NATIONAL ASSESSMENT PROGRAM – SCIENCE LITERACY

Assessment Framework

2023

Contact details

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Contents

1. Overview

1.1. Background

The National Assessment Program assessment in Science Literacy (NAP–SL) is one of 3 national sample assessments developed and managed by the Australian Curriculum, Assessment and Reporting Authority (ACARA). Together with the NAP–Civics and Citizenship (NAP–CC) and the NAP–Information and Communication Technology Literacy (NAP–ICTL), this assessment supports measurement of progress towards the objectives outlined in the Alice Springs (Mparntwe) Education Declaration (2019). Each of these national sample assessments is conducted on a rolling 3-yearly basis and uses stratified random samples of students in Year 6 and Year 10 to monitor the extent to which Australian schooling meets the goals of the Declaration.

One of the main objectives of NAP–SL is to monitor and report trends in science literacy achievement. The assessment is an important source of information about what Australian students know, understand and can do in the context of science literacy. It seeks to measure students' cognitive competencies in science by assessing both students' science knowledge and their capacity to use this knowledge as they engage in processes of scientific inquiry.

Furthermore, NAP–SL administers a questionnaire to understand students' attitudes to, and engagement with, science as well as their science experiences both at school and outside of school. Student achievement data are complimented with this and additional background information on student demographic factors and educational context, such as NAPLAN performance, geographic location and school size are considered during sample selection. This allows for the analysis of contextual factors that influence students' educational outcomes to be considered in relation to science literacy achievement.

NAP–SL contributes to the measurement of commitments in the Alice Springs (Mparntwe) Education Declaration by measuring the science literacy of Australian students in Years 6 and 10. The Declaration has 2 interrelated *Education Goals for Young Australians*:

1. The Australian education system promotes excellence and equity
2. All young Australians become:
    - confident and creative individuals
    - successful lifelong learners
    - active and informed members of the community.

NAP–SL is designed to ensure that student progress and achievement in science literacy is measured in meaningful ways. It contributes to:

- assessment **for** learning - enabling teachers to use information about student science literacy to inform their teaching
- assessment **of** learning - assisting teachers, education leaders, parents, the community, researchers and policy makers to use evidence of student proficiency in science literacy to assess student achievement against recognised goals and standards and drive improvements in student outcomes.

The first science literacy assessment was conducted in 2003 with Year 6 students only. The assessment has been repeated with a new sample of Year 6 students every 3 years to identify trends over time. In 2015, NAP–SL transitioned to online administration, enabling the incorporation of innovative assessment approaches. In July 2016, the Education Council decided to extend NAP–SL to Year 10 students from 2018. This decision was intended to reinforce assessment of science literacy progress of Australian students, through the use of assessment at the end of primary schooling and at the end of compulsory science education. In addition, assessment at both Year 6 and Year 10 enables comparisons with international assessments and surveys that assess science literacy at these levels.

These developments, along with the publication of the Australian Curriculum: Science in 2010, necessitated the development of a new framework for assessing science literacy, which was undertaken in 2018. The updated framework for NAP–SL 2023 maintains the 2018 assessment framework but contains refined specifications for both the Year 6 and the Year 10 science literacy assessments. The NAP–SL 2023 framework draws on the new national declaration on education goals for all Australians (The Alice Springs (Mparntwe) Education Declaration), is updated to reflect recent refinements to the Foundation – Year 10 Australian Curriculum, and continues to provide the basis for an effective measure of students' science literacy over time.

1.2 What does NAP – Science Literacy measure?

NAP–SL measures science literacy as defined in the Australian Curriculum: Science: 'An ability to use scientific knowledge, understanding, and inquiry skills to identify questions, acquire new knowledge, explain science phenomena, solve problems and draw evidence-based conclusions in making sense of the world, and to recognise how understandings of the nature, development, use and influence of science help us make responsible decisions and shape our interpretations of information' (ACARA. (n.d.)).

The construct of science literacy is further informed by the rationale of the Australian Curriculum: Science (ACARA, 2023 (a)) that aims for students to develop:

- an understanding of important science concepts and processes, the practices used to develop scientific knowledge, of science's contribution to our culture and society, and its uses in our lives
- the scientific knowledge, understandings and skills to make informed decisions about local, national and global issues and to succeed in science-related careers.

In developing scientific literacy, students use critical and creative thinking skills and challenge themselves to ask questions and draw evidence-based conclusions using scientific knowledge and practices.

This construct of science literacy is consistent with recent definitions of science literacy internationally. The Programme for International Student Assessment (PISA) defines scientific literacy as 'the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen' (OECD, 2019) and requires competencies in explaining phenomena scientifically, evaluating and designing scientific enquiry, and interpreting data and evidence scientifically.

Similarly, the United States National Academies of Sciences, Engineering and Medicine define scientific literacy as the 'knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity.' (National Research Council, 1996). Aspects of science literacy are described as:

- the understanding of scientific practices (e.g. formulation and testing of hypotheses, probability/risk, causation versus correlation)
- content knowledge (e.g. knowledge of basic facts, concepts, and vocabulary)

- understanding of science as a social process (e.g. the criteria for the assignment of expertise, the role of peer review, the accumulation of accepted findings, the existence of venues for discussion and critique, and the nature of funding and conflicts of interest).

The NAP–SL student questionnaire, introduced as a student survey for Year 6 students in 2009 and expanded to include questions relevant for Year 10 students in 2018, provides descriptive information about student attitudes and their understanding of activities related to science. It also provides information about factors that influence students' science literacy proficiency. The student questionnaire gathers information about students' attitudes to, and interests in, science and their science experiences in school and non-school settings. The questionnaire also includes questions of relevance for Year 10 students, gathering information about students' perception of the importance of science and their potential intentions of pursuing careers in science, technology, engineering and mathematics (STEM)-related fields.

NAP–SL 2023 will again include a student questionnaire intended to evaluate student attitudes to science, including critical aspects such as attitudes towards the scientific community, the importance of peer review in the development of scientific knowledge, and the use of science to challenge misinformation.

1.3 Organisation of the framework

The NAP–SL 2023 Assessment Framework provides historical information about the origin and development of NAP–SL, a description of what is assessed in NAP–SL aligned with the Australian Curriculum: Science, and the structure of the assessment.

The framework includes the following chapters:

Chapter 1: **Overview** provides background information on the NAP–SL 2023 Assessment Framework.

Chapter 2: **Content Dimension** describes the content domains — the specific subject matter to be covered in the assessment.

Chapter 3: **Cognitive Dimension** describes the targeted thinking skills and intellectual processes elicited as students respond to the assessment tasks.

Chapter 4: **Item Types** describes the types of assessment items and response formats that would be required to capture the variability and complexity of student performance in relation to the dimensions discussed in chapters 2 and 3.

Chapter 5: **Assessment Structure and Reporting** outlines the design of the assessment including the student questionnaire and reporting structure.

2. Content dimension

The content dimension defines the content domains – the specific subject matter covered in the assessment. For the NAP–SL 2023 Assessment Framework, the content domains and sub-domains are organised according to the strands and sub-strands of the Australian Curriculum: Science, respectively, and guide the content to be covered in NAP–SL 2023.

The following section, *2.1 Content in the Australian Curriculum: Science*, describes each of the strands in the Australian Curriculum, including refinements to the Australian Curriculum: Science made following the 2021 cycle of curriculum review recommended by Australian Education Ministers.

Following a general description of the content of each strand is an outline of the organisation of the content for the NAP–SL Year 6 and Year 10 assessments. Content domains and the target percentages of items to be allocated to each domain are specified, based on the 2018 NAP–SL assessment framework.

2.1. Content in the Australian Curriculum: Science

The Australian Curriculum: Science has 3 interrelated strands: Science Understanding, Science as a Human Endeavour and Science Inquiry (ACARA, 2023 (a)). Each strand of the Australian Curriculum: Science is populated with content descriptions that describe at each year level what is to be taught and what students are expected to learn, including the knowledge, understanding and skills relating to the learning area of science. A set of achievement standards describe the depth of understanding and the sophistication of knowledge and skill expected of students.

2.1.1. Science Understanding

Science Understanding refers to the selection and integration of appropriate science knowledge to explain and predict phenomena, and to the application of that knowledge to new situations. Science knowledge refers to facts, concepts, principles, laws, theories and models that have been established over time.

The Science Understanding strand comprises 4 sub-strands.

Biological Sciences

The biological sciences sub-strand is concerned with understanding living things including animals, plants and microorganisms, and their interdependence and interactions within ecosystems. The core concepts developed within this sub-strand are:

- a diverse range of living things have evolved on Earth over hundreds of millions of years; this process is ongoing
- biological systems are interdependent and interact with each other and their environment
- the form and features of living things are related to the functions that their body systems perform.

Earth and Space Sciences

The earth and space sciences sub-strand is concerned with Earth's dynamic structure and its place in the cosmos. The core concepts developed within this sub-strand are:

- Earth is part of an astronomical system; interactions between Earth and celestial bodies influence the Earth system
- the Earth system comprises dynamic and interdependent systems; interactions between these systems cause continuous change over a range of scales

- all living things are connected through Earth's systems and depend on sustainability of the Earth system.

Physical Sciences

The physical sciences sub-strand is concerned with understanding the nature of forces and motion, and matter and energy. The core concepts developed within this sub-strand are:

- forces affect the motion and behaviour of objects
- energy can be transferred and transformed from one form to another and is conserved within systems.

Chemical Sciences

The chemical sciences sub-strand is concerned with understanding the composition and behaviour of substances. The core concepts developed within this sub-strand are:

- the chemical and physical properties of substances are determined by their structure at a range of scales
- substances change and new substances are produced by rearranging atoms; these changes involve energy transfer and transformation.

2.1.2. Science as a Human Endeavour

Science as a Human Endeavour refers to the nature of science, including the role of science inquiry in developing science knowledge, and the factors that affect the use and advancement of science. This strand highlights the development of science as a unique way of knowing and doing, and the role of science in contemporary decision-making and problem-solving.

The Science as a Human Endeavour strand comprises 2 sub-strands.

Nature and Development of Science

This sub-strand develops an appreciation of the unique nature of science and scientific knowledge, including that scientific knowledge is based on empirical evidence and can be modified in light of new or reinterpreted evidence. The core concepts developed within this sub-strand are:

- science inquiry values curiosity, creativity, accuracy, objectivity, perseverance and scepticism
- science knowledge is a result of individual and collaborative efforts, and advances reflect historical and global contributions
- science knowledge is built on empirical evidence; however, all science knowledge can be changed in light of new or reinterpreted evidence.

Use and Influence of Science

This sub-strand explores how science knowledge and applications affect individuals and communities, including informing their decisions and identifying responses to contemporary issues. The core concepts developed within this sub-strand are:

- scientific knowledge, practices and products are influenced by ethical, environmental, social and economic factors
- science, technology and engineering are interconnected; advances in one field can lead to advances in other fields

- science knowledge, balanced with ethical and social considerations, contributes to understanding complex contemporary issues and identifying responses.

2.1.3. Science Inquiry

Science inquiry is concerned with the diverse ways that scientists study the natural world and propose explanations based on evidence (National Research Council, 2000). This strand is concerned with investigating ideas, developing explanations, solving problems, drawing valid conclusions, evaluating claims and constructing evidence-based arguments. This strand provides opportunities for students to achieve deeper understanding of the science concepts and how scientific thinking applies to these understandings. This strand has been renamed from 'Science Inquiry Skills' to reflect that scientific inquiry involves both skill and cognitive dimensions.

The Science Inquiry strand comprises 5 sub-strands.

Questioning and Predicting

This sub-strand involves identifying and constructing investigable questions, proposing hypotheses and predicting possible outcomes. The core concepts developed within this sub-strand are:

- science inquiry involves making observations and predictions, asking questions, and constructing and testing explanations for natural and physical phenomena
- science inquiry may be done to describe a phenomenon, explore relationships, test a theory or model, or design solutions.

Planning and Conducting

This sub-strand involves making decisions about how to investigate or solve a problem and carrying out an investigation, including the generation and recording of data. The core concept developed within this sub-strand is:

- science inquiries should be designed to systematically generate or collect valid and reliable primary and secondary data in a safe, ethical and interculturally aware way.

Processing, Modelling and Analysing

This sub-strand involves analysing and representing data in meaningful and useful ways, and identifying trends, patterns and relationships in data. The core concept developed within this sub-strand is:

- mathematical thinking underpins science practices of representing objects and events, analysing data and modelling relationships.

Evaluating

This sub-strand involves considering the quality of available evidence and the merit or significance of a claim, proposition, explanation or argument with reference to that evidence. The core concept developed within this sub-strand is:

- evaluating evidence enables development of explanations, decision-making and designed solutions.

Communicating

This sub-strand involves conveying information or ideas to others in ways appropriate to the purpose and audience. The core concept developed within this sub-strand is:

- critiquing and communicating science ideas effectively is critical to advancing science and influencing environmental, social and economic futures.

2.2. NAP–SL 2023 content domains and target percentages

Table 2.1 shows the proposed content domains, sub-domains and target percentages of assessment items for domains/sub-domains for the Year 6 and Year 10 assessment. To maintain consistency with previous NAP–SL cycles, and to ensure representative distribution of domains in alignment with the Australian Curriculum: Science, the target percentages of items for NAP–SL 2023 remain similar. There will be an even distribution of items across the Science Understanding sub-domains, consistent both with the equivalent percentages of content statements in each sub-strand of the Australian Curriculum and the equivalent percentages in the previous NAP-SL assessment frameworks. The distribution of items across sub-domains of Science as a Human Endeavour and Science Inquiry content domains may vary, but will provide the coverage of all sub-domains.

Table 2.1: Target percentages for content domains and sub-domains in the Year 6 and Year 10 assessment

Content domain	Target percentage	Content sub-domain
Science Understanding	45%	Biological sciences
		Chemical sciences
		Earth and space sciences
		Physical sciences
Science as a Human Endeavour	15%	Nature and development of science
		Use and influence of science
Science Inquiry	40%	Questioning and predicting
		Planning and conducting
		Processing, modelling and analysing
		Evaluating
		Communicating

2.2.1. Year 6 assessment

The Year 6 assessment aligns with both the organisation and content of the Australian Curriculum: Science. The Year 6 assessment comprises 3 content domains that align to the 3 strands of the Australian Curriculum: Science — Science Understanding, Science as a Human Endeavour and Science Inquiry. The content of the Year 6 assessment will address the range of levels required for effective demonstration of scientific literacy across the curriculum. The content will be refined to incorporate concepts in the Science Understanding strand for Foundation to Year 5. The concepts outlined in the Science as Human Endeavour and Science Inquiry strands are described in 2-year bands and therefore concepts outlined in these strands from Foundation to Year 6 will be incorporated in the content of the Year 6 assessment.

The recommended target percentages of assessment items for the content domains in NAP–SL 2023 are broadly consistent with those of the previous NAP–SL assessments. The NAP–SL 2018 assessment framework carefully mapped the content domains to earlier NAP–SL assessments, ensuring similar coverage of content across domains. The recommended target percentages for the Science Understanding sub-domains are consistent with the equivalent percentages for the content statements in each sub-strand of the Australian Curriculum: Science, and with the equivalent sub-domain percentages in the previous NAP–SL assessment frameworks.

Items written for the Science as a Human Endeavour domain may assess applications of science to students' everyday lives and to society, or they may assess students' understanding of the nature and development of science (e.g. students' understanding of the nature of scientific predictions, tests and evidence). Science as a Human Endeavour may also serve as a context for assessment items related to the Science Understanding and Science Inquiry content domains. However, only those items that explicitly assess students' understanding related to the nature, development and applications of science will be classified explicitly within Science as a Human Endeavour.

The distribution of items across sub-domains of Science as a Human Endeavour and Science Inquiry content domains may vary from those provided in Table 2.1 but will provide coverage of all sub-domains. It is intended that the Science Inquiry items will broadly target an equal distribution of all sub-domains.

2.2.2. Year 10 assessment

The Year 10 assessment aligns with the organisation and content of the Australian Curriculum: Science. The Year 10 assessment comprises 3 content domains that align to the 3 strands of the Australian Curriculum: Science — Science Understanding, Science as a Human Endeavour and Science Inquiry. The content of the Year 10 assessment will address the range of levels required for effective demonstration of scientific literacy across the curriculum. The content will be refined to incorporate concepts in the Science Understanding strand up to Year 9. The concepts outlined in the Science as Human Endeavour and Science Inquiry strands are described in 2-year bands and therefore concepts outlined in these strands to Year 10 will be incorporated in the content of the Year 10 assessment.

The target percentages of assessment items show the recommended targets where each domain is the primary focus of the assessment, consistent with previous NAP–SL assessments. In the practice of science, the 3 strands of Science Understanding, Science as a Human Endeavour and Science Inquiry are closely integrated; the work of scientists reflects the nature and development of science, is built around scientific inquiry and seeks to respond to and influence society's needs. The strands of the Australian Curriculum: Science are intended to be implemented in an integrated manner. Similarly, the NAP–SL assessment is structured to require students to, at times, engage with a combination of domains, particularly at Year 10 when it is expected that students have developed a more sophisticated understanding of the knowledge and skills of science.

For example, in addition to items that focus explicitly on Science Inquiry, students will be engaged in science practices as they use science knowledge to respond to items and tasks classified under the Science Understanding domain, such as those that ask students to use knowledge to make predictions, construct explanations, create and use models, etc. Similarly, in addition to items that explicitly assess content on Use and Influence of Science in the Science as a Human Endeavour domain, some items within the Science Understanding domain will require students to use science knowledge by applying it to societal issues.

The expected target percentages of items for the Science Understanding sub-domains in Year 10 reflect the intent of the Australian Curriculum, which places equal emphasis on the science disciplines.

The distribution of items across sub-domains of Science as a Human Endeavour and Science Inquiry content domains may vary from those shown in Table 2.1 but will provide the coverage of all sub-domains. It is intended that the assessment items allocated to Science Inquiry will broadly target an equal distribution of all sub-domains.

2.3. Content sequences

Designing effective assessment for NAP–SL requires the articulation of content sequences for the science content outlined in the Australian Curriculum: Science that describe the essential elements of the construct(s) in sufficient detail to guide item development and illustrate how the construct(s) can be assessed at different levels of sophistication. Through a process of identifying sub-topics within the content domain, aligning content descriptions with the Australian Curriculum: Science to these sub-topics, and consultation with relevant published research regarding sequences of learning, content sequences were developed to inform item development for NAP–SL 2018.

The content sequences developed in 2018 will be used to guide item development in NAP–SL 2023 to ensure consistency with NAP–SL 2018. The content sequences and alignment to the content descriptions will be updated to reflect refinements to the Australian Curriculum: Science since the initial development in 2018. The content sequence for the Science Understanding domain is shown in Table 2.2.

Table 2.2 Content sequence for the Science Understanding domain of NAP–SL

Biological Sciences	Chemical Sciences	Earth and Space Sciences	Physical Sciences
Interdependence of life	Matter – structure, properties and changes	Earth in space	Forces and motion
Flow of matter and energy in ecosystems		Earth structure and processes	
Multi-cellular systems			
DNA and inherited characteristics		Earth's resources and geochemical cycles	Energy forms, transfer and conservation
Diversity and evolution			

The content descriptions addressed in each of the Science Understanding concepts will be refined to include only the content described in section 2.3 of this assessment framework. For example, in the assessment of content relating to DNA and inherited characteristics, content such as the following will be incorporated:

- compare characteristics of living and non-living things and examine the differences between the life cycles of plants and animals (Year 3, AC9S3U01)
- examine how particular structural features and behaviours of living things enable their survival in specific habitats (Year 5, AC9S5U01)
- describe the form and function of reproductive cells and organs in animals and plants, and analyse how the processes of sexual and asexual reproduction enable survival of the species (Year 9, AC9S9U02).

2.4. Key ideas, cross-curriculum priorities and general capabilities

2.4.1. Key ideas

The inclusion of the key ideas in the Australian Curriculum is designed to support the coherence of science understanding within and across year levels, enabling students to connect diverse phenomena and frame their deepening understanding in the context of systems thinking (ACARA, 2023 (a)).

The 6 key ideas of the Australian Curriculum: Science that represent key aspects of a scientific view of the world and bridge knowledge and understanding across the disciplines of science are:

- patterns, order and organisation
- form and function
- stability and change
- scale and measurement

- matter and energy
- systems.

These align closely with the cross-cutting concepts described by the National Research Council's 'A Framework for K-12 Science Education' (2012) (Patterns; Cause and effect: Mechanism and explanation; Scale, proportion and quantity; Systems and system models; Energy and matter: Flows, cycles and conservation; Structure and function; Stability and change).

Furthermore, the 6 key ideas of the Australian Curriculum: Science encompass the ten ideas of science (Harlen, 2015) that make explicit core ideas that can be used to explain and make predictions about a range of related phenomena in the natural world. These concepts, fundamental to an understanding of science, provide a way of connecting knowledge in a multi-disciplinary manner across the content of the Australian Curriculum: Science.

In the Australian Curriculum: Science, there are 6 key ideas that represent key aspects of a scientific view of the world and bridge knowledge and understanding across the disciplines of science:

Patterns, order and organisation

An important aspect of science is recognising patterns in the world around us, and ordering and organising phenomena at different scales. As students progress from Foundation to Year 10, they build skills and understanding that will help them to observe and describe patterns at different scales, and develop and use classifications to organise events and phenomena and make predictions.

Form and function

Many aspects of science are concerned with the relationships between form (the make-up of an aspect of an object or organism) and function (the use of that aspect). As students progress from Foundation to Year 10, they see that the functions of both living and non-living objects rely on their forms, such as the features of living things or the nature of a range of materials, and their related functions or uses.

Stability and change

Many areas of science involve the recognition, description and prediction of stability and change. Early in their schooling, students recognise that in their observations of the world around them, some properties and phenomena appear to remain stable or constant over time, whereas others change. Students become increasingly adept at quantifying change through measurement and looking for patterns of change by representing and analysing data in tables or graphs.

Scale and measurement

Quantification of time and spatial scale is critical to the development of science understanding as it enables the comparison of observations. As students progress from Foundation to Year 10, their understanding of relative sizes and rates of change develops and they are able to conceptualise events and phenomena at a wider range of scales, including working with scales beyond human experience and quantifying magnitudes, rates of change and comparisons using formal units of measurement.

Matter and energy

Many aspects of science involve identifying, describing and measuring transfers of energy and matter. As students progress through Foundation to Year 10, they become increasingly able to explain phenomena in terms of the flow of matter and energy.

Systems

Science frequently involves thinking, modelling and analysing in terms of systems in order to understand, explain and predict events and phenomena. As students progress through Foundation to Year 10, they explore, describe and analyse increasingly complex systems. Students become increasingly aware that systems can exist as components within larger systems, and that one important part of thinking about systems is identifying boundaries, inputs and outputs.

Appendix A shows examples of the Year 5 and Year 9 content descriptions from the 3 strands of the Australian Curriculum: Science mapped to the key ideas. This mapping is not exhaustive and the ability to incorporate key ideas may depend on the context underpinning assessment items. The grey shaded cells indicate where this is the case, and the context is likely to inform alignment, if any, to the key ideas.

2.4.2. Cross-curriculum priorities

The Australian Curriculum includes 3 cross-curriculum priorities: Aboriginal and Torres Strait Islander Histories and Cultures, Asia and Australia's Engagement with Asia, and Sustainability. The priorities give students the tools and language to engage with and better understand their world at national, regional and global dimensions.

Aboriginal and Torres Strait Islander Histories and Cultures

The Aboriginal and Torres Strait Islander Histories and Cultures priority refers to the opportunity for all students to deepen their knowledge of Australia by engaging with the world's oldest continuous living cultures. Aboriginal and Torres Strait Islander histories and cultures are relevant to many of the aspects of the core concepts of the Australian Curriculum: Science including knowledges, technologies, processes, contributions to science and ethical considerations.

Asia and Australia's Engagement with Asia

The Asia and Australia's Engagement with Asia priority reflects Australia's extensive engagement with Asia in social, cultural, political and economic spheres. The Asia region plays an important role in scientific research and development, including research and development in areas such as medicine, natural resource management, nanotechnologies, communication technologies and natural disaster prediction and management.

Sustainability

The Sustainability priority is fundamental to understanding the ways social, economic and environmental systems interact to support and maintain human life; appreciating and respecting the diversity of views and values that influence sustainable development and participating critically and acting creatively in determining more sustainable ways of living. Within the context of science literacy, sustainability refers to the importance of predicting possible effects of human and other activity, and to developing management plans or alternative technologies that minimise these effects.

In the NAP–SL 2023 assessment, key concepts of all cross-curriculum priorities may provide contexts for assessing specific understandings of the content domains. Sustainability may provide contexts for assessing science literacy in the disciplines of chemical, biological, physical and Earth and space systems, such as the interconnectedness of Earth's biosphere, geosphere, hydrosphere and atmosphere. Aboriginal and Torres Strait Islander Histories and Cultures may provide contexts for assessing students' science understanding, such as knowledges relating to chemistry, physics, geology, botany, zoology, physiology, genetics, meteorology, astronomy, nutrition, hydrology, ecology, and the development and use of technologies. Asia and Australia's Engagement with Asia may provide contexts for assessing students' science literacy through knowledge about diverse environments, the interactions between human activity and the environment, how these influences impact the region, including Australia and that can have global impact.

All cross-curriculum priorities may be integrated in contexts for assessing aspects of the Science as a human endeavour and Science inquiry content domains. Such contexts may include the contributions of scientists, including First Nations Peoples, to scientific research and development, and the influence of cultural perspectives and world views on individual and collaborative scientific endeavours.

2.4.3. General capabilities

The general capabilities are a significant dimension of the Australian Curriculum that encompasses the knowledge, skills, behaviours and dispositions that support students to live and work successfully. The Australian Curriculum includes 7 general capabilities that are addressed through the content of the learning areas. Aspects of all of the 7 general capabilities relevant to the assessment of science literacy, particularly the Critical and Creative Thinking capability, will be incorporated into NAP–SL 2023 as indicated below.

Critical and Creative Thinking

NAP–SL is particularly well-suited to incorporating aspects of the Critical and Creative Thinking (CCT) capability. Aspects of critical and creative thinking arise from important cognitive skills inherent in scientific inquiry and in broader scientific thinking. These elements of the Critical and Creative Thinking capability from the Australian Curriculum have guided the development of the cognitive dimension of NAP–SL 2023 assessment framework – the thinking skills and intellectual processes to be engaged in by the students as they respond to the assessment tasks (see Section 3). The key ideas for Critical and Creative Thinking are organised into 4 interrelated elements in the learning continuum, with each element consisting of a number of sub-elements. Table 2.3 shows the elements and sub-elements of the CCT learning continuum.

Table 2.3: Elements and sub-elements of the Critical and Creative Thinking learning continuum in the Australian Curriculum

Element	Sub-elements	Target percentage
Inquiring	Develop questions	20%
	Identify, process and evaluate information	
Generating	Connect ideas and create possibilities	10%
	Consider alternatives	
	Put ideas into action	
Analysing	Interpret concepts and problems	50%
	Draw conclusions and provide reasons	
	Evaluate actions and outcomes	
Reflecting	Think about thinking (metacognition)	20%
	Transfer knowledge	

Literacy

Literacy encompasses the knowledge and skills students need to access, understand, evaluate and communicate information in oral, print, visual and digital texts. Within the context of the NAP–SL, aspects of the literacy capability are found within the reading comprehension demands of both the stimuli and the questions and in the requirements of students to compose responses to questions.

Explicit definitions of terms are not part of the NAP–SL; however, vocabulary is important in science communication and the selection of science terms to be included in the assessment items will be guided by the range of terms that appear in the Australian Curriculum: Science. The Year 6 assessment will include vocabulary relating to the Science Understanding strand for Foundation to Year 5, and Foundation to Year 6 for the Science as a Human Endeavour and Science Inquiry strands. The Year 10 assessment will include vocabulary relating to the Science Understanding strand up to Year 9, and to Year 10 for the Science as a Human Endeavour and Science Inquiry strands. Where the intent of an item is to assess understanding of a science idea, then specific scientific terminology will not impede a student’s ability to respond to the item.

While literacy plays an important role in science learning and assessment, it is important that the difficulty of items does not derive primarily from the amount and the complexity of the stimulus material and instructions. The NAP–SL stimuli and items will be written to a level appropriate for the students assessed and the literacy demand of items will be monitored by expert review to ensure suitability for the students undertaking the assessment.

Numeracy

Numeracy encompasses the skills, behaviours and dispositions that students need to use mathematics in a wide range of situations. It involves students recognising and understanding the role of mathematics in the world and having the dispositions and capacities to use mathematical knowledge and skills purposefully.

In the NAP–SL assessment, students will be expected to show dispositions and capacities to use appropriate mathematical knowledge and skills. In particular, students will be required to use aspects of the numeracy learning progression, including using measurement, analysing data, identifying trends and patterns from numerical data and graphs, using mathematical relationships to calculate and predict values, and using mathematical tools to provide evidence in support of hypotheses or positions.

Items that assess predominantly numeracy skills will be avoided. If numeracy is required for understanding and responding to an item, it will be at a level appropriate to the assessment, and numeracy content in NAP–SL will be monitored by expert review.

Digital Literacy

Digital literacy refers to the ability to use digital technologies effectively and appropriately to access, create and communicate information and ideas, solve problems and work collaboratively. Within NAP–SL, aspects of digital literacy arise from the online delivery of the NAP–SL assessment, in which students use the online system to undertake specific tasks. Students will be expected to use their digital literacy to access information and collect, record, analyse and represent data.

Ethical Understanding

Ethical Understanding refers to identifying and investigating the nature of ethical concepts and understanding how reasoning can assist ethical judgement. Within the Australian Curriculum: Science, students develop their understanding of ethical concepts and ethical decision-making processes in relation to science investigations, codes of practice, and the use of scientific information and science applications. They learn about ethical procedures for investigating and working with people, animals, data and materials. Students use scientific information to evaluate claims and to inform ethical decisions about a range of social, environmental and personal issues. They consider their own roles as discerning citizens and learn to analyse biases and assumptions as they apply ethical concepts when making decisions in complex situations.

In the context of NAP–SL, aspects of ethical understanding arise in the context of planning investigations and considering solutions to social and personal issues. Students will be expected to consider the implications of their investigations on the environment and living organisms. They will also be expected to take into account ethical considerations when reporting data and when asked to make decisions about social or environmental issues.

Intercultural Understanding

Intercultural Understanding requires students to learn about and engage with diverse cultures in ways that recognise commonalities and differences, create connections and cultivate mutual respect. Intercultural understanding is an essential part of living with others in the diverse world of the twenty-first century.

In the context of NAP–SL, students will be expected to recognise that intercultural understanding refers to the contributions that diverse cultural perspectives have made to the development, breadth and diversity of science knowledge and applications. They will be expected to consider how science benefits from participation and collaboration from a diversity of cultures and recognise that scientists work in and engage with culturally diverse communities to address issues of local and international importance.

Personal and Social Capability

Personal and social capability in the Australian Curriculum: Science requires students to direct their own learning, plan and carry out investigations, and become independent learners who can apply science understanding and practices to make decisions. Students will be expected to use their scientific knowledge to propose solutions to issues that impact their lives (such as health, nutrition and environmental change), and to consider the application of science to meet personal and social needs.

2.5. Assessment item contexts

The Australian Curriculum: Science aims to develop students' scientific literacy, including providing students with the capability to investigate the natural world and changes made to it through human activity. Further, students are encouraged to develop scientific capacities, including the ability to think and act in scientific ways, which contributes to their development as confident, self-motivated and active members of society. As such, NAP–SL assesses students' scientific literacy and cognitive competencies in specific contexts that have relevance to their lives.

Contexts are also required to remain sensitive to cultural identities in acknowledgment of the demographic diversity of Australian classrooms. Science literacy items focus on situations relating to personal, school, local, national, global, contemporary and historical contexts. The focus is on providing contexts from real-world situations of importance, while providing significant assessment opportunities. For example, historical contexts can provide the opportunity for assessing students' understanding of the processes and practices involved in advancing scientific knowledge; contemporary contexts can provide opportunity to assess students' understanding of the use and influences of science as society continues to be faced with challenges relating to environmental sustainability, health and natural resources.

Formal specifications are not set for contexts allocations in NAP–SL. Assessment items may be embedded in both familiar and less familiar contexts. The contexts are designed to avoid irrelevant extraneous information that is not relevant to the construct. Contexts are selected to be appropriate for the ages of the students undertaking the assessment.

3. Cognitive dimension

3.1. Cognitive dimension and cognitive processes

An important feature of the NAP–SL 2023 assessment framework is the explicit definition of a cognitive dimension within the assessment of science literacy and across all 3 content domains. This is consistent with other major assessments of scientific literacy such as PISA (OECD, 2019) and TIMSS (Mullis & Martin, 2017). The purpose of this chapter is to establish nationally consistent definitions and to provide an explanation of the cognitive dimension of the science literacy measurement construct in the NAP–SL assessments. The definitions and taxonomy used to develop the cognitive domain are consistent with those used in international science assessments including PISA and TIMSS. The cognitive dimension seeks to make explicit the science focused thinking skills that will be engaged by the students to respond to the assessment tasks.

The cognitive dimension in this framework is guided by the ways that science knowledge, science inquiry, and knowledge about science can be used by students, and the cognitive complexities that are inherent in these uses. It draws on several frameworks that define cognitive demand (including the revised Bloom's Taxonomy (Anderson & Krathwohl, 2001)), as well as on the cognitive processes that underpin critical and creative thinking as defined by the General Capability in the Australian Curriculum (ACARA, 2023 (b)). It is adapted here to link more explicitly to both conceptual understandings and abilities, applying one dimension to all 3 content domains of the NAP–SL (Science Understanding, Science as a Human Endeavour and, most evidently, Science Inquiry). This is consistent with other international frameworks, which incorporate aspects of science inquiry skills into a single cognitive demand rating scale. For example, the OECD also drew inspiration from the revised Bloom's taxonomy (Anderson & Krathwohl, 2001), in addition to Webb's Depth of Knowledge Webb, 1997) in their PISA Science assessment.

The cognitive dimension in NAP–SL represents the cognitive processes required in the application of science concepts.

The cognitive dimension in NAP–SL has 3 areas:

- knowing and using procedures
- reasoning, analysing and evaluating
- synthesising and creating.

It is recommended that the cognitive dimension is used by item writers, along with the content descriptions and achievement standards, as a guide to designing items, rather than merely as a framework to classify items. While there is no prescribed target percentage of items for each of the areas, NAP–SL will provide coverage of all areas of the cognitive dimension. Given the stronger focus on CCT for NAP–SL 2023, it is envisaged that the assessment instrument will include an increased percentage of items requiring Reasoning, analysing and evaluating skills than for the previous cycle. The coverage of the 3 cognitive dimensions in the 2018 cycle is provided in Table 3.1.

Table 3.1 NAP–SL 2018 coverage of the 3 cognitive dimensions

Cognitive dimension	Target percentage of overall assessment
Knowing and using procedures	50 %
Reasoning, analysing and evaluating	35 %
Synthesising and creating	15 %

Knowing and using procedures requires knowledge of facts and definitions as well as the ability to illustrate scientific concepts by providing or identifying examples. In this area of the cognitive domain, students should be able to relate scientific concepts to simple observable phenomena. It also includes knowing simple procedures as well as the ability to perform simple science processes or procedures (e.g. make simple observations, measure, use a scale or units).

In the context of Science Inquiry specifically, this area encompasses the knowledge and use of (practical) skills and procedures. These include the use and identification of appropriate measuring instruments and the mechanical aspects of constructing simple tables and graphs, which are necessary but not in themselves sufficient to carry out most aspects of inquiry.

Reasoning, analysing and evaluating requires students to engage in applying knowledge, skills, processes, equipment and methods (e.g. classify, compare, contrast, organise data, collect, display data, use a diagram to illustrate a relationship, give a simple explanation) in contexts likely to be familiar or straightforward. It also requires students to analyse information and evaluate evidence and arguments with respect to quality, relevance and sufficiency of data.

In the context of Science Inquiry specifically, this area also encompasses the application of procedural understanding related to inquiry processes (e.g. when students need to make decisions about what and when to measure, how many times and over what time period as well as errors that could arise given a particular experimental set-up).

Synthesising and creating requires students to consider a number of different factors, variables or concepts, put elements together (e.g. concepts, evidence, procedures, skills) into a coherent whole or compile elements in new ways or into something new and different. Through compiling elements, students should be able to form a coherent hypothesis, argument, or explanation. Tasks in *Synthesising and creating* are generally more open-ended or unstructured, can use more complex or unfamiliar scientific phenomena, and can involve more than one approach or strategy; they require considerable cognitive effort because there is not likely to be a well-rehearsed method or pathway to approaching the task.

In the context of Science Inquiry specifically, this area encompasses creating and using models, planning and designing scientific investigations, and carrying out extended investigations to solve a problem (from specifying a problem to designing and conducting the investigation, to analysing and evaluating the data [critically interpreting the data and methods of data collection], and forming conclusions drawing on concepts and evidence).

3.2. Critical and Creative Thinking in NAP–SL

In order to highlight the extent to which CCT is integrated into the cognitive dimension as assessed by the NAP-SL assessment, an explicit map of the CCT continuum aligned to the cognitive dimension is provided below. This mapping demonstrates the integration of CCT within the assessment of science literacy. The cognitive dimension represents the cognitive processes required in the application of science concepts and represents the assessable elements of CCT. CCT elements are assessed through all 3 cognitive areas. Tables 3.2 – 3.4 include cognitive areas that are used to illustrate each of the processes described in the cognitive dimension of NAP–SL and provides a mapping to the CCT elements/sub-elements to demonstrate the relationship between CCT and the 3 cognitive areas. This comprehensive, but not exhaustive mapping is intended to illustrate the representation and possible coverage of CCT within and across the cognitive areas. Not demonstrated in this mapping, for brevity purposes, is the extent to which the elements can be demonstrated in relation to performance expectations. The progression of development of CCT skills will also be taken into account during the item development process.

Table 3.2: Knowing and using procedures

Knowing and using procedures			
Cognitive area	**Description**	**CCT Element**	**CCT Sub-element**
Recognise	Make or identify accurate statements about science phenomena, concepts, relationships, procedures or statements about the scientific endeavour; recognise an instance of a concept/entity/ generalisation (e.g. producers or decomposers in a food web)	Inquiring	Identify, process and evaluate information
Define	Identify statements that define particular concepts and content	Inquiring	Identify, process and evaluate information
Describe	Make straightforward observations of features/objects; identify and extract information from simple data sources or diagrams; describe factual information, processes and relationships about science or the scientific endeavour	Inquiring	Identify, process and evaluate information
Illustrate with examples	Identify or provide examples that support/clarify statements about the scientific endeavour or statements about particular science concepts, relationships and theories	Inquiring	Identify, process and evaluate information
Relate	Relate science concepts to phenomena and observations	Inquiring	Identify, process and evaluate information
Use tools and procedures	Demonstrate skills in the use of science equipment, tools, measurement devices/scales, mechanical aspects of constructing and reading graphs and tables	Inquiring	Identify, process and evaluate information

Table 3.3 Reasoning, analysing and evaluating

Reasoning, analysing and evaluating			
Cognitive area	**Description**	**CCT Element**	**CCT Sub-element**
Compare/ Contrast/ Classify	Identify similarities and differences between objects, processes or ideas; organise and process information; classify objects or processes based on characteristics/properties	Inquiring	Identify, process and evaluate information
		Inquiring	Identify, process and evaluate information
Represent	Make representations (e.g. diagrams) to describe and illustrate aspects of concepts, structures, relationships, processes; make or use representations to communicate or find solutions to problems	Inquiring Reflecting	Identify, process and evaluate information Transfer knowledge
Collect, analyse and interpret data	Make decisions about variables to be investigated and controlled, measurements to conduct; represent data in tables and graphs using appropriate labelling and scales; identify and summarise patterns in the data; interpolate/extrapolate from data	Inquiring	Identify, process and evaluate information
		Analysing	Interpret concepts and problems
		Analysing	Evaluate actions and outcomes
Make inferences	Make inferences from data, information given and/or own knowledge; give reasons/evidence to support an inference	Analysing	Interpret concepts and problems Draw conclusions and provide reasons
		Reflecting	Transfer knowledge

Predict/ Explain	Make predictions based on evidence and concepts; give reasons to support predictions; construct and defend explanations based on evidence and/or concepts; transfer knowledge into new contexts by making predictions and constructing explanations in new situations	Generating	Put ideas into action
		Reflecting	Transfer knowledge
Analyse information, evidence and arguments	Pose questions to probe assumptions, to identify gaps in information, evidence or arguments, or to investigate ideas or issues; prioritise information/evidence required to draw a conclusion or to make a decision; identify facts, observations or data that can be used as evidence to support an explanation, conclusion or argument; identify whether there is sufficient evidence to justify a claim, explanation or conclusion; identify evidence needed to decide among competing claims, explanations or solutions; integrate new information or evidence into ideas	Inquiring	Develop questions
		Analysing	Interpret concepts and problems Draw conclusions and provide reasons
Evaluate information, evidence, procedures and arguments	Evaluate information and evidence according to criteria such as relevance, bias, validity and/or reliability; evaluate claims, conclusions and arguments with respect to quality of evidence and reasoning supporting them; recognise flaws (e.g. gaps) in reasoning; consider and evaluate alternative explanations, processes and solutions; evaluate steps of investigations	Inquiring	Identify, process and evaluate information
		Inquiring	Identify, process and evaluate information
		Generating	Consider alternatives

Table 3.4 Synthesising and creating

Synthesising and creating			
Cognitive area	**Description**	**CCT Element**	**CCT Sub-element**
Generate hypotheses	Generate hypotheses based on background knowledge, preliminary observations, and logic; generate and test alternative hypotheses; identify and justify the thinking processes behind such hypotheses	Generating	Put ideas into action
Construct arguments and draw conclusions	Construct sound and valid arguments supported by evidence and logical reasoning; draw conclusions that address questions/hypotheses and are supported with evidence; draw or support conclusions using evidence and scientific understanding; adapt conclusions as new evidence becomes available; draw general conclusions that go beyond the experimental or given conditions	Analysing	Interpret concepts and problems Draw conclusions and provide reasons
		Reflecting	Transfer knowledge
Create and use models	Create models to explain a phenomenon or make a prediction (using imagery or analogies, as relevant); adapt models as new evidence becomes available; use computer simulations to test models under different conditions	Generating	Put ideas into action
Plan and design investigations	Plan and design whole investigations appropriate for answering scientific questions or solving problems	Analysing	Draw conclusions and provide reasons

Make connections	Make connections between different concepts and areas of science; make decisions considering both scientific and social factors and trade-offs; synthesise complex information to inform a course of action	Analysing	Draw conclusions and provide reasons
		Generating	Create possibilities
Solve problems	Seek and provide solutions to problems that require consideration of different factors and/or concepts; identify, assess and test options, implications and consequences when seeking solutions; propose alternative solutions to problems; justify the reasons behind choosing particular options/solutions; design solutions to problems of social significance, using science knowledge, considering a range of perspectives and trade-offs, and assessing risks	Analysing	Evaluate actions and outcomes
		Generating	Consider alternatives

As Tables 3.2 – 3.4 show, Science Literacy is a particularly well-suited construct within which to consider CCT. There are numerous opportunities to apply CCT and the associated processes in the cognitive dimension in science literacy in the classroom, and these scenarios can be transformed into assessment items. For example, a primary school teacher who has been teaching students about plants asks them, "What experiment could we do to test what we know about plants?" Before coming up with ideas for the experiment, students are assisted by the teacher in a brainstorming exercise about everything they know about plants: types of plants, parts of plants, conditions they need and so on. This assists them to consider what aspect of their knowledge of plants could be a suitable basis for an experiment (Cognitive Dimension – Collect, analyse, and interpret data; CCT – Identify, process and evaluate information). To advance this a science teacher can ask their class to brainstorm ideas for an experimental design to ascertain whether plants need light to survive (Plan and design investigations – Cognitive Dimension). The class work together to categorise the ideas and make judgements about how different the ideas are from each other (Cognitive Dimension - Compare/Contrast/Classify; CCT - Identify, process and evaluate information). The categories might focus on, for example, ideas with a common metric for considering survival or a common way of excluding light. The teacher encourages the students to think of any other types of ideas (CCT – Draw conclusions and provide reasons).

3.3. Cognitive processes in a balanced assessment

NAP–SL items will be classified according to the cognitive areas and cognitive processes they seek to engage in students. This will ensure that the NAP–SL assessment will include items that cover a range of complexity and that students will be asked to use knowledge and skills in a variety of ways, some associated with higher and some with lower demand. This means that the assessment will be able to provide information on how students across the ability range can deal with tasks at different levels of demand.

The difficulty of an item is differentiated from the complexity or cognitive demand of the item. Item difficulty relates to the proportion of students answering a given item correctly while item demand relates to the cognitive processes necessary for successful completion of a task. NAP–SL aims to develop items that ultimately provide both a broad coverage of item difficulties and include items with a range of cognitive demands.

In NAP–SL often elements such as reasoning and inquiry are most commonly associated with scientific tasks; however, there are many opportunities in which to also measure creative elements. For example, in the context of 'the chemical and physical properties of substances are determined by their structure at a range of scales' (Science Understanding core concept) students can demonstrate their ability to 'connect ideas and create possibilities' (CCT) by brainstorming different procedural aspects of investigating substances and then explore and combine ideas to create an innovative solution (Synthesising and Creating -Cognitive Dimension).

3.4. Developing performance expectations

The science content sequence and the processes listed in Tables 3.2 – 3.4 provides the foundation for the development of 'performance expectations' which articulate the types of tasks that provide evidence of student understanding and proficiency with the constructs assessed. Statements within content sequences, that are linked to the content descriptions of the Australian Curriculum: Science specify the knowledge and skills expected of students, while the processes in Tables 3.2 – 3.4 specify how the students are envisaged to engage with the knowledge and skills. The combination of statements relating to content sequence and a cognitive process can lead to a performance expectation for a given content statement. The collective performance expectations for each content statement across the sequence will further articulate the assessment domain, and reflect the expectations stated in the Australian Curriculum: Science achievement standards.

A major initiative of the NAP–SL 2023 assessment framework and subsequent instrument development work is to increase the focus on CCT by introducing formal coverage of CCT. A focus for this work will be to develop new items that specifically provide opportunities for students to demonstrate their CCT ability and associated cognitive processes (as outlined in the cognitive dimension) in the context of science literacy. ACER test developers will develop new items using the CCT continuum, the cognitive dimension of NAP–SL, the relevant science content descriptions, and the Australian Curriculum: Science achievement standards. Items will be developed to cover a range of the cognitive processes, including considerations of item demand (complexity of the cognitive processes required) and anticipated item facility (percentage of students that are likely to answer the item correctly).

4. Contextual framework

In addition to measuring students' cognitive competencies in science literacy, the NAP–SL also collects contextual information about participating students. This contextual element was first introduced in 2009 with the inclusion of a survey of students' attitudes and behaviours related to various aspects of science literacy. The incorporation of these largely affective processes has been complemented by the collection of student background data via jurisdictional- or school-level provision of student enrolment data. For NAP–SL, the inclusion of this contextual aspect not only allows us to examine the rich attitudinal and behavioural data of participating students, but also permits a better understanding of the factors associated with variations in student achievement.

This section documents the various contextual factors that are considered within the NAP–SL assessment, as well as the instruments used to collect them.

4.1 Student questionnaire

The NAP–SL student questionnaire, first introduced as the student survey in 2009, has been improved and enhanced to provide information that is better aligned with the Australian Curriculum: Science and the definition of science literacy (section 1.2), particularly pertaining to the Science as a Human Endeavour strand. The questionnaire covers 3 broad areas:

- Science as a Human Endeavour
- student engagement with science
- teaching and learning in science.

Further, the questionnaire gathers information about Year 10 students' perceptions of the relevance of science for future study and career opportunities in science, technology, engineering and mathematics (STEM)-related fields.

In order to monitor changes in student experiences, attitudes, values and engagement with various aspects of science literacy, the following constructs administered in previous NAP–SL assessments will be included in the student questionnaire:

- student perceptions of the nature of science
- student reports of science-related activities undertaken at school
- student reports of science-related activities undertaken outside of school
- student reports of science topics studied at school
- student beliefs on who is involved in science.

Further details about these constructs can be found in the 2015 and 2018 NAP–SL technical reports (ACARA 2017, ACARA 2020).

In order to ensure the questionnaire reflects the most recent changes in NAP–SL since the previous cycle (in particular the Critical and Creative Thinking component of general capabilities), it will be expanded to include:

- student reports on school climate for encouraging CCT
- self-efficacy in undertaking CCT in application to problem solving

- student reports on outside of school environment for encouraging CCT (i.e. from family and friends)
- student attitudes towards the value of CCT
- student self-reports on engagement in undertaking CCT activities.

In response to the role of science during national emergencies (in particular the global COVID-19 pandemic), the questionnaire will include relevant content on student beliefs towards science when facing such challenges (for instance, student attitudes towards the use of science to challenge misinformation).

The questionnaire outcomes will be reported including their correlation with students' overall achievement in science literacy at the national as well as state and territory levels. The questionnaire responses will be scaled to provide construct indicators of students' perception and engagement.

4.2 Student background data

For NAP–SL, additional contextual variables at a student and school level are examined in tandem with the attitudinal and behavioural data collected via the student questionnaire. Student background data, as these variables are collectively known, are used to construct a more extensive profile of individual- and school-level factors for participating students.

The provision of these data is facilitated at a school and jurisdictional level allowing for a range of variables to be reliably collected. The data are informed by the information provided by students' caregivers at the time of enrolment in school.

The specific background variables collected for use in NAP–SL are:

- state or territory in which students' attend school
- school sector (Catholic, Government or Independent)
- geographic location of the school
- students' gender
- students' age
- students' Indigenous status
- students' language background
- occupation category of students' parents/caregivers, and
- highest level of education of students' parents/caregivers.

(To find out about what data are collected as part of testing programs and how ACARA handles personal information it collects, please refer to ACARA's Privacy Policy)

5. Assessment structure and reporting

5.1. Assessment structure

The specifications for distributions of items across content domains in this framework also reflect the item distributions from previous NAP–SL cycles (see Chapter 2, p. 8). The assessment of the cognitive dimension within science literacy for 2023 also reflects the construct of earlier NAP–SL cycles; greater magnification of CCT will be brought into focus for analysis and reporting.

The NAP–SL uses a cluster rotation design similar to that used in other sample-based international assessments. It is envisaged that NAP–SL 2023 will follow a similar cluster rotation design to NAP–SL 2018, such as that shown for the Year 10 2018 main study in Table 5.1.

Table 5.1: Test design for Year 10 main study, NAP–SL 2018

Test form	Block 1	Block 2	Block 3	Inquiry task
1	Cluster 1	Cluster 2	Cluster 4	Task 1
2	Cluster 2	Cluster 3	Cluster 5	Task 2
3	Cluster 3	Cluster 4	Cluster 6	Task 1
4	Cluster 4	Cluster 5	Cluster 7	Task 2
5	Cluster 5	Cluster 6	Cluster 8	Task 1
6	Cluster 6	Cluster 7	Cluster 1	Task 2
7	Cluster 7	Cluster 8	Cluster 2	Task 1
8	Cluster 8	Cluster 1	Cluster 3	Task 2

In the rotation design, assessment forms are assembled so that each form is linked through common clusters to other forms. To achieve the rotation design for the NAP–SL, the items are written in contextual units. Each unit contains between one and 5 items that are developed around a single theme or stimulus. Clusters are then constructed by grouping units together. Clusters are grouped together into assessment forms. Each assessment form will contain 3 components: a set of objective test items, an inquiry task and a set of questionnaire items.

Clusters that are intended to contain vertical link items should provide a good sampling of the content and cognitive domains of the assessment framework across both year levels. As the Year 10 science literacy proficiency standard was defined for the first time during the reporting phase of NAP–SL 2018, it is now possible to include an inquiry task as a link between Year 6 and Year 10 in NAP–SL 2023.

5.2. Response formats and item types

The content and cognitive dimension and ensuing performance expectations suggest that to capture the variability and different levels of complexity of performance, different types of assessment items and response formats will be required. To take an extreme case, an assessment that consists only of multiple-choice questions would not be representative of the construct(s) nor capture the range of cognitive demands as defined in Chapters 2 and 3 of this framework.

Within the limitations of the item authoring and test delivery systems, 2 main types of response formats are suitable for use in NAP–SL to assess the understandings and abilities identified in the framework. These response formats are **selected response** and **constructed response** formats that provide a range of opportunities for students to demonstrate their proficiency across the elements of the CCT General Capability, content dimension and cognitive dimension. Response formats can be categorised by how much they constrain student responses on a continuum from highly constrained items to items with few constraints. Highly constrained item types are response formats such as multiple choice that limits student responses to a set of predefined options but have the benefit of being able to be scored automatically. Items with few constraints conventionally include constructed response item types. These item types can offer insight into student reasoning and understanding, however scoring of constructed response items cannot be automated and requires human marking. Intermediate-constrained response type items are a type of digital assessment format that falls between highly constrained selected-response item types and fully constructed open-response type items. Intermediate-constrained response type items provide greater openness of student response than highly constrained items and are able to be automatically scored. Examples of intermediate-constrained items include items where students are given a choice of words to complete a statement, position organisms in a food web or place objects in a particular order based on their size or position. These formats resolve 2 main concerns with multiple-choice items: when a limited set of options is provided, students can back solve (rather than directly solve a problem/answer a question, by testing each of the provided options) or student thinking may be prompted by the option (students 'recognise' the answer). Intermediate-constrained response types are supported by the NAP–SL item authoring and test delivery systems and provide the opportunity to combine automated scoring with appropriately targeted content and cognitive demand.

CCT skills are complex cognitive processes and inferences about student proficiency can only be made through students demonstrating their ability to apply the skills. A good assessment will provide ample opportunity for students to demonstrate their CCT skills. Some item formats, such as constructed response and intermediate-constrained, will provide the space for students to demonstrate the critical and creative thinking processes they go through to reach their response. Typically, these item formats capture more than just the final response, they are also able to capture the pathway to get there, some elaboration, or justification. Conventional multiple choice does not provide students with the opportunity to explain or elaborate on their thinking processes and as such may not work as well at capturing students' CCT ability.

Each of the response formats is associated with multiple item types. As outlined by Scalise (2009), there are many item types that can be used in computer-based testing.

In **selected-response** formats, students respond to a question by selecting the answer(s) they believe is/are more justifiable from a given set of alternatives. With computer-based testing, there is a wide variety of selected-response formats to use (Scalise, 2009). However, a greater variety of formats in the assessment does not necessarily make a better test. Items that use 'drag and drop' utility can often be completed more efficiently using a multiple-choice format. The uses of 'drag and drop' listed below are less constrained in assessing categorising, ranking and sequencing than multiple-choice or their paper-and-pencil equivalents. In general, the type of performance expectation(s) identified for development should guide the response format(s) used, not the other way around. The item types listed are sequenced here from highly constrained item response types to the more intermediate constrained item response types.

- **Multiple-choice:** Options may be words, graphical, pictorial and may incorporate new media. In the NAP–SL 2023 assessment, whenever possible, there will be 4 options in each multiple-choice item. When assessing use of knowledge to predict and explain phenomena or understanding of the nature of evidence, students' misconceptions, mental models and alternate ways of thinking about the natural world should guide the development of item contexts. Misconceptions and alternate ways of thinking will not explicitly become distractors as this can often make the psychometric profile of an item different to conventional items in standardised tests (Sadler, 1998).

- **Multiple-choices:** Select more than one option (including 'all that apply').

- **Two-tier multiple choice:** Select an option for a prediction, explanation etc. and then select from a different set of options to justify reasoning. This format appears to offer an efficient way of assessing higher cognitive demand items related to making and justifying hypotheses, predictions, explanations and arguments. The sequential responses will need to be integrated in a way that avoids interdependence of items.

- **Interactive match (drag and drop)**: Select, drag and drop words, graphical or pictorial elements for classification purposes or to place items in order.
- **Interactive match (draw lines):** 2 columns of options that can be connected by drawing lines from an option in one column to an option in the second column. Options for this item type may be images, numbers, words or descriptions.
- **Interactive match (checkbox):** Select a checkbox from columns within a table. Multiple responses are required generally using a dichotomous scale, for example odd/even or yes/no. Checkbox can also be used for items comparing aspects or properties of 2 or more concepts against 2 or more criteria, such as a list of variables that can be classified as independent, dependent or controlled.
- **Interactive gap match:** Select from multiple words to insert at various points in a sentence or passage.
- **Interactive graphic gap match:** Select from a range of options (either text or image) that can be dragged or dropped into one or more destinations on an image. Used for ordering, classification, completion of tables or labelling of diagrams and graphs.
- **Hotspot:** Select one or more predefined areas on a diagram, graph or other image.
- **Composite (inline choice):** Select an answer from a drop-down menu. Options in the drop-down menu are usually numbers, single words or short sentence fragments of 2 to 3 words. An item to contain several inline choices where multiple responses are required.
- **Composite (multiple interactions):** 2 or more interactions of the listed item types, where there are related concepts that constitute parts of a whole. The use of multiple interactions is appropriate where different cognitive demands are required, as multiple interactions with an item with identical cognitive demands increase the time taken to respond without eliciting any further information about student ability.

In **constructed-response** formats, students respond to a question by generating a response (rather than selecting a response from a given set of alternatives). Constructed-response items include short-constructed response and extended-constructed response items.

- **Short-constructed:** One or 2 words, a phrase or numerical response is required as a response to an item. Short-constructed response items that could instead be completed with multiple-choice format should be avoided. The short-constructed format might be more appropriate when recall rather than recognition of information is important or greater depth of understanding is required than what can be probed with a multiple-choice question. Supplying titles for tables and graphs, graph labels and table headings would also be classified as short-response items.
- **Single numerical:** Enter a single numerical answer in a text box, including setting values for input variables in simulations.
- **Extended-constructed (extended text):** One sentence up to a couple of paragraphs are required as a response to an item. This format would be utilised to respond to a question that requires students to apply or integrate concepts, probe students' deeper understanding, and/or probe students' ability to communicate. It is particularly useful for tasks targeting the *Synthesising and creating* cognitive dimension.
- Extended-constructed items in the past NAP–SL assessments had scoring categories with up to 6 score points. Items with higher scoring categories can be used to tap into the more multifaceted content descriptions and advanced cognitive dimensions (in particular those that require integration/synthesis of concepts or ideas/evidence from different sources). Trialled items with higher scoring categories that were able to distinguish student scientific

literacy proficiency by Rasch analysis were used in the 2018 NAP–SL Main Study. Such open questions that enable students to use their own words to explain a scientific concept or draw conclusions based on evidence, especially in an unfamiliar context, facilitates assessment of higher science proficiency levels (Hackling, 2012). These items can be composite items, as defined in QTI v2.1, if the item requires multiple interactions and the strength of the relationship between these interactions is such that the item cannot be broken easily into independent, standalone parts.

5.3. Additional technological enhancements

The NAP–SL 2023 assessments will take advantage of technology-based enhancements to items. These enhancements can broaden the ranges of stimulus material presented, of content assessed, and of the cognitive complexity of the responses required.

Examples of technology-based enhancements include:

- Students may observe a video or animation describing a phenomenon, experiment or investigation (instead of reading a stimulus text). Several phenomena, processes, experiments, etc. have been excluded from previous assessments as stimulus material because they are difficult to describe or make accessible to students, and/or their description results in high reading load. This includes phenomena and processes that happen over time, too quickly, too slowly; are on too small or too large a scale to observe directly.
- Students may view data from various external sources, multiple sources of information or media presentations as stimulus material for assessing interactions between science and society.
- Students may be asked to respond to a Predict-Observe-Explain situation, in which they make a prediction about an event, observe video or animation that is likely to surprise them, and ask them to add to or change their ideas about what happened. Other enhancements are presented in the next section on inquiry tasks. Note: Where possible, additional non-subject matter-specific enhancements may be included, following ACARA's Guidelines for the Development of Accessible NAPLAN Online Items (ACARA, 2018).

5.4. Science inquiry tasks

5.4.1. Inquiry tasks in previous NAP–SL cycles

In addition to an objective test, the first 3 cycles of the NAP–SL (2006, 2009 and 2012) included a 45-minute practical component. Its purpose was to provide students with an opportunity to experience practical aspects of science within a formal assessment and test the conventions of science literacy in more depth than was possible in the objective test (ACARA, 2015). In NAP–SL 2015, a 45-minute online inquiry task was introduced that targeted similar content as the previous NAP–SL practicals.

A limitation of NAP–SL 2015 inquiry tasks is their restricted degree of openness. The degree of openness of a task relates to who defines the problem to be studied, who chooses the method and how many solutions are available. The first 2 considerations can be placed in a continuum from closely defined to not defined, while the last consideration ranges from one solution to many solutions. Students were placed in an observer's role rather than being active participants, followed step-by-step instructions to collect data and were guided with structured questions through the steps of interpreting and evaluating the data. Students were not directly engaged in a practical activity but were tested on a range of relevant science inquiry skills based on their observations from a video stimulus.

For NAP–SL 2018, 4 inquiry tasks were developed for trial at each year level. In the main study, 2 inquiry tasks were administered at each year level — 2 40-minute tasks at Year 6 and 2 50-minute tasks at Year 10. Each student was presented with one of the 2 inquiry tasks. This is consistent with the number and duration of inquiry tasks in previous NAP–SL cycles. The tasks primarily targeted abilities from the Science Inquiry Skills (now Science Inquiry) content sequences, with many of the items targeting the cognitive domains of *Knowing and using procedures* and *Reasoning, analysing and evaluating,* and a few targeting *Synthesising and creating*. The tasks were related to science concepts within the content sub-domain Science Understanding; however, the inquiry skills rather than the concepts were in the foreground of the assessment. The tasks were in the middle of the content-lean, content-rich continuum (content-rich tasks require in-depth understanding of subject matter for task execution; content-lean tasks are not dependent on prior subject-matter knowledge; performance only depends on information given in the assessment situation) (Baxter & Glaser, 1998) and the concepts embedded in the tasks were well within grasp of most students. Such accessible content was chosen to minimise issues of content-knowledge gaps preventing students demonstrating their inquiry skills.

5.4.2. Inquiry tasks in NAP–SL 2023

The inquiry tasks for NAP–SL 2023 will be computer-based and focus on aspects of inquiry that cannot be effectively or efficiently assessed in shorter tasks/items. In addition to planning and carrying out investigations, this would include the notion of the overall evaluation of an inquiry in terms of the credibility of the evidence gathered and the solution produced. An overall strategy for the development of the assessment instrument will be established upfront. It will consider the abilities to be assessed through shorter stimuli and secondary data in the first part of the assessment, and the abilities that are better assessed through inquiry tasks. For example, to enable in-depth assessment of some aspects of the inquiry tasks, time-consuming aspects of data representation (e.g. graph drawing) may be assessed in item sets in the first part of the assessment.

As discussed in a previous section (Additional technological enhancements), computer-based tasks significantly broaden the type of inquiry with which students can engage, and as a result the content that can be readily assessed and the cognitive complexity of the required responses. These enhancements will be incorporated in NAP–SL 2023 where possible, within the capabilities of the online assessment platform and item response types supported by the platform.

For example, students may:

- explore phenomena and processes that are too slow or too fast to observe in the real world, or not visible to the naked eye (e.g. decomposition)
- explore phenomena or processes that would be considered hazardous (e.g. using hot materials) or messy (e.g. using water)
- develop, use and test representations to model the real world (e.g. the Solar System)
- carry out repetitions/replications of experiments within short assessment times (e.g. tabulated data of experimental replicates for analysis).

Technology gives developers the ability to manipulate the degree of openness of the task and capture process data. Computer-based inquiry tasks provide opportunities to assess a whole investigation, from understanding the problem, planning how to go about the investigation, implementing that plan, collecting the data, drawing conclusions from the data, and evaluating the whole investigation as one integrated process. Not all inquiry tasks developed have to be experiments. Tasks should also assess other methods of scientific inquiry, such as observation, classifying, pattern seeking, and modelling, rather than only fair-test experiments. Technology opens the possibility for different types of inquiry that are, for example, too difficult to carry out in a practical assessment session or require looking at data over time. Such types of inquiry may be carried out by students at the planning and predicting level only, with students presented with secondary data to complete the inquiry. The inquiry task is not an end in itself – it is a means to obtain valid information about the level of student abilities related to important aspects of the content domains.

Approaches other than a single inquiry task, such as the administration of 2 shorter tasks, may also be explored in NAP–SL 2023. A key consideration is whether they lead to less efficient use of assessment time due to the need for students to familiarise themselves with 2 pieces of stimuli and sets of tools rather than one.

NAP–SL 2023 technology-enhanced inquiry tasks will be open-ended where possible, include more items targeting the cognitive domain *Synthesising and creating,* and link explicitly to the Critical and Creative Thinking General Capability. This includes giving students an opportunity to determine for themselves the procedures that will yield robust evidence that can be used for justifying their conclusions or solutions to a problem.

A key challenge in the design of inquiry tasks is how to provide open-ended environments to tap into difficult-to-assess constructs while giving all students the opportunity to demonstrate what they can do and, at the same time, preserving the independence of the items.

Drawing on the previous analysis, the development of NAP–SL 2023 inquiry tasks will:

- explore the advantages and disadvantages of including 2 smaller inquiry tasks vs. one longer task
- develop tasks that relate to or connect 2 or more concepts within different Science Understanding sub-domains; the concepts selected will be those that are typically understood reasonably well by students
- use a question that is contextualised as authentically as possible to guide the task, regardless of the type (investigation, experiment etc.) and should be contextualised as authentically as possible; the question will engage students in solving a problem rather than requiring them to carry out procedures, without an end-goal
- use a well-defined question to guide the task while retaining students' choice(s) of method and solution
- make available a range of appropriate tools/resources so that students can select appropriate instruments and make appropriate measurements
- provide a range of response formats (see section Response formats and item types)
- maintain independence of items; that is, a correct or incorrect reply to one item will not lead to a correct or incorrect reply to another item; this may place constraints that impact on assessing authentic inquiry practices, for example, planning and then subsequently conducting experiments according to the proposed plan are, by their nature, dependent

5.5. Reporting proficiency in science literacy

The approach to reporting used by the NAP–SL has been developed in previous assessment cycles and is based on the definition and description of a number of levels of proficiency in science literacy. In previous cycles, descriptions were developed to characterise typical student performance at each proficiency level. The proficiency levels were used to summarise and report on the performance of Year 6 students (across Australia as well as in individual states and territories), to compare performance across subgroups of students and to report on the performance of students over time. The extension of the assessment scale in 2018 to include Year 10 outcomes resulted in a change to the width and subsequent relabelling of the proficiency levels.

For NAP–SL 2023 the revised assessment framework, and the continuum of student achievement described within the proficiency levels, will support the following advances:

- Proficiency levels and descriptions will be revised and enriched using information gathered from items designed with a greater emphasis on CCT.
- Proficiency level descriptions will be aligned with the expectations of the refined Australian Curriculum: Science, as the assessment items and their descriptions will be guided by content and cognitive framework dimensions that reflect the knowledge and capabilities articulated in the Australian Curriculum.

- Anticipated stronger alignment between the NAP–SL assessment and the Australian Curriculum and use of technology-enhanced response formats in the assessment means that the results for the 2023 cycle will provide more useful data about Australian students' performance related to the specific knowledge, skills and capabilities included in the Australian Curriculum (including those that are harder to assess with traditional response formats) and will support more in-depth feedback on planning and strategies for future science programs. This includes the identification of opportunities and gaps in how students approach and respond to critical thinking tasks and how they engage with open-ended scenarios that require a deeper level of planning, analysis and synthesis.

6. References

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7. Appendix A

Table A1: Mapping of Australian Curriculum: Science content descriptions with key ideas

This mapping is not exhaustive and the ability to incorporate key ideas may depend on the context underpinning assessment items. The grey shaded cells indicate where this is the case, and the context is likely to inform alignment, if any, to the key ideas.

Year 5	
Science understanding	**Key ideas**
Biological sciences	Form and function
Examine how particular structural features and behaviours of living things enable their survival in specific habitats AC9S5U01	Sub-structures work together in systems to serve particular functions Function can be predicted by analysis of form/structure
Earth and space sciences	Stability and change
Describe how weathering, erosion, transportation and deposition cause slow or rapid change to Earth's surface AC9S5U02	Stability might be disturbed either by sudden changes or gradual changes over time
Physical sciences	Matter and energy
Identify sources of light, recognise that light travels in a straight path and describe how shadows are formed and light can be reflected and refracted AC9S5U03	Energy moves through and can cause observable changes to systems
Chemical sciences	Matter and energy
Explain observable properties of solids, liquids and gases by modelling the motion and arrangement of particles AC9S5U04	Energy moves through and can cause observable changes to systems
Science as a human endeavour	**Key Ideas**
Nature and development of science	
Examine why advances in science are often the result of collaboration or build on the work of others AC9S5H01	
Use and influence of science	
Investigate how scientific knowledge is used by individuals and communities to identify problems, consider responses and make decisions AC9S5H02	
Science Inquiry	**Key Ideas**
Questioning and predicting	Patterns, order and organisation
Pose investigable questions to identify patterns and test relationships and make reasoned predictions	Patterns may be causal or correlational

AC9S5I01	Some patterns have an underlying cause that cannot be observed at the same spatial or temporal scale
Planning and conducting	Scale and measurement
Plan and conduct repeatable investigations to answer questions, including, as appropriate, deciding the variables to be changed, measured and controlled in fair tests; describing potential risks; planning for the safe use of equipment and materials; and identifying required permissions to conduct investigations on Country/Place AC9S5I02	The use of appropriate units of measurement is important
Use equipment to observe, measure and record data with reasonable precision, using digital tools as appropriate AC9S5I03	
Processing, modelling and analysing	Patterns, order and organisation Scale and measurement Systems
Construct and use appropriate representations, including tables, graphs and visual or physical models, to organise and process data and information and describe patterns, trends and relationships AC9S5I04	Classification helps us to organise objects and events; some objects/events can be difficult to fit within existing classification systems Patterns may be causal or correlational. Models can be used to investigate systems that are too large or small, or occur over timescales that are too fast or slow, to observe directly Generalisations about relationships within systems can be made Some relationships can impact on other relationships
Evaluating	Patterns, order and organisation
Compare methods and findings with those of others, recognise possible sources of error, pose questions for further investigation and select evidence to draw reasoned conclusions AC9S5I05	Identifying patterns and relationships within and between scientific findings
Communicating	
Write and create texts to communicate ideas and findings for specific purposes and audiences, including selection of language features, using digital tools as appropriate AC9S5I06	

Year 9	
Science understanding	**Key ideas**
Biological sciences	Form and function Stability and change Systems
Compare the role of body systems in regulating and coordinating the body's response to a stimulus, and describe the operation of a negative feedback mechanism AC9S9U01	Structures and systems can be analysed to determine how they function Microscopic form determines macroscopic properties and functions Systems in dynamic equilibrium are stable due to feedback mechanisms Models can be used to predict the behaviour of a system, but these predictions have limited precision and

	reliability due to the assumptions and approximations inherent in models Systems may interact with other systems; have sub-systems, and be part of larger complex systems
Describe the form and function of reproductive cells and organs in animals and plants, and analyse how the processes of sexual and asexual reproduction enable survival of the species AC9S9U02	The form and function of a system is determined by the form, functions, and interconnections of its parts
Earth and space sciences	Stability and change Patterns, order and organisation Systems
Represent the carbon cycle and examine how key processes including combustion, photosynthesis and respiration rely on interactions between Earth's spheres (the geosphere, biosphere, hydrosphere and atmosphere) AC9S9U03	Systems in dynamic equilibrium are stable due to feedback mechanisms Change and rates of change can be quantified and modelled at different scales Patterns in systems can be observed at different scales and can be related Energy drives cycling of matter within and between systems Changes of energy and matter in a system can be described in terms of energy transfer and matter flows into, out of and within a system
Physical sciences	Matter and energy Patterns, order and organisation Form and function
Use wave and particle models to describe energy transfer through different mediums and examine the usefulness of each model for explaining phenomena AC9S9U04	Changes of energy and matter in a system can be described in terms of energy transfer and matter flows into, out of and within a system Identifying and describing the relationships that underpin patterns, including cause and effect Patterns in systems can be observed at different scales and can be related Structures and systems can be analysed to determine how they function
Apply the law of conservation of energy to analyse system efficiency in terms of energy inputs, outputs, transfers and transformations AC9S9U05	The total amount of energy and matter in closed systems is conserved
Chemical sciences	Form and function Matter and energy Patterns, order and organisation
Explain how the model of the atom changed following the discovery of electrons, protons and neutrons and describe how natural radioactive decay results in stable atoms AC9S9U06	The form and function of a system is determined by the form, functions and interconnections of its parts Changes of energy and matter in a system can be described in terms of energy transfer and matter flows into, out of and within a system

Model the rearrangement of atoms in chemical reactions using a range of representations, including word and simple balanced chemical equations, and use these to demonstrate the law of conservation of mass AC9S9U07	The total amount of energy and matter in closed systems is conserved Identifying and describing the relationships that underpin patterns, including cause and effect.
Science as a human endeavour	
Nature and development of science	
Explain how scientific knowledge is validated and refined, including the role of publication and peer review AC9S9H01	
Investigate how advances in technologies enable advances in science, and how science has contributed to developments in technologies and engineering AC9S9H02	
Use and influence of science	
Analyse the key factors that contribute to science knowledge and practices being adopted more broadly by society AC9S9H03	
Examine how the values and needs of society influence the focus of scientific research AC9S9H04	
Science inquiry	
Questioning and predicting	Patterns, order and organisation
Develop investigable questions, reasoned predictions and hypotheses to test relationships and develop explanatory models AC9S9I01	Patterns may be causal or correlational Some patterns have an underlying cause that cannot be observed at the same spatial or temporal scale
Planning and conducting	Scale and measurement
Plan and conduct valid, reproducible investigations to answer questions and test hypotheses, including identifying and controlling for possible sources of error and, as appropriate, developing and following risk assessments, considering ethical issues, and addressing key considerations regarding heritage sites and artefacts on Country/Place AC9S9I02	
Select and use equipment to generate and record data with precision to obtain useful sample sizes and replicable data, using digital tools as appropriate AC9S9I03	The use of appropriate units of measurement is important
Processing, modelling and analysing	Patterns, order and organisation Scale and measurement Systems

Select and construct appropriate representations, including tables, graphs, descriptive statistics, models and mathematical relationships, to organise and process data and information AC9S9I04	Classification helps us to organise objects and events; some objects/events can be difficult to fit within existing classification systems Models can be used to investigate systems that are too large or small, or occur over timescales that are too fast or slow, to observe directly Generalisations about relationships within systems can be made
Analyse and connect a variety of data and information to identify and explain patterns, trends, relationships and anomalies AC9S9I05	Patterns may be causal or correlational Some relationships can impact on other relationships
Evaluating	Patterns, order and organisation
Assess the validity and reproducibility of methods and evaluate the validity of conclusions and claims, including by identifying assumptions, conflicting evidence and areas of uncertainty AC9S9I06	
Construct arguments based on analysis of a variety of evidence to support conclusions or evaluate claims, and consider any ethical issues and cultural protocols associated with accessing, using or citing secondary data or information AC9S9I07	Identifying patterns and relationships within and between scientific findings
Communicating	
Write and create texts to communicate ideas, findings and arguments effectively for identified purposes and audiences, including selection of appropriate content, language and text features, using digital tools as appropriate AC9S9I08	