermost in your mind is likely to be, "What do I actually teach these students?" You will most likely have a good sense of how to construct a lesson plan or sequence of lessons, but might feel uncertain about what content needs to be explored and where to access this information.

In some schools, especially larger ones, there may be well-documented teaching programs that set out a sequence of learning and teaching activities. Other schools may have little to draw upon. However, it can be difficult to pick up another teacher's program and use it without understanding why particular outcomes, learning activities or assessments are specified. It is a bit like following a knitting pattern without having a picture of the whole garment. Who knows what the final product will look like? You need to be aware of what your students might already know from primary school and what they will need to know by the time you have finished working together. The most important source of information about *what* to teach and *how* and *why* will be formal curriculum documents.

Formal curriculum documents are provided to teachers by government educational jurisdictions to help them to know *what* to teach and *why*. These documents may be supported by a syllabus which prescribes in greater detail *what* is taught and *how*. The curriculum documents help teachers to plan teaching programs and lessons, select curriculum resources, develop learning activities, and assess students' learning. Science curriculum documents provide information about the sequence, breadth and depth of science learning at each year level. Typically, scientific concepts are revisited throughout the years of schooling so that students are exposed to similar concepts in increasing complexity as they progress. Although the terminology varies, the content areas of biology, chemistry, physics and earth and space science and the process areas of laboratory skills, scientific inquiry, nature of science and the role of science in society are generally included in formal curriculum documents.

The *experiential* curriculum (i.e., the learning activities that students participate in) depends not only on the *formal* curriculum, but a number of other factors including:

- curriculum support documents provided by the education sector (e.g., government, Catholic and independent);
- curriculum resources (e.g., laboratory equipment, textbooks, science garden, animals) available at the school;
- ICT resources and support (e.g., laptops, mobile technologies);
- technical support (i.e., laboratory technicians);
- the priority given to science compared with other curriculum areas in your school and state/territory;
- time allocation (e.g., single periods, block time);
- financial budget allocated to science in the school;
- teacher background, experience, expertise and interest;
- teacher beliefs about how science should be taught;
- student factors such as achievement levels, aspirations, previous science experiences and attitudes to science; and
- community and parental expectations.

To summarise, *curriculum* provides big picture information about what to teach and why, whereas *syllabus* enables the drilling down to provide greater detail into what to teach and how. Both curriculum and syllabus documents are drawn upon to inform the development of *unit* or *program* outlines, which unpack the content to be taught and provide a learning sequence, and the creation of *lesson plans*, which provides guidance to how content is delivered on a daily basis.

THE AUSTRALIAN CURRICULUM IN SCIENCE

As of 2019, the *Australian Curriculum - Science* is fully implemented in government schools in its intended form in five of the eight states and territories – the Australian Capital Territory (ACT), the Northern Territory, Queensland, South Australia and Tasmania. The science curriculum document is available in both a paper-based and a hyperlinked web-based version (http://www.australiancurriculum.edu.au). The online version has functionality that allows users to search according to their needs (e.g. specifying particular year levels, strands of science, etc.).

While all states and territories have endorsed the Australian curriculum not all have adopted it in its entirety. The states of New South Wales, Victoria and Western Australia each have their own version of curriculum documents for teachers in their state jurisdictions to be guided respectively by:

- the New South Wales Syllabus (https://syllabus.nesa.nsw.edu.au/science/);
- Victorian Curriculum (http://victoriancurriculum.vcaa.vic.edu.au/science/introduction/rationale-and-aims); and
- Western Australian Curriculum (https://k10outline.scsa.wa.edu.au/home/teaching/curriculum-browser/science-v8).

These curricula encompass and are largely consistent with the Australian curriculum, but have been contextualised to suit the setting or draw upon agreed aspects. The Catholic and Independent education sectors in all states and territories work in a similar way by linking with the Australian curriculum in their own versions of curriculum in ways that make sense in terms of their ethos, communities and students' needs. It should be acknowledged that education settings drawing on particular philosophical approaches to learning and teaching (e.g. Montessori, International Baccalaureate) are guided by different curriculum guidelines and tend to not make direct links with the Australian curriculum.

For the purpose of this chapter and given its pivotal role in curriculum development and implementation regardless of location or jurisdiction, the *Australian Curriculum - Science* will be the focus for the remainder of this chapter. Drawing on Walker's (2003) definition of curriculum, introduced earlier in this chapter, the purpose, organisation and content of the Australian science curriculum are summarised below.

Purpose

The Australian science curriculum describes the rationale and aims of school science education from Foundation (the year prior to commencing Year 1) through to Year 12. In the rationale, science is described as a "dynamic, collaborative and creative human endeavour arising from our desire to make sense of our world through exploring the unknown, investigating universal mysteries, making predictions and solving problems" (ACARA, 2016). Linking back to the purpose of science education in schools as briefly explored in the introductory section of this chapter, this quote provides insights into the intentions of the science curriculum to support students in becoming scientifically literate. It aims to achieve this through the provision of a strong grounding in science conceptual understandings as well as scientific methodologies and the development of critical and creative thinking skills that build students' capabilities to investigate the world around them.

Arising from these intentions, there are seven aims of the science curriculum across all year levels. They are summarised as:

1. An interest in science;
2. An understanding that science explains the living and non-living world;
3. An understanding of scientific inquiry;
4. An ability to communicate scientifically to a range of audiences;
5. An ability to solve problems and make informed evidence-based decisions;
6. An understanding of historical and cultural contributions to science; and,
7. A knowledge base in biological, chemical, physics, earth and space sciences.

The way the Australian science curriculum is organised, as explored in the next section, helps to explain how these intentions are realised.

Organisation

The curriculum is organised into three interrelated *strands*: science understanding, science as a human endeavour and science inquiry skills. Together these strands unpack the understandings, knowledge and skills that learners need to develop a scientific understanding of their experiences and the world. Individually each strand has a particular purpose, which will be briefly outlined. *Science understanding* (SU) focuses on the content required to address the key ideas and skills of science and is situated within appropriate contexts for the learner (e.g. year level, needs, settings, etc.). *Science as a human endeavour* (SHE) supports students in connecting with science as a way of knowing and doing and highlights the role of decision-making and problem-solving in science, but in ways that take into account ethical and socially-responsible practices and implications. *Science inquiry skills* (SIS) (see Chapter 7) enables students to develop the thinking and procedural tools needed to move towards deeper, more meaningful science conceptual understandings, such as questioning, predicting, organising data, making sense of findings, and ways of communicating their ideas and understandings.

Each of these strands are further divided into *sub-strands*. SU has four sub-strands, SHE is divided across two areas and SIS has been broken down into five parts. The sub-strands are described in more detail in the content section below, but essentially build upon each other conceptually and in complexity across the years of schooling. It is intended that the strands are taught in an integrated way.

In addition to the strand and sub-strand structure inherent in the Australian science curriculum, there are six *overarching ideas* that are fundamental to science education, in particular, in that they highlight the key aspects of a scientific world view and bridge understanding and knowledge dimensions across the science strands and sub-strands. The overarching ideas, with a brief description of what they cover, are:

1. Patterns, order and organisation;
   Recognising patterns in the world along with ordering and organising science phenomena using meaningful scales of measurement (e.g., states of matter, the seasons, biological classification, sub-atomic particles)
2. Form and function;
   Form refers to the characteristics of an object/organism, whereas function refers to how those characteristics impact on its use (e.g., biological adaptations, atomic structures, energy and matter flow, interaction of forces)
3. Stability and change;
   Understanding that some phenomena are stable over time, while others change (e.g., relationships between organisms, chemical reactions, building and erosion of mountains, impact of force)
4. Scale and measurement;
   Articulation of time and scale is important in the development of science understanding as it provides a benchmark for comparisons (e.g., geological time, biodiversity, size of atoms, distances in space, quantum physics)
5. Matter and energy; and
   Ability to describe observations of and changes in phenomena using the terminology of matter and energy (e.g., matter recycling and energy flow, energy transfer and transformation, cellular respiration)
6. Systems.
   Making sense of phenomena (including predicting what will happen) by exploring, describing and analysing based on systems (e.g., organ systems, carbon cycle, opposing forces, chemical reactions)

In examining the organisational aspects of the curriculum in greater detail, across all learning areas of the Australian curriculum (science included), there are broad skills and behaviours that are considered important for all young people to achieve. These skills and behaviours are referred to as *general capabilities* and are embedded in the content of all curriculum areas. They are intended to provide opportunities to add richness and depth to student learning within the different key learning areas, which in this case is science. The general capabilities and examples of how they might be understood in reference to science learning and teaching are:

1. Literacy;
   E.g. interpreting media articles, presenting claims, formulating hypothesis, using technical science vocabulary accurately, and language appropriate for context and audience
2. Numeracy;
   E.g. measurement (use of formal units), representing data (tables and graphs), identifying patterns and trends in numerical data, and statistical analysis of data
3. ICT competence;
   E.g. accessing information, representing science phenomena, as a digital aid (i.e. animation and simulation), and for communicating science understanding
4. Critical and creative thinking;
   E.g. generating new or novel ideas and solutions, encouraging open-mindedness in making sense of the world, and enabling active inquiry (e.g. predicting, speculating)
5. Personal and social capability;
   E.g. taking initiative, applying scientific knowledge to daily life, displaying curiosity, questioning, and making informed decisions about issues that impact their lives
6. Ethical understanding; and
   E.g. forming and making ethical judgements, understanding integrity in science, applying ethical guidelines, and using scientific information to inform ethical decision-making processes
7. Intercultural understanding.
   E.g. contribution of different cultural perspectives to science knowledge, awareness of culturally diverse ways of making sense of the world, and demonstrating cultural sensitivity in relation to some areas of debate in science

Finally, in still thinking about curriculum organisation from a bigger picture perspective, there are three *cross-curriculum priorities* that need to be included in all learning areas including science. The inclusion of these priorities stems from the Melbourne Declaration (MCEETYA, 2008), a statement and commitment from all state and territory governments that led to a set of goals to ensure high-quality schooling for all young Australians. This included the development of a curriculum, from which the Australian curriculum arose, that is relevant, contemporary and engaging for students. From this Declaration, three key areas were identified and intended to be interwoven through the curriculum for the benefit of individuals and Australia collectively as they draw on regional, national and global components to enrich and enliven learning.

The cross-curriculum priorities in brief are:

1. Aboriginal and Torres Strait Islander histories and cultures;
   Provision of opportunities to deepen knowledge and understanding through the elements of identity and living communities by drawing on insights from the key ideas of country/place, people and culture

2. Asia and Australia's engagement with Asia; and
   Building on and extending regional connectedness by developing an understanding through three key concepts: Asia and its diversity, achievement and contributions of the peoples of Asia, and Asia-Australia engagement
3. Sustainability.
   With a focus on more sustainable patterns of living, there are three underlying conceptual areas to connect with in terms of how humans interact with each other and their environments: systems, worldviews and futures

Within each curriculum area, icons are used to indicate opportunities to develop or apply one or more of these cross-curriculum priorities as a way to enhance the learning of a particular topic or content. It is worth noting that not all content descriptors within the Australian science curriculum lend themselves to a connection with a priority area and that they are only identified when relevant. There is, however, greater opportunities to link with many, if not most, of the general capabilities on a more regular basis.

Content
Foundation to Year 10
As identified previously in this chapter, the science curriculum from Foundation to Year 10 comprises three interrelated strands of *science understanding*, *science as a human endeavour and science inquiry skills*. Each strand is further divided into sub-strands. For example, in Years 7 to 10, *science understanding* is divided into four sub-strands - biological, chemical, earth and space, and physical sciences. Table 4.1 summarises the strands and sub-strands in the Australian science curriculum.

Insert table 4.1 about here

For each year level from Foundation to Year 10 there is a *year level description*, a *year achievement standard* and a number of annotated *work samples*. These work samples provide evidence of student learning in relation to the required achievement standard and illustrate satisfactory, above satisfactory and below satisfactory student achievement. This is intended to assist teachers in making judgements about the quality of their students' achievement. There are also *content descriptions* for each of the sub-strands, which identify key conceptual understandings and knowledge. *Elaborations* associated with each content description provide further insights and examples of the content to be addressed. Although these terms may initially seem confusing, they are used consistently throughout the curriculum documents and will become familiar through regular use.

In developing and implementing quality science learning opportunities at a secondary level, it is useful to understand the science education approaches many students would have been connected with during their primary schooling. From the outset, it is important to recognise that primary teachers are educated to be generalists rather than (content) specialists as is the focus in secondary contexts. This means that their initial teacher education has equipped them to teach across all learning areas and develop significant pedagogical expertise. While primary teachers might not feel entirely confident about their levels of science knowledge at times, they have an in-depth understanding of how to foster the conditions required to promote quality science learning practices in their classrooms (Fitzgerald & Smith, 2016). These practices include developing a questioning mind, the ability to work collaboratively, gathering evidence through use of the senses, and connecting science with the students' lived experiences. Science learning in primary classrooms is often experienced through the lens of inquiry-based approaches (e.g. as used to scaffold the *Primary Connections* (AAS, 2018) resources) and connected with overarching topics or issues (e.g. sustainability, water, diversity, etc.). Making links with the community and relevant expertise (e.g. parents, scientists, researchers) to enhance what is happening in science lessons are also common practices adopted by primary teachers (Smith et al., 2018).

Years 11 and 12

In the Australian curriculum in science there are four science subjects; biology, chemistry, earth and environmental science, and physics. The content of each subject aligns closely with the current senior secondary subjects of biology, chemistry and physics as it is offered in all states and territories and earth and environmental science as offered in Western Australia and New South Wales. Psychology is taught as a science subject at Years 11 and 12 (earlier in some instances) in the Australian Capital Territory, the Northern Territory, South Australia, Tasmania, Victoria, Western Australia and, as of 2019, Queensland. Each of the subjects is divided into four units (one per semester across the two years of study) and the content is organised under the same three strands as the Foundation to Year 10 science curriculum – science understanding, science as a human endeavour and science inquiry skills. At the end of Year 12, students complete an external examination that contributes to an Australian Tertiary Admission Ranking (ATAR) for university admission.

SUMMARY OF KEY POINTS

This chapter describes the purpose of science education and argues that a quality curriculum is essential to develop the next generation of scientists and to ensure all Australians have a high level of scientific literacy. The purpose, organisation and structure of a curriculum is discussed and details of the Australian science curriculum, including aspects of the content, are described. Although the Australian curriculum documents may initially seem daunting, it is important to realise that support is available from state curriculum bodies, education sectors, professional associations and colleagues.

DISCUSSION QUESTIONS

1. Visit the website of the Australian curriculum (http://www.australiancurriculum.edu.au). Select a year level, strand, sub-strand and science content description. Look at the elaborations to assist you to identify three learning activities that you could use in teaching this part of the curriculum.
2. Consider a unit of work on human body systems to be taught in Year 9 science. What opportunities might there be to integrate some of the general capabilities into this learning experience? What connections could be made to one or more of the cross-curriculum priorities?
3. Identify a contemporary issue in your community (e.g. single-use plastics) and investigate the ways in which it might connect with the strands and sub-strands in the Australian Curriculum – Science. How might you leverage this real-world problem to create a meaningful science learning and teaching opportunity?

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Table 4.1: Strands and sub-strands in the Australian curriculum in science

	Strands		
	Science understanding	*Science as a human endeavour*	*Science inquiry skills*
Sub-strands	Biological sciences: *Living things*	Nature and development of science	Questioning and predicting
	Chemical sciences: *Composition and behaviour of substances*	Use and influence of science	Planning and conducting
	Earth and space sciences: *Earth's dynamic structure and its place in the cosmos*		Processing and analysing data and information
	Physical sciences: *Nature of forces and motion, matter and energy*		Evaluating
			Communicating