Science in Practice 2019 v1.0

Applied Senior Syllabus

This syllabus is for implementation with Year 11 students in 2019.

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Contents

1 Course overview

1.1 Introduction

1.1.1 Rationale

Science is a dynamic, collaborative and future-focused field of human endeavour that has emerged from a need to understand natural phenomena. Studying science contributes to the development of a sense of wonder and engagement with the natural world. To have an informed voice in charting the future of society and to effectively participate in society and everyday life, where science and technology play significant and increasing roles, students need to be scientifically literate. Scientific literacy is a way of thinking and a way of viewing and interacting with the world that is developed through engaging in the practical and analytical approaches of scientific inquiry.

Senior secondary students are able to ask increasingly sophisticated questions about new ideas and information. Science in Practice supports and focuses the development of these questions by encouraging inquiry and a respect for evidence and reasoning. It develops critical thinking skills through the evaluation of claims using systematic reasoning and an enhanced scientific understanding of the natural and physical world. Science in Practice is practical, with experiments and hands-on investigations at its heart. Practical activities engage students, producing excitement and curiosity. Investigations develop a deeper understanding of the nature of science and of a particular topic or context. They foster problem-solving skills that are transferable to new situations.

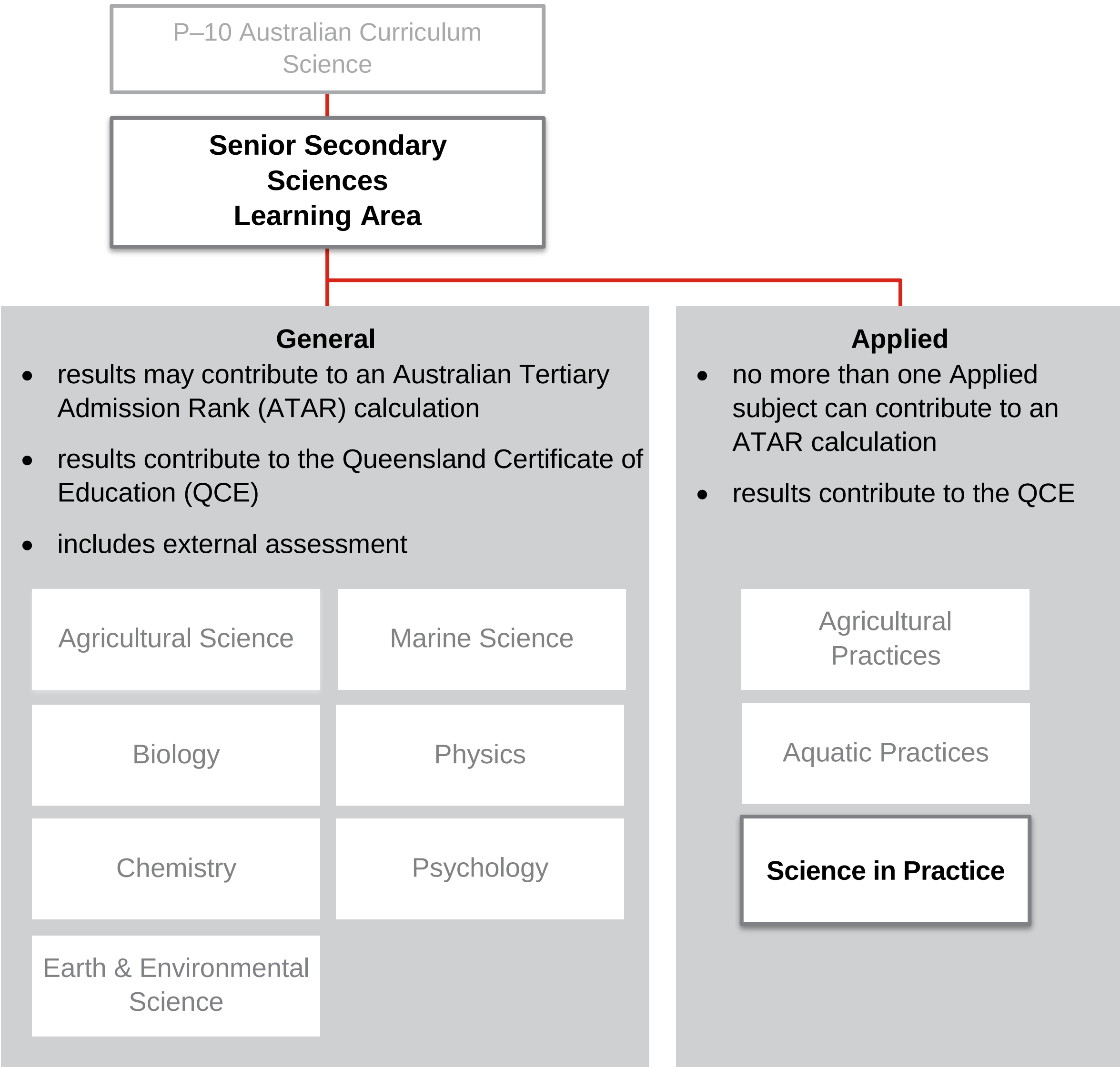
The core of Science in Practice focuses on ‘Scientific literacy and working scientifically’, ‘Workplace health and safety’, and ‘Communication and self-management’. Science in Practice uses a contextualised approach, where modules of work deliver the core through electives — ‘Science for the workplace’, ‘Resources, energy and sustainability’, ‘Health and lifestyles’, ‘Environments’, and ‘Discovery and change’. Learning experiences within modules of work are interdisciplinary, including aspects of at least two science disciplines — Biology, Chemistry, Earth and Environmental Science and Physics. The objectives of the course ensure that students apply what they know and understand to plan investigations, analyse research and evaluate evidence.

Pathways

A course of study in Science in Practice is inclusive and caters for a wide range of students with a variety of backgrounds, interests and career aspirations. It can establish a basis for further education and employment in many fields, e.g. animal welfare, food technology, forensics, health and medicine, the pharmaceutical industry, recreation and tourism, research, and the resources sector.

1.1.2 Learning area structure

Figure 1: Summary of subjects offered in the Science learning area



1.2 Teaching and learning

1.2.1 Dimensions and objectives

The dimensions are the salient properties or characteristics of distinctive learning for this subject. The objectives describe what students should know and be able to do by the end of the course of study.

Progress in a particular dimension may depend on the knowledge, understanding and skills developed in other dimensions. Learning through each of the dimensions increases in complexity to allow for greater independence for learners over a four-unit course of study.

The standards have a direct relationship with the objectives, and are described in the same dimensions as the objectives. Schools assess how well students have achieved all of the objectives using the standards.

The dimensions for a course of study in this subject are:

- Dimension 1: Knowing and understanding
- Dimension 2: Analysing and applying
- Dimension 3: Planning and evaluating.

Dimension 1: Knowing and understanding

Knowing and understanding refers to the recall, description and explanation of relevant scientific understanding that forms the basis for scientific literacy. It involves retrieving relevant knowledge from memory, constructing meaning from instructional messages, and recognising, interpreting, explaining and demonstrating the scientific knowledge needed to discuss scientific issues.

Objectives

By the conclusion of the course of study, students should:

- describe and explain scientific facts, concepts and phenomena in a range of situations
- describe and explain scientific skills, techniques, methods and risks.

When students describe and explain, they give an account of characteristics or features, and provide additional information that demonstrates understanding of scientific facts, concepts and phenomena as well as skills, techniques, methods and risks. They recognise and recall relevant facts, and they interpret, classify, compare and summarise scientific data, information, techniques, processes and practices.

Dimension 2: Analysing and applying

Analysing and applying incorporates components of scientific inquiry including analysing research findings and data, collecting and recording quantitative and qualitative data, and applying research and practical scientific skills. This data and information is communicated and presented to meet particular purposes and audience needs.

Objectives

By the conclusion of the course of study, students should:

- analyse data, situations and relationships
- apply scientific knowledge, understanding and skills to generate solutions

- communicate using scientific terminology, diagrams, conventions and symbols.

When students analyse, they distinguish relevant from irrelevant information, dissect situations to ascertain and examine constituent parts, and identify patterns, similarities and differences, for the purpose of finding meaning or relationships.

When students apply, they carry out or use procedures based on the context in a given situation. They use scientific understanding, practical scientific skills, research processes and methods, to investigate scenarios and phenomena, and to solve problems. Students use materials, equipment and technology safely.

When students communicate, they share and present scientific data and information for particular purposes and audiences. They construct evidence-based arguments, use appropriate scientific language, diagrams, conventions, symbols and representations to convey meaning.

Dimension 3: Planning and evaluating

Planning and evaluating incorporates components of scientific inquiry, including planning investigations, developing and refining research questions or hypotheses, evaluating evidence and drawing conclusions about scientific questions and issues in contemporary and authentic scientific contexts.

Objectives

By the conclusion of the course of study, students should:

- plan scientific activities and investigations
- evaluate reliability and validity of plans and procedures, and data and information
- draw conclusions, and make decisions and recommendations using scientific evidence.

When students plan, they generate methods and procedures to conduct scientific activities and investigations that will allow them to explore questions and test hypotheses guided by scientific understanding and information gathered in research.

When students evaluate, they examine and judge the merit or significance or value of plans, procedures, data and information, considering the consistency and reproducibility of results, the quality of the methods and how results relate to known scientific facts and understanding.

When students draw conclusions, and make decisions and recommendations, they make logical inferences based on results of findings, scientific facts, concepts, theories or laws. They provide a judgment or an answer after considering various alternatives. Students take into account ethical frameworks and guidelines based on scientific evidence and consider contemporary values and needs.

1.2.2 Underpinning factors

There are five factors that underpin and are essential for defining the distinctive nature of Applied syllabuses:

- applied learning
- community connections
- core skills for work
- literacy
- numeracy.

These factors build on the general capabilities found in the P–10 Australian Curriculum. They overlap and interact, are derived from current education, industry and community expectations, and inform and shape Science in Practice.

All Applied syllabuses cover all of the underpinning factors in some way, though coverage may vary from syllabus to syllabus. Students should be provided with a variety of opportunities to learn through and about the five underpinning factors across the four-unit course of study.

Applied learning and community connections emphasise the importance of applying learning in workplace and community situations. Applied learning is an approach to contextualised learning; community connections provide contexts for learning, acquiring and applying knowledge, understanding and skills. Core skills for work, literacy and numeracy, however, contain identifiable knowledge and skills which can be directly assessed. The relevant knowledge and skills for these three factors are contained in the course dimensions and objectives for Science in Practice.

Applied learning

Applied learning is the acquisition and application of knowledge, understanding and skills in real-world or lifelike contexts. Contexts should be authentic and may encompass workplace, industry and community situations.

Applied learning values knowledge — including subject knowledge, skills, techniques and procedures — and emphasises learning through doing. It includes both theory and the application of theory, connecting subject knowledge and understanding with the development of practical skills.

Applied learning:

- links theory and practice
- integrates knowledge and skills in real-world and/or lifelike contexts
- encourages students to work individually and in teams to complete tasks and solve problems
- enables students to develop new learnings and transfer their knowledge, understanding and skills to a range of contexts
- uses assessment that is authentic and reflects the content and contexts.

Community connections

Community connections build students' awareness and understanding of life beyond school through authentic, real-world interactions. This understanding supports transition from school to participation in, and contribution to, community, industry, work and not-for-profit organisations. 'Community' includes the school community and the wider community beyond the school, including virtual communities.

Valuing a sense of community encourages responsible citizenship. Connecting with community seeks to deepen students' knowledge and understanding of the world around them and provide them with the knowledge, understanding, skills and dispositions relevant to community, industry and workplace contexts. It is through these interactions that students develop as active and informed citizens.

Schools plan connections with community as part of their teaching and learning programs to connect classroom experience with the world outside the classroom. It is a mutual or reciprocal arrangement encompassing access to relevant experience and expertise. The learning can be based in community settings, including workplaces, and/or in the school setting, including the classroom.

Community connections can occur through formal arrangements or more informal interactions. Opportunities for community connections include:

- organising an event for the school or local community
- working with community groups in a range of activities
- attending industry expos and career 'taster' days
- participating in mentoring programs and work shadowing
- gaining work experience in industry
- participating in community service projects or engaging in service learning
- interacting with visitors to the school, such as community representatives, industry experts, employers, employees and the self-employed
- undertaking field work (see Developing a module of work)
- internet, phone or video conferencing with other school communities.

Core skills for work

In August 2013, the Australian Government released the *Core Skills for Work Developmental Framework (CSfW)*[1]. The *CSfW* describes a set of knowledge, understanding and non-technical skills that underpin successful participation in work.[2] These skills are often referred to as generic or employability skills. They contribute to work performance in combination with technical skills, discipline-specific skills, and core language, literacy and numeracy skills.

The *CSfW* describes performance in ten skill areas grouped under three skill clusters, shown in Table 1 below. These skills can be embedded, taught and assessed across Science in Practice.

Table 1: Core skills for work skill clusters and skill areas

	Skill cluster 1: Navigate the world of work	Skill cluster 2: Interacting with others	Skill cluster 3: Getting the work done
Skill areas	• Manage career and work life • Work with roles, rights and protocols	• Communicate for work • Connect and work with others • Recognise and utilise diverse perspectives	• Plan and organise • Make decisions • Identify and solve problems • Create and innovate • Work in a digital world

Literacy in Science in Practice

The information and ideas that make up the Science in Practice are communicated in language and texts. Literacy is the set of knowledge and skills about language and texts that is essential for understanding and conveying this content.

Each Applied syllabus has its own specific content and ways to convey and present this content. Ongoing systematic teaching and learning focused on the literacy knowledge and skills specific to Science in Practice is essential for student achievement.

Students need to learn and use knowledge and skills of reading, viewing and listening to understand and learn the content of Science in Practice. Students need to learn and use the

[1] More information about the *Core Skills for Work Developmental Framework* is available at https://docs.education.gov.au/node/37095.

[2] The term 'work' is used in the broadest sense: activity that is directed at a specific purpose, which may or may not be for remuneration or gain.

knowledge and skills of writing, composing and speaking to convey the Science in Practice content they have learnt.

In teaching and learning in Science in Practice, students learn a variety of strategies to understand, use, analyse and evaluate ideas and information conveyed in language and texts.

To understand and use Science in Practice content, teaching and learning strategies include:

- breaking the language code to make meaning of scientific language and texts, including graphics, diagrams and tables
- comprehending language and texts to make literal and inferred meanings about science content
- using scientific ideas and information in classroom, real-world and/or lifelike contexts to progress their own learning.

To analyse and evaluate Science in Practice content, teaching and learning strategies include:

- making conclusions about the purpose and audience of scientific language and texts
- analysing the ways language is used to convey ideas and information in science texts
- transforming language and texts to convey scientific ideas and information in particular ways to suit audience and purpose.

Relevant aspects of literacy knowledge and skills are assessed, as described in the standards.

Numeracy in Science in Practice

Numeracy is about using mathematics to make sense of the world and applying mathematics in a context for a social purpose.

Numeracy encompasses the knowledge, skills, behaviours and dispositions that students need to use mathematics in a wide range of situations. Numeracy 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.[3]

Although much of the explicit teaching of numeracy skills occurs in Mathematics, being numerate involves using mathematical skills across the curriculum. Therefore, a commitment to numeracy development is an essential component of teaching and learning across the curriculum and a responsibility for all teachers.

To understand and use Science in Practice content, teaching and learning strategies include:

- identifying the specific mathematical information
- providing learning experiences and opportunities that support the application of students' general mathematical knowledge and problem-solving processes
- communicating and representing the language of numeracy in teaching, as appropriate.

Relevant aspects of numeracy knowledge and skills are assessed, as described in the standards.

[3] ACARA, General capabilities, Numeracy, www.australiancurriculum.edu.au/GeneralCapabilities/Numeracy/Introduction/Introduction.

1.2.3 Planning a course of study

Science in Practice is a four-unit course of study.

Units 1 and 2 of the course are designed to allow students to begin their engagement with the course content, i.e. the knowledge, understanding and skills of the subject. Course content, learning experiences and assessment increase in complexity across the four units as students develop greater independence as learners.

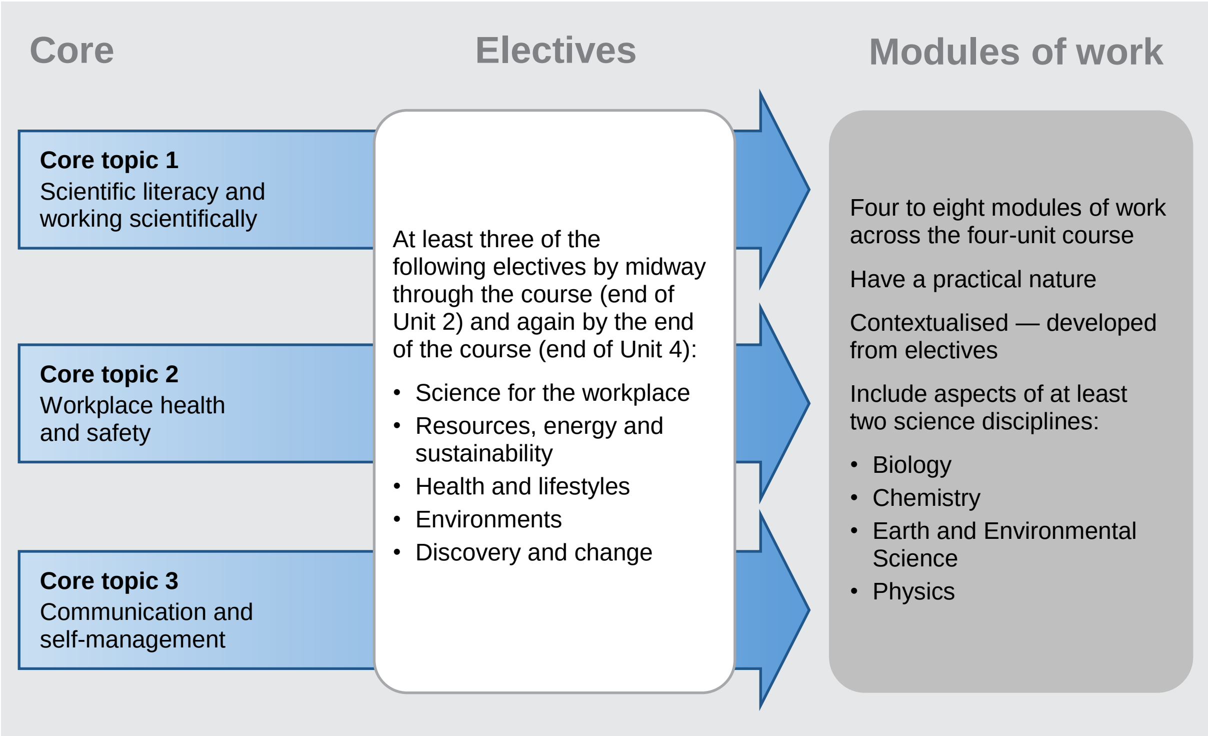
Units 3 and 4 consolidate student learning.

The minimum number of hours of timetabled school time, including assessment, for a course of study developed from this Applied syllabus is 55 hours per unit. A course of study will usually be completed over four units (220 hours).

A course of study for Science in Practice includes:

- core topics — 'Scientific literacy and working scientifically', 'Workplace health and safety' and 'Communication and self-management' — and their associated concepts and ideas integrated into modules of work across Units 1 and 2, and further developed in Units 3 and 4 (see Core)
- electives — at least three electives by midway through the course (end of Unit 2) and again by the end of the course (end of Unit 4) (see Electives)
- modules of work — four to eight modules of work over the four-unit course, where modules of work must:
  - have a practical nature
  - use a contextualised approach (see Developing a module of work) developed from one (or more) elective/s
  - include learning experiences from aspects of at least two science disciplines (Biology, Chemistry, Earth and Environmental Science or Physics)
- field work — at least five hours of field work by midway through the course (end of Unit 2) and again by the end of the course (end of Unit 4) (see Developing a module of work).

Figure 2: A course of study — the relationship between core, electives and modules of work



1.2.4 Developing a module of work

Modules of work must integrate aspects of the concepts and ideas from each of the core topics (see Core), have a practical nature, and use a contextual approach developed from one (or more) elective/s that facilitate/s the inclusion of learning experiences from aspects of at least two science disciplines (Biology/Chemistry/Earth and Environmental Science/Physics) (see Electives).

Modules of work developed through contexts enable students to identify science in their world and understand the importance of science in their lives. By engaging with scientific concepts in a range of contexts, students have the opportunity to develop informed and transferable understandings.

A context that is purposeful and significant for learning is a framework that links concepts and learning experiences in real-world situations. A context can be developed using:

- a key question or series of questions
- investigation/s
- hypotheses to be tested
- a problem or problems to be solved
- design challenges
- issues.

When developing a module of work schools:

- establish a focus for the context based on one or more of the electives
- identify relevant concepts and ideas, and associated subject matter, from the core topics
- consider suitable assessment techniques, identifying the objectives from the dimensions, and concepts and ideas from the core topics, that will be assessed
- outline a teaching and learning sequence that identifies the relevant facts and concepts from at least two science disciplines (Biology, Chemistry, Earth and Environmental Science or Physics) that students will learn.

Field work

Field work forms an integral part of this syllabus. It is important that schools recognise the need to provide adequate time for learning experiences of a practical nature and connect classroom experience with the world outside the classroom by planning connections with community as part of their teaching and learning programs (see Underpinning factors).

Five to 10 hours by midway through the course (end of Unit 2) and again by the end of the course (end of Unit 4) is recommended for student field work. Field work may range from local, short-duration activities to an extended excursion, e.g. visiting local industries, places of work, research laboratories and museums; accessing mobile laboratories, displays and resources; and researching local natural environments such as bushland, creeks and dams.

Defining *inquiry* in science education

This syllabus provides guidance to support schools in aligning a chosen pedagogical framework with the curriculum and assessment expectations outlined in this syllabus. This guidance clarifies the use of the term *inquiry* and articulates a framework to describe the process of inquiry. The purpose of this guidance is to prevent misunderstandings and problematic conflations and their subsequent negative impact on student learning. As Abrams, Southerland and Silva (2008, p. xv) stated in their book, *Inquiry in the Classroom: Realities and opportunities*:

> Inquiry in the classroom can be conceived as a complex set of ideas, beliefs, skills, and/or pedagogies. It is evident that attempting to select a singular definition of inquiry may be an insurmountable and fruitless task. Any single definition of inquiry in the classroom would necessarily reflect the thinking of a particular school of thought, at a particular moment in time, or a particular goal, and such a singular definition may serve to limit legitimate and necessary components of science learning. **However, operating without a firm understanding of the various forms of inquiry leaves science educators often 'talking past' one another, and often results in very muddled attempts in the classroom.**

Uses of the term *inquiry*

Common phrases involving the term *inquiry* have been listed below:

- science inquiry
- science inquiry skills
- the inquiry process
- inquiry-based learning.

This syllabus refers to the first three uses listed above. The first, *science inquiry*, defines the practical work of a scientist (Harlen 2013). The second, *science inquiry skills*, refers to the skills required to do the work of a scientist (Harlen 2013). The third, *the inquiry process*, is a framework that can be used to describe the process of asking a question and then answering it.

The final phrase, *inquiry-based learning*, refers to a variety of teaching and learning strategies an educator may choose to use within their school's pedagogical framework. Although a school may choose to adopt an inquiry-based pedagogy, this syllabus is *not* intended to endorse or recommend an inquiry-based learning approach.

Science inquiry and science inquiry skills

Science inquiry involves identifying and posing questions and working to answer them. It is concerned with evaluating claims, investigating ideas, solving problems, reasoning, drawing valid conclusions and developing evidence-based arguments. It can easily be summarised as the 'work of a scientist' (Hackling 2005).

Within this syllabus, it is expected that students will engage in *aspects* of the work of a scientist by engaging in science inquiry (Tytler 2007).

Science inquiry skills are the skills required to do the work of a scientist. They include writing research questions, planning, conducting, recording information and reflecting on investigations; processing, analysing and interpreting evidence; evaluating conclusions, processes and claims; and communicating findings (ACARA 2015c).

It is expected that students are taught science inquiry skills (Krajcik et al 2000). The syllabus outlines a number of these skills in the subject matter. Teachers decide how the science inquiry skills are to be developed. For example, teachers will determine opportunities to:

- develop, rehearse and refine science inquiry skills
- engage students in scaffolded or open-ended science inquiry tasks
- formatively assess science inquiry skills.

Framework to describe the inquiry process

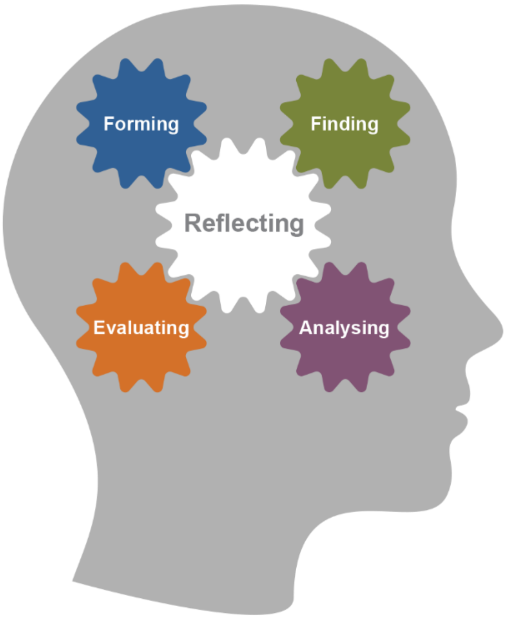
In order to support student engagement in activities involving inquiry, it is useful to establish a common language or framework to distinguish between stages of the process.

The stages involved in any inquiry are:

- forming and describing the inquiry activity
- finding valid and reliable evidence for the inquiry activity
- analysing and interpreting the evidence selected
- evaluating the conclusions, processes or claims.

This framework uses reflection as the connection between, and driver of, all the stages. The progression through the inquiry process requires reflection on the decisions made and any new information that has emerged during the process to inform the next stage. Each stage of the inquiry process is worthy of reflection, the result of which may be the revision of previous stages (Marzano & Kendall 2007).

Figure 3: Stages of inquiry process



Scientific literacy

Science in Practice continues the development of scientifically literate individuals who are able to:

- connect scientific knowledge to everyday life and the world around them
- respond critically and analytically to new technologies and associated issues
- understand uncertainty and risk, how scientists work, and the impact of science on people's lives
- understand the evolving and interdisciplinary nature of science, the links with technology, and the complexity of systems with many interconnected effects (such as balancing economic, social, energy and environmental factors)
- identify scientific questions, and investigate and draw evidence-based conclusions
- be sceptical and questioning of claims made by others
- think critically about significant contemporary issues, using an understanding of science
- apply their knowledge in a broad range of relevant practical situations, including field work
- use community and industry resources; and use technology
- collaborate and work safely and effectively in teams
- participate as informed and responsible citizens in decision-making processes, making informed decisions about the environment and their own health and wellbeing.[4]

[4] Adapted from Rennie, L 2006, *The community's contribution to science learning: Making it count*, Proceedings of the Australian Council for Educational Research, Melbourne, p. 6. And Tytler, R 2007, 'Re-imagining Science Education: Engaging students in science for Australia's future', *Australian Education Review*,

1.2.5 Aboriginal perspectives and Torres Strait Islander perspectives

The Queensland Government has a vision that Aboriginal and Torres Strait Islander Queenslanders have their cultures affirmed, heritage sustained and the same prospects for health, prosperity and quality of life as other Queenslanders. The QCAA is committed to helping achieve this vision, and encourages teachers to include Aboriginal perspectives and Torres Strait Islander perspectives in the curriculum.

The QCAA recognises Aboriginal peoples and Torres Strait Islander peoples, their traditions, histories and experiences from before European settlement and colonisation through to the present time. Opportunities exist in Science in Practice to encourage engagement with Aboriginal peoples and Torres Strait Islander peoples, strengthening students' appreciation and understanding of:

- frameworks of knowledge and ways of learning
- contexts in which Aboriginal peoples and Torres Strait Islander peoples live
- contributions to Australian society and cultures.

Aboriginal peoples and Torres Strait Islander peoples have successfully managed their environment for thousands of years. The land provides the primary resources for clothes, food, building materials and all the other items required for a healthy sustainable life. Traditional land use practices of Aboriginal peoples and Torres Strait Islander peoples include the use of resources in such a way that they are renewed and not exhausted.

Aboriginal peoples and Torres Strait Islander peoples rely on specific knowledge of the local area, including the complex diversity of plants and animals found there and the physical environment and ecology in which they live. There is a deep understanding of season changes and how they affect ways of life.

Aboriginal peoples and Torres Strait Islander peoples have diverse relationships with, connections to and understanding of the Australian environment. Aboriginal peoples refer to 'Country' while Torres Strait Islander peoples refer to 'Place' — the significant place they have a symbiotic connection to and relationship with, including the people, flora, fauna, waterways, sky, spirituality (ancestors) and weather cycles.

Guidelines about Aboriginal perspectives and Torres Strait Islander perspectives and resources for teaching are available at www.qcaa.qld.edu.au/k-12-policies/aboriginal-torres-strait-islander-perspectives.

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http://research.acer.edu.au/aer/3, pp. 26–27.

2 Subject matter

2.1 Core

The core is the conceptual base for the four-unit course of study and is what all students who undertake this subject will have the opportunity to learn. The core of this subject consists of three interrelated topics:

- Scientific literacy and working scientifically
- Workplace health and safety
- Communication and self-management.

Each core topic has concepts and ideas that require exploration in an interrelated way and are not intended to be treated in isolation. The concepts and ideas have associated knowledge, understanding and skills. Together these are designed to encapsulate and develop an understanding of science, the role it plays in society and how people are expected to work in a scientific context.

The concepts and ideas from the core topics will be explored and developed on multiple occasions. Not that all the concepts and ideas will necessarily be covered in each module of work, but they must be covered midway through the course (end of Unit 2) and again by the end of the course (end of Unit 4). The associated knowledge, understanding and skills should be covered through learning experiences by the end of the four-unit course of study.

The core topics are presented in tables on the following pages.

2.1.1 Core topic 1: Scientific literacy and working scientifically

Focus	
This core topic is designed to encourage students to become scientifically informed individuals. Scientific literacy is a way of thinking and a way of viewing and interacting with the world; it is encouraged and developed through working scientifically. Working scientifically encompasses the practical and analytical approaches of scientific inquiry and investigation. When working scientifically students make sense of the phenomena they experience as they investigate, understand and communicate.	
Concepts and ideas	**Knowledge, understanding and skills**
Scientific literacy Informed participation in a technologically and scientifically advanced society requires scientific literacy (C1.1).	• relevant facts and concepts of Biology, Chemistry, Earth and Environmental Science or Physics that explain various phenomena in different contexts • scientific knowledge needed to discuss relevant contemporary scientific issues • ethical implications of science research and technology • evidence-based arguments
Scientific methodology Scientific methodology involves asking questions about the natural world and systematically collecting and analysing data to address the question (C1.2).	• research questions and/or hypotheses – problems and/or issues that can be investigated scientifically – hypothesis writing • variables: – dependent – independent – controlled (and the importance of controlled variables) – measurement • reliability, accuracy and precision: – technology use – sources of error • results: – patterns, trends, and anomalies – results checked against scientific concepts and theories
Thinking scientifically Thinking scientifically involves: • asking for evidence to support a claim before accepting it as reasonable • admitting to being uncertain when evidence is lacking • rejecting a claim as unreasonable, when evidence does not support it (C1.3).	• validity and reliability of claims • quality of methodologies and evidence • evidence and reasoning for accepting or rejecting claims • evidence-based conclusions (claims that fit with data, information and evidence)

2.1.2 Core topic 2: Workplace health and safety[5]

Focus	
This core topic is designed to introduce students to the principles and practices of workplace health and safety when operating in a scientific context, e.g. the safe use of equipment and resources either in or outside the laboratory. Workplace health and safety legislation requires that a risk assessment be carried out before performing laboratory procedures. This risk assessment should follow the hierarchy of control to minimise the risks. Risk assessments should consider all aspects of the activity and be undertaken before starting. Different activities may require more considerations due to their levels of associated risks. Health and safety risk management involves: • identifying the hazards • assessing the risks • controlling the risks • monitoring and reviewing the level of safety.	
Concepts and ideas	**Knowledge, understanding and skills**
Workplace safety Workplace safety rules are required for working in a scientific area (C2.1).	• workplace health and safety requirements and safe operational scientific procedures • workplace health and safety documents, e.g. – safety data sheets (SDS) – standard operating procedures (SOP) – relevant Australian standards
Risk assessment Risk assessments are conducted to identify hazards and prevent potential incidents; and hazard reports are conducted to identify concerns and prevent harm (C2.2).	• hazard identification, assessment and reporting (in the laboratory and the field) • hazardous substances — reading labels and SDS • administrative control for hazardous substances and situations
Safe working procedures Safe working procedures are essential when participating in scientific activities and taking precautions will reduce the potential of incidents and injuries (C2.3).	• personal protection equipment (PPE) • surroundings adapted to meet safety requirements • precautions to prevent injury, e.g. when handling glass and/or hot objects • correct SOP when: – using hazardous substances – handling and using a range of tools, technologies and equipment – handling biological materials such as live animal and plant specimens, microorganisms and materials for dissection – working in the laboratory and in the field

[5] Teachers should access the *Curriculum Activity Risk Management Guidelines* provided by the Department of Education, Training and employment: http://www.education.qld.gov.au/curriculum/carmg/index.html.

2.1.3 Core topic 3: Communication and self-management

Focus	
This core topic is designed to increase awareness of the balance between discipline-specific skills and those necessary for the workplace. It is important for students to develop communication and self-management skills, including initiative, teamwork, problem-solving, planning and organisation and technological competence. These, along with the General capabilities[6] are also beneficial for successful participation in Australian society. In a world where knowledge rapidly becomes obsolete the ability to identify, access, network and communicate new information is vital for career success.	
Concepts and ideas	**Knowledge, understanding and skills**
Communication Participation in contemporary Australian society and work requires clear and appropriate oral and written communication (C3.1).	• communication in a scientific context: – using scientific terminology – recording accurate and thorough data using appropriate formats • communication in a workplace: – using language for the workplace – following oral and written instruction and information – giving clear oral and written communication – using technology to communicate information clearly and concisely
Self-management Self-management skills are required in the workplace, laboratory and field (C3.2).	• work with minimal supervision: – following safe work practices when carrying out procedures – recognising industry standards – applying work ethics • team work in the workplace: – communicating interpersonally – self-organising – identifying collective goals – defining and allocating roles – persisting • organisation and preparation of materials and/or equipment for self and others • time management — completing tasks within agreed timeframes
Problem-solving Development of problem-solving skills that allows for initiative in the planning and organisation of activities (C3.3).	• problem-solving skills including: – clarifying issues and problems to frame a possible problem-solving process – working systematically through issues – generating alternative approaches – modifying and refining ideas when circumstances change – applying knowledge and problem-solving skills to new contexts – analysing and synthesising information to inform a course of action

[6] 'General capabilities, a key dimension of the Australian Curriculum, are addressed explicitly in the content of the learning areas.' ACARA, *General capabilities in the Australian Curriculum*, www.australiancurriculum.edu.au/generalcapabilities/overview/general-capabilities-in-the-australian-curriculum.

2.2 Electives

2.2.1 Science for the workplace

Focus	Science disciplines
The nature of work and the skills work requires, change rapidly. New skills in the workplace are in demand all the time; at the same time some skills are becoming obsolete. Employers argue that communication, teamwork, problem solving, initiative and enterprise, planning and organising, self-management, and learning and technology skills are as important as professional, paraprofessional and technical skills. Students should explore and develop an awareness of science as it operates in common or local workplaces. A module of work may be designed, which provides opportunities to apply scientific knowledge and skills to specific work roles and/or environments. This will depend on ease of access to community resources, local trades and industry, and the needs and interests of the students.	Biology (B) Chemistry (C) Earth and Environmental Science (E) Physics (P)

Examples
Investigate and apply scientific knowledge and skills related to specific career opportunities in industries such as viticulture, brewing, mining, dairy and cheese production, bread-making, electrotechnology or other trades, water-quality management, veterinary science, sports science, and chemical and civil engineering. (B/C/E/P)
Solve problems in specific contexts related to industries such as fashion design, hospitality, farming, fisheries and agriculture, sports science and recreation — using a scientific approach and skills that can be transferred across different career paths. (B/C/E/P)
Ask how an organisation such as Choice uses science for consumer protection. (B/C/P)
Study the science involved in electrical trades, including basic circuits, electrical quantities, and measurement techniques, soldering and fabrication, electrical safety, the physiological effects of electricity on human body, and biomedical signals such as electrocardiograms (ECGs).(B/C/P)
Learn how to make evidence-based decisions by applying the principles of scientific scepticism (questioning whether a claim is supported by reproducible empirical research) to test a claim that may or may not be a myth. (B/C/E/P)
Act as a science advisor for a film or television show, identifying and explaining where they get the science right and wrong. Examples include sound in space, time taken for information to travel large distances, alien biology, the effect of gravity, the motion of spaceships in space, the use of terminology, e.g. parsec. (B/E/P)
Undertake a simulated crime scene investigation, using forensic science techniques and approaches. (B/C/P)
Ask how safety technologies protect people in the workplace. (B/C/P)
Investigate the personal hygiene policies of various work settings and evaluate their likely efficacy. (B/C)
Investigate and explain how an appliance, such as a microwave oven or LCD television, works. (B/C/P)
Undertake a science design challenge in a team, developing teamwork and leadership skills valued by employers. For example: • develop a water-quality test kit (C/E) • develop and test an antibacterial cleaning agent (B/C) • construct an efficient solar hot-water heater (E/P) • design and test a model ‘earthquake-proof’ building (E/P) • model an artificial pump and valve for the circulatory system. (B/P)

2.2.2 Resources, energy and sustainability

Focus	Science disciplines
Solutions to humanity's energy and resource challenges are likely to come from the application of science and technology. Students should develop an awareness of the consequences of using resources by considering their short-term and long-term impacts as well as their sustainability. 'Fossil fuels will continue to play a major role in our regional and global energy needs … joint research, development, deployment and transfer of low and zero emission technologies for their cleaner use, particularly coal, will be essential. It is also important to enhance energy efficiency and diversify energy sources and supplies, including renewable energy. For those economies which choose to do so, the use of nuclear energy, in a manner ensuring nuclear safety, security and non-proliferation in particular its safeguards, can also contribute' (APEC Sydney Declaration, 2007).[7]	Biology (B) Chemistry (C) Earth and Environmental Science (E) Physics (P)
Examples	
Research whether solar photovoltaic systems the most efficient renewable energy source for Australian houses. (C/P)	
Explain the considerations behind producing an economically and environmentally sustainable crop. (B/E)	
Ask whether Australia can really be the 'food bowl' of South-East Asia by considering the land, water, fertilisers and chemicals required to grow food crops. (B/C/E)	
Research the likely impacts of global energy requirements. (B/C/E/P)	
Consider what place nuclear energy has in Australia's future. (B/E/P)	
Research and test building materials that meet a specific purpose — e.g. the design of an energy-efficient house and the transfer of heat through a material. (C/E/P)	
Test the hypothesis that dishwashers are more water-efficient than washing by hand. (E/P)	
Investigate: • the role that non-renewable and/or renewable energy plays in developing economies (E/P) • the role of alternative energy sources in an agricultural context — biofuels, wind and solar (B/C/E/P) • rare earth minerals — what they are, and where and how they are found and extracted (E/P) • the process of mineral extraction from ore (C/E) • the difference in types of unleaded fuels (C/E) • whether Australia has enough fossil fuels to be independent from imports (C/E/P) • how to measure the water consumption of farms (B/E) • where the rubber from car tyres originates and what happens to it once it's used (B/C/E) • whether the food choices of Australians are sustainable — consider ecological footprint and health, and make comparisons to other countries (B/C/E) • strategies to reduce water pollution — personal, commercial or government initiatives. (C/E/P)	
Conduct an impact study on the technologies in a building and outline a plan to substitute high energy/ecological footprint technologies with low footprint replacements.	

[7] Australia–Pacific Economic Cooperation (APEC) 2007, *Sydney APEC Leaders' Declaration on Climate Change, Energy Security and Clean Development*, Sydney, Australia, www.apec.org/Meeting-Papers/Leaders-Declarations/2007/2007_aelm/aelm_climatechange.aspx.

2.2.3 Health and lifestyles

Focus	Science disciplines
Individuals and industry have a responsibility, to themselves and to society, to promote health. Increasing numbers of individuals are being diagnosed with diseases such as asthma, arthritis, cancer, obesity, allergies, diabetes and cardiovascular disease. The impacts of science on health and safety have accelerated in the last century. Students should understand the potential impact of science, that it has great implications for the future and affects not only humans, but also plants and animals. Science can provide preventative measures and solutions to health and lifestyle challenges. 'A … challenge for the future is to engage the methods of science in addressing the entire gamut of factors affecting health; these include behavioural and environmental influences … Thus we must consider all levels of biological organisation — from cellular and molecular to functional systems, organisms and populations' (Hamburg & Nightingale, 1984).[8]	Biology (B) Chemistry (C) Earth and Environmental Science (E) Physics (P)

Examples
Explain the science behind Australian government recommendations for diet and exercise. (B/C)
Explain the relationship between bones and skeletal muscles and body movements, and how sports scientists use this knowledge. (B/P)
Examine road safety regulations and safe driving recommendations, and use science to demonstrate an understanding of why they are what they are, e.g. the two-second rule for safe following distance. (B/P)
Evaluate the science behind a claim of the cosmetics industry, e.g. conditioner makes hair 'stronger'. (B/C)
Explain the underlying science of a specific diagnostic medical technology, e.g. ultrasound. (B/C/P)
Evaluate different methods researchers employ to mitigate confounding variables, such as the placebo effect and regression to the mean, to validate the efficacy of a medical intervention. (B/C)
Investigate: • the 'hidden' sugar content of foods and drinks (B/C) • a particular 'lifestyle disease', considering diet and other lifestyle factors (B/C) • a 'fad' diet (B/C) • the increase in allergies and food intolerances (B/C) • the science behind recommendations for use of smart phones (B/P) • the use of growth and other hormones in the livestock industry (B/C/E) • water quality and waterborne diseases in less developed countries (B/C/E/P) • the re-hydration claims of sports drinks and recommend who should consume them and when they should consume them (B/C) • an infectious disease — how it is transmitted, its effect, how epidemiologists model its spread, and how it is controlled and treated (B/C) • human interactions and the effect of technology use on circadian rhythms (B/C/E/P) • how a particular pharmaceutical was developed and its effect on the body. (B/C)
Ask how cognitive biases are minimised by conducting double-blind randomised controlled trials, e.g. testing the hypothesis that people like the taste of bottled water more than tap water. (B/C)
Review the evidence for and against a particular claim in sports performance science, such as the claim that barefoot running results in fewer injuries. (B/P)
Gather data comparing the rate at which capsules, tablets, enteric-coated tablets, and slow-release tablets dissolve and investigate how effectively they are absorbed into the body. (B/C)

[8] Hamburg, DA & Nightingale, EO 1984, 'Science for health in the future' in *Health Affairs*, 3, no.4, pp. 94–109, http://content.healthaffairs.org/content/3/4/94.citation.

2.2.4 Environments

Focus	Science disciplines
Environments can be defined by their geology and ecology, their size, or whether they are natural or human-made. Students should understand that the management of environments relies on understanding their individual components, inherent interrelationships, and the impact of the human species on them. As part of, and determining factors in, the environment, human interactions with the Earth have a profound effect on present and future generations. Science can inform these complex global problems. ‘When human numbers were small, our technology simple and our consumption mainly for survival, nature was generally able to absorb our impact … Consider this: … in a mere 100 years, the population of the planet has quadrupled. Almost all the modern technology we take for granted has been developed and expanded since the late 1800s … these factors have amplified humanity’s ecological footprint … consequently we are now altering the chemical, physical and biological makeup of the planet on a geological scale’ (David Suzuki, 2008).[9]	Biology (B) Chemistry (C) Earth and Environmental Science (E) Physics (P)

Examples
Research whether human activities are harming an ecosystem, e.g. a rainforest ecosystem, the fisheries of Moreton Bay or the Great Barrier Reef. (B/C/E)
Ask how regulations are designed to counteract the impact of commercial and recreational fishing. (B/E)
Consider whether we are living in an ‘extinction period’. (B/C/E/P)
Undertake water quality testing. (C/E)
Undertake vegetation sampling and soil testing in a defined area. (C/E)
Explore how the Australian environment has changed over time. (B/E)
Conduct an energy audit and rate a building for its environmental design. (E/P)
Investigate: • the impacts of: – irrigation, soil salinity and sustainable farming (B/C/E) – an introduced species in a specific environment (B/E) – the industrial uses of water — including an Australian case study (B/C/E/P) • water and sanitation in less developed countries (B/C/E/P) • the movement of water through different substrates — clay, topsoil, and sand (C/E/P) • the biodegradability of soaps and soap-less detergents (B/C) • the biological productivity of a marine environment (B/C/E/P) • environmental damage caused by various types of waste (including from energy sources and vehicles), exploring the relevant biological and chemical processes developed to minimise this (B/C/E) • a specific disaster or accident, human caused or natural. (B/C/E/P)
Design a program to control a specific pest. (B/C/E/P)
Design and maintain a habitat for a species, e.g. red claw lobster, barramundi, poultry, or worms. (B/C/E)
Explain the science behind warning devices that detect or predict natural disasters and human emergencies. (B/C/E/P)
Design a highly fertile soil for a vegetable garden. (B/C/E)

[9] Suzuki, D, 2008 ‘The challenge of the 21st century: Setting the real bottom line’, lecture presented to the Commonwealth Foundation, London, UK.

2.2.5 Discovery and change

Focus	Science disciplines
Changing circumstances and paradigms often precipitate rapid progress in science. These circumstances could include: crises, global change, the work of individuals, changes in technology and new frontiers for exploration. Cutting-edge technology has forged new frontiers, from computer-based drug design to landing a probe on a comet. Students should examine discoveries in science or where scientific understanding has been challenged and modified. The motives for doing science can include natural curiosity; seeing economic opportunity; and recognition of threats to health, safety, or the national or personal interest. Scientific discoveries often result in an explosion of knowledge and technology. At a sophisticated level these filter down to consumers in a short period of time and at economical rates. They can also lead to the development of new industry and employment opportunities. 'Science and innovation are recognised internationally as key for boosting productivity, creating more and better jobs, enhancing competitiveness and growing an economy … [Skills in Science, Technology, Engineering and Mathematics] are the lifeblood of emerging knowledge-based industries — such as biotechnology, information and communications technology (ICT) and advanced manufacturing — and provide competitive advantage to established industries — such as agriculture, resources and healthcare' (Australian Government, 2014).[10]	Biology (B) Chemistry (C) Earth and Environmental Science (E) Physics (P)

Examples
Explain the science behind a medical technology, e.g. artificial heart valve, pacemaker, hearing aid. (B/C/P)
Outline the key components required to undertake a human mission to Mars. (B/C/E/P)
Compare a biological system to human-developed equivalent, e.g. an eye to a camera, animal echolocation to radar or lidar, plant photosynthesis to artificial photosynthesis. (B/C/P)
Compare and contrast the properties and application of natural and synthetic polymers. (B/C)
Reconstruct the evidence Kepler and Galileo gathered for the heliocentric model of the solar system — Kepler's laws of planetary motion and Galileo's observations of Jupiter's moons. (E/P)
Investigate commercial activity that has led to scientific innovation, such as the: • development of chemical technology for production of substances applied to hair and skin (B/C) • use of chemistry and biology to improve the appearance, taste and/or shelf life of food (B/C) • development of 'gorilla glass' (C/P) • application of nanotechnology in drug delivery (B/C/P) • development of wearable fitness trackers. (B/P)
Construct and test a model rocket, and explain how rockets get into orbit. (C/E/P)
Compare and contrast different potential future energy technologies, such as fission, fusion, wind, solar, geothermal, smart grids, and artificial photosynthesis. (B/C/E/P)
Examine the development of electricity, from the first explorations of the ancient Greeks and natural philosophers of the Enlightenment, through to its production and application in modern society (C/E/P)

[10] Office of the Chief Scientist 2014, *STEM: Australia's future*, Australian Government, Canberra, www.chiefscientist.gov.au/wp-content/uploads/STEM_AustraliasFuture_Sept2014_Web.pdf.

Describe and explain the likely impacts of science over the next 100 years. Consider climate change, space travel, communication, water management, food technologies, transport, air quality, or housing. (B/C/E/P)
Investigate and discuss the scientific plausibility of proposed energy technologies used in science fiction, e.g. ‘Dyson spheres’ (Larry Niven, *Ringworld*), ‘Unobtainium’ (James Cameron, *Avatar*), and ‘zero-point vacuum energy’ (Arthur C Clark, *The Songs of Distant Earth*). (C/E/P)

3 Assessment

3.1 Assessment — general information

Assessment is an integral part of the teaching and learning process. It is the purposeful, systematic and ongoing collection of information about student learning outlined in the syllabus.

The major purposes of assessment are to:

- promote, assist and improve learning
- inform programs of teaching and learning
- advise students about their own progress to help them achieve as well as they are able
- give information to parents, carers and teachers about the progress and achievements of individual students to help them achieve as well as they are able
- provide comparable exit results in each Applied syllabus, which may contribute credit towards a Queensland Certificate of Education (QCE); and may contribute towards Australian Tertiary Admission Rank (ATAR) calculations
- provide information about how well groups of students are achieving for school authorities and the State Minister responsible for Education.

Student responses to assessment opportunities provide a collection of evidence on which judgments about the quality of student learning are made. The quality of student responses is judged against the standards described in the syllabus.

In Applied syllabuses, assessment is standards-based. The standards are described for each objective in each of the three dimensions. The standards describe the quality and characteristics of student work across five levels from A to E.

3.1.1 Planning an assessment program

When planning an assessment program over a developmental four-unit course, schools should:

- administer assessment instruments at suitable intervals throughout the course
- provide students with opportunities in Units 1 and 2 to become familiar with the assessment techniques that will be used in Units 3 and 4
- assess all of the dimensions in each unit
- assess each objective at least twice by midway through the course (end of Unit 2) and again by the end of the course (end of Unit 4)
- assess only what the students have had the opportunity to learn, as prescribed in the syllabus and outlined in the study plan.

For a student who studies four units, only assessment evidence from Units 3 and 4 contributes towards decisions at exit.

Further guidance can be found in the QCE and QCIA policy and procedures handbook.

3.1.2 Authentication of student work

Schools and teachers must have strategies in place for ensuring that work submitted for summative assessment is the student's own.

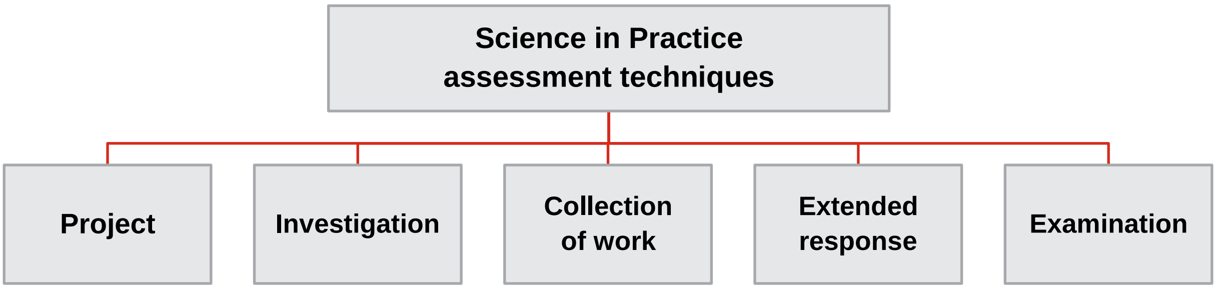
Judgments about student achievement are based on evidence of the demonstration of student knowledge, understanding and skills. Schools ensure responses are validly each student's own work.

Guidance about authentication strategies which includes guidance for drafting, scaffolding and teacher feedback can be found in the QCE and QCIA policy and procedures handbook.

3.2 Assessment techniques

The diagram below identifies the assessment techniques relevant to this syllabus. The subsequent sections describe each assessment technique in detail.

Figure 4: Science in Practice assessment techniques



Schools design assessment instruments from the assessment techniques relevant to this syllabus. The assessment instruments students respond to in Units 1 and 2 should support those techniques included in Units 3 and 4.

For each assessment instrument, schools develop an instrument-specific standards matrix by selecting the syllabus standards descriptors relevant to the task and the dimension/s being assessed (see Standards matrix).

The matrix is used as a tool for making judgments about the quality of students' responses to the instrument and is developed using the syllabus standards descriptors. Assessment is designed to allow students to demonstrate the range of standards (see Determining an exit result). Teachers give students an instrument-specific standards matrix for each assessment instrument.

Where students undertake assessment in a group or team, instruments must be designed so that teachers can validly assess the work of individual students and not apply a judgment of the group product and processes to all individuals.

Evidence

Evidence includes the student's responses to assessment instruments and the teacher's annotated instrument-specific standards matrixes. Evidence may be direct or indirect. Examples of direct evidence include student responses to assessment instruments or digital recordings of student performances. Examples of indirect evidence include student notes, teacher observation recording sheets or photographic evidence of the process.

Further guidance can be found in the QCE and QCIA policy and procedures handbook.

Conditions of assessment

Over a four-unit course of study, students are required to complete assessment under a range of conditions (see Planning an assessment program).

Conditions may vary according to assessment. They should be stated clearly on assessment instruments and reflect the conditions stated for each technique. Where support materials or particular equipment, tools or technologies are used under supervised conditions, schools must ensure that the purpose of supervised conditions (i.e. to authenticate student work) is maintained.

Assessment of group work

When students undertake assessment in a group or team, instruments must be designed so that teachers can validly assess the work of individual students and not apply a judgment of the group product and processes to all individuals.

3.2.1 Project

Purpose

This technique assesses a response to a single task, situation and/or scenario in a module of work that provides students with authentic and/or real-world opportunities to demonstrate their learning.
The student response will consist of a collection of **at least two** different assessable components, demonstrated in different circumstances, places and times, and may be presented to different audiences, and through differing modes.

Dimensions to be assessed

This assessment technique is to be used to determine student achievement in objectives from all of the following dimensions:

- Knowing and understanding
- Analysing and applying
- Planning and evaluating.

All objectives from each dimension must be assessed.

Types of projects

A project occurs over a set period of time. Students may use class time and their own time to develop a response.

A project consists of **at least two different assessable components** from the following:

- written, e.g. a set of data
- spoken, e.g. an explanation of a procedure
- multimodal, e.g. a presentation of a set of data and an explanation of its purpose and meaning
- performance, e.g. a demonstration of a procedure
- product e.g. model energy-efficient house.

The selected assessable components must contribute significantly to the task and to the overall result for the project. A variety of technologies may be used in the creation or presentation of the response.

Note: Spoken delivery of a written component; or a transcript of a spoken component (whether written, electronic, or digital) constitutes one component, not two.

Examples of projects in Science in Practice include:

- developing a water quality test kit (product) and giving a sales pitch to a potential customer, demonstrating how it works (performance)
- developing and testing an antibacterial cleaning agent (product) and producing a short video demonstrating how it works (multimodal presentation)
- constructing an efficient solar hot-water heater (product) and reporting on its efficacy (written)
- designing and testing a model ‘earthquake-proof’ building (product) and documenting the process though a photo story (multimodal non-presentation)
- designing and testing a model energy-efficient house for the Queensland climate (product) and recording a short podcast/interview about the science underpinning the choice of materials used (spoken).

Written component

This component requires students to use written language to communicate ideas and information to readers for a particular purpose. A written component may be supported by references or, where appropriate, data, tables, flow charts or diagrams.

Examples include:

- reports, which will normally be presented with section headings, and may include tables, graphs and/or diagrams, and analysis of data supported by references
- articles for magazines or journals.

Spoken component
This component requires students to use spoken language to communicate ideas and information to a live or virtual audience (that is, through the use of technology) for a particular purpose. Examples include: • oral presentations • debates • interviews • podcasts • seminars.
Multimodal component
This component requires students to use a combination of at least two modes **delivered at the same time** to communicate ideas and information to a live or virtual audience for a particular purpose. The selected modes are integrated to allow both modes to contribute significantly to the multimodal component. Modes include: • written • spoken/signed • nonverbal, e.g. physical, visual, auditory. The multimodal component can be a presentation or non-presentation. Examples of presentations include delivery of a slide show, a short video clip, or webinar. An example of a non-presentation is a webpage with embedded media (graphics, images, audio or video). A variety of technologies may be used in the creation or presentation of the component. Replication of a written document into an electronic or digital format does not constitute a multimodal component.
Performance component
This component refers to physical demonstrations as outcomes of applying a range of cognitive, technical, physical and/or creative/expressive skills. Performance components involve student application of identified skill/s when responding to a task that involves solving a problem, providing a solution, or conveying meaning or intent. Examples include: • delivery of demonstrations, i.e. given procedures or student-designed experimental procedures • setting up, monitoring and maintaining systems, e.g. aquariums, ecosystems and habitats • organising and delivering presentation tasks, e.g. segments at events such as a science competition, forum or Science Week events.
Product component
This component refers to the creation of a product and will be the outcome of applying a range of cognitive, technical, physical and/or creative/expressive skills. Examples of products include: • models, e.g. computer simulation, energy-efficient model, DNA model, water heater • scientific equipment, e.g. test kit • prototypes, e.g. energy converter such as a solar oven • automated control systems.

Assessment conditions	Units 1–2	Units 3–4
Written component	400–700 words	500–900 words
Spoken component	1½ – 3½ minutes	2½ – 3½ minutes
Multimodal component • non-presentation • presentation	 6 A4 pages max (or equivalent) 2–4 minutes	 8 A4 pages max (or equivalent) 3–6 minutes

Performance component	Schools provide students with some continuous class time to develop and demonstrate the performance component/s of their project.
Product component	Schools provide students with some continuous class time to develop the product component/s of their project.

Further guidance

When implementing assessment instruments for the project technique, teachers:

- define for students or work with students to define the task, situation or scenario, and purpose for the project; all components of the project must clearly relate to this single task, situation or scenario
- establish the required length of student responses within the assessment conditions (see above); the required length of student responses should be considered in the context of the tasks — longer is not necessarily better; word lengths and time limits are given as guides
- clearly indicate the dimensions and objectives that will be assessed and explain to students the requirements of the task, including instrument-specific standards
- teach the objectives, knowledge, understanding and skills students need to complete all components of the project
- teach the requirements for each component of the project, e.g. diagrams, report writing, equipment use, data analysis, referencing
- allow some continuous class time for students to work towards completing each component of the project; independent student time may also be required to complete the response
- implement strategies to promote authentication of student work, e.g. note-taking, journals or logs, drafting, research checklists, referencing, teacher observation sheets
- consult, negotiate and provide feedback while students are developing their response to the project, e.g. to provide guidance about ethical matters and to monitor the progress of student work.

See Developing a module of work for further guidance on using inquiry in Science in Practice.

3.2.2 Investigation

Purpose

This technique assesses investigative practices and the outcomes of applying these practices. Investigation includes locating and using information beyond students' own knowledge and the data they have been given. In Science in Practice, investigations involve research and follow the methods of scientific inquiry. They provide opportunity for assessment to be authentic and set in contexts similar to those that might be encountered by scientists.

Dimensions to be assessed

This assessment technique is to be used to determine student achievement in objectives from all of the following dimensions:

- Knowing and understanding
- Analysing and applying
- Planning and evaluating.

All objectives from each dimension must be assessed.

Types of investigations

An investigation occurs over a set period of time. Students may use class time and their own time to develop a response. In this assessment technique, students investigate or research a specific question or hypothesis through collection, analysis and synthesis of primary and/or secondary data obtained through research.

Examples of investigations in Science in Practice include:

- testing different commercial antibacterial cleaning agents
- testing the movement of water through different substrates — clay, topsoil, and sand
- investigating if a car is a safe place to be in an electrical storm
- investigating how 'earthquake-proof' buildings are constructed
- testing the hypothesis that dishwashers are more water efficient than washing by hand, or that people like the taste of bottled water more than tap water
- exploring the development of a specific technology.

Written response

This response requires students to use written language to communicate ideas and information to readers for a particular purpose. A written response may be supported by references or, where appropriate, data, tables, flow charts or diagrams.

Examples include:

- reports, which will normally be presented with section headings, and may include tables, graphs and/or diagrams, and analysis of data supported by references.
- articles for magazines or journals
- essays, e.g. analytical, persuasive/argumentative, informative
- reviews, e.g. popular science article, film
- letters to the editor
- field-trip or industry-site visit report.

Spoken response

This response requires students to use spoken language to communicate ideas and information to a live or virtual audience (that is, through the use of technology) for a particular purpose.

Examples include:

- oral presentations
- debates
- interviews
- podcasts
- seminars.

Multimodal response		
This response requires students to use a combination of at least two modes **delivered at the same time** to communicate ideas and information to a live or virtual audience for a particular purpose. The selected modes are integrated to allow both modes to contribute significantly to the multimodal response. Modes include: • written • spoken/signed • nonverbal, e.g. physical, visual, auditory. The multimodal response can be a presentation or non-presentation. Examples of presentations include delivery of a slide show, a short video clip, or webinar. An example of a non-presentation is a webpage with embedded media (graphics, images, audio or video). A variety of technologies may be used in the creation or presentation of the response. Replication of a written document into an electronic or digital format does not constitute a multimodal response.		
Assessment conditions	**Units 1–2**	**Units 3–4**
Written	500–800 words	600–1000 words
Spoken	2–4 minutes	3–4 minutes
Multimodal • non-presentation • presentation	8 A4 pages max (or equivalent) 3–5 minutes	10 A4 pages max (or equivalent) 4–7 minutes

Further guidance
When implementing assessment instruments for the investigation technique, teachers: • establish a focus for the investigation, or work with the student to develop a focus • allow class time for the student to effectively undertake each part of the investigation assessment as well as some independent student time • establish the required length of student responses within the assessment conditions (see above); the required length of student responses should be considered in the context of the tasks — longer is not necessarily better; word lengths and time limits are given as guides • implement strategies to promote the authenticity of student work; strategies may include note-taking, journals or experimental logs, drafting, research checklists, referencing and/or teacher observation sheets • provide scaffolding as a part of the teaching and learning that supports student development of the requisite knowledge, understanding and skills integral to completing an assessment task and demonstrating what the assessment requires; the scaffolding should be reduced in Units 3 and 4 as students develop greater independence as learners • provide students with learning experiences in the use of appropriate communication strategies, including the generic requirements for presenting research, e.g. research report structures, referencing conventions • clearly indicate the dimensions and objectives that will be assessed and explain to students the requirements of the task, including instrument-specific standards. See Developing a module of work for further guidance on using inquiry in Science in Practice.

3.2.3 Collection of work

Purpose

This technique assesses a response to **a series of tasks relating to a single topic** in a module of work. The student response will consist of a collection of at least three assessable components provided at different times and may be demonstrated in different circumstances and places.

Dimensions to be assessed

This assessment technique is to be used to determine student achievement in objectives from all of the following dimensions:

- Knowing and understanding
- Analysing and applying
- Planning and evaluating.

Not every objective from each dimension needs to be assessed in each task.

Types of collections of work

A collection of work consists of **at least three assessable components** selected from :

- written component, e.g. a set of data
- test component, e.g. short response items or response to stimulus
- spoken component, e.g. an explanation of a procedure
- multimodal component, e.g. a presentation of a set of data and an explanation of its purpose and meaning
- performance component, e.g. demonstration of a procedure.

The selected assessable components must contribute significantly to the overall result for the collection of work. A variety of technologies may be used in the creation or presentation of the component.

Note: Spoken delivery of a written component; or a transcript of a spoken component (whether written, electronic, or digital) constitutes one component, not two.

Examples of collections of work include:

- renewable and non-renewable energy:
  - demonstration of the set-up of and data collection from a solar cell (performance)
  - analysis of data from a wind turbine (written)
  - short test about fundamental knowledge and understanding of the chemistry, earth and environmental science and physics of renewable and non-renewable energy (test)
- testing the claims of products for consumer protection:
  - annotated bibliography of research on a chosen cosmetic (written)
  - argument map outlining the claims of a technology product and providing evidence and reasoning for accepting or rejecting the claim (written)
  - speech addressing the claims of a popular food or drink (spoken).

Written component

This response requires students to use written language to communicate ideas and information to readers for a particular purpose. A written response may be supported by references or, where appropriate, data, tables, flow charts or diagrams.

Examples include:

- reports, which will normally be presented with section headings, and may include tables, graphs and/or diagrams, and analysis of data supported by references
- articles for magazines or journals
- letters to the editor
- essays, e.g. analytical, persuasive/argumentative, informative.

Test component
This component typically consists of a small number of items that may include students responding to some of the following activities: • drawing, labelling or interpreting equipment, graphs, tables or diagrams • short items requiring multiple-choice, single-word, sentence or short paragraph responses • calculating using algorithms • responding to seen or unseen stimulus materials • interpreting ideas and information. Tests occur under supervised conditions as students produce work individually and in a set time to ensure authenticity. Questions, scenarios and problems are typically unseen. If seen, teachers must ensure the purpose of this technique is not compromised. Stimulus materials may also be used and may be seen or unseen. Unseen questions, statements or stimulus materials should not be copied from information or texts that students have previously been exposed to or have directly used in class.
Spoken component
This component requires students to use spoken language to communicate ideas and information to a live or virtual audience (that is, through the use of technology) for a particular purpose. Examples include: • oral presentations • debates • interviews • podcasts • seminars.
Multimodal component
This component requires students to use a combination of at least two modes **delivered at the same time** to communicate ideas and information to a live or virtual audience for a particular purpose. The selected modes are integrated to allow both modes to contribute significantly to the multimodal component. Modes include: • written • spoken/signed • nonverbal, e.g. physical, visual, auditory. The multimodal component can be a presentation or non-presentation. Examples of presentations include delivery of a slide show, a short video clip, or webinar. An example of a non-presentation is a webpage with embedded media (graphics, images, audio or video). A variety of technologies may be used in the creation or presentation of the component. Replication of a written document into an electronic or digital format does not constitute a multimodal component.
Performance component
This component refers to physical demonstrations as outcomes of applying a range of cognitive, technical skills. Performance components involve student application of identified skill/s when responding to a task that involves solving a problem, or conveying meaning or intent. Examples include: • delivery of demonstrations, i.e. given procedures or student-designed experimental procedures • setting up, monitoring and maintaining systems, e.g. aquariums, ecosystems and habitats • organising and delivering presentation tasks, e.g. segments at events such as a science competition, forum or Science Week events.

Assessment conditions	Units1–2	Units 3–4
Written component	150–250 words	200–300 words
Spoken component	1–2 minutes	1½– 2½ minutes
Multimodal component • non presentation • presentation	 4 A4 pages max (or equivalent) 1½–2½ minutes	 6 A4 pages max (or equivalent) 2–3 minutes
Performance component	Schools provide students with some continuous class time to develop and demonstrate the performance component/s of the collection of work.	
Test component	20–30 minutes 50–150 words per item (diagrams and workings not included in word count)	20–30 minutes 50–250 words per item (diagrams and workings not included in word count)

Further guidance
When implementing assessment instruments for the collection of work technique, teachers: • define for students or work with students to define the topic and purpose for the collection of work; all components of the collection of work must clearly relate to this single topic • establish the required length of student responses within the assessment conditions (see above); the required length of student responses should be considered in the context of the tasks — longer is not necessarily better; word lengths and time limits are given as guides • clearly indicate the dimensions and objectives that will be assessed and explain to students the requirements of the task, including instrument-specific standards • teach the objectives, knowledge, understanding and skills students need to complete all components of the collection of work • teach the requirements for each component of the collection of work, e.g. diagrams, report writing, demonstration of procedures • allow some continuous class time for students to work towards completing each component; independent student time may also be required to complete the response • implement strategies to promote authentication of student work, e.g. note-taking, journals or logs, drafting, research checklists, referencing, teacher observation sheets • consult, negotiate and provide feedback while students are developing their response to the project, e.g. to provide guidance about ethical matters and to monitor the progress of student work.

3.2.4 Extended response

Purpose
This technique assesses the interpretation, analysis/examination and/or evaluation of ideas and information in provided stimulus materials. While students may undertake some research in the writing of the extended response, it is not the focus of this technique.
Dimensions to be assessed
This assessment technique is to be used to determine student achievement in objectives from all of the following dimensions: • Knowing and understanding • Analysing and applying • Planning and evaluating. Not every objective from each dimension needs to be assessed in each task.
Types of extended response
An extended response occurs over a set period of time. Students may use class time and their own time to develop a response. Students respond to a question or statement about the provided stimulus materials. Stimulus material could include: • scientific texts, e.g. journal/research article • media texts, e.g. letter to the editor, documentary • data and statistics • infographics.
Written response
This response requires students to use written language to communicate ideas and information to readers for a particular purpose. A written response may be supported by references or, where appropriate, data, tables, flow charts or diagrams. Examples include: • reports, which will normally be presented with section headings, and may include tables, graphs and/or diagrams, and analysis of data supported by references • articles for magazines or journals • essays, e.g. analytical, persuasive/argumentative, informative • reviews, e.g. literature, film • letters to the editor • conclusions and recommendations based on data analysis.
Spoken response
This response requires students to use spoken language to communicate ideas and information to a live or virtual audience (that is, through the use of technology) for a particular purpose. Examples include: • oral presentations • debates • interviews • podcasts • seminars.

Multimodal response		
This response requires students to use a combination of at least two modes **delivered at the same time** to communicate ideas and information to a live or virtual audience for a particular purpose. The selected modes are integrated to allow both modes to contribute significantly to the multimodal response. Modes include: • written • spoken/signed • nonverbal, e.g. physical, visual, auditory. The multimodal response can be a presentation or non-presentation. Examples of presentations include delivery of a slide show, a short video clip, or webinar. An example of a non-presentation is a webpage with embedded media (graphics, images, audio or video). A variety of technologies may be used in the creation or presentation of the response. Replication of a written document into an electronic or digital format does not constitute a multimodal response.		
Assessment conditions	**Units 1–2**	**Units 3–4**
Written	500–800 words	600–1000 words
Spoken	2–4 minutes	3–4 minutes
Multimodal • non-presentation • presentation	 8 A4 pages max (or equivalent) 3–5 minutes	 10 A4 pages max (or equivalent) 4–7 minutes
Further guidance		
An extended response usually requires students to make some form of decision regarding a question or issue raised in the stimulus. They will support the decision with logical argument. The response may be supported by appropriate tables of data, diagrams and flowcharts. When implementing assessment instruments for the extended response technique, teachers: • provide stimulus for students and establish a focus for the extended response, or work with students to select suitable stimulus and/or develop a focus for the extended response • establish the required length of student responses within the assessment conditions (see above); the required length of student responses should be considered in the context of the tasks — longer is not necessarily better; words lengths and time limits are given as guides • clearly indicate the dimensions and objectives that will be assessed and explain to students the requirements of the task, including instrument-specific standards • teach the objectives, knowledge, understanding and skills students need to complete the extended response • teach the written, spoken or multimodal form/s required for student responses, e.g. report, presentation, seminar • allow some continuous class time for students to work towards completing each component of the project; independent student time may also be required to complete the response • implement strategies to promote authentication of student work, e.g. note-taking, journals, logs, drafting, research checklists, referencing, teacher observation sheets • consult, negotiate and provide feedback while students are developing their extended response, e.g. to provide guidance about ethical matters and to monitor the progress of student work.		

3.2.5 Examination

Purpose
This technique assesses the application of a range of cognition to provided questions, scenarios and/or problems. Responses are completed individually, under supervised conditions and in a set timeframe.
Dimensions to be assessed
This assessment technique is to be used to determine student achievement in objectives from all of the following dimensions: • Knowing and understanding • Analysing and applying • Planning and evaluating. Not every objective from each dimension needs to be assessed in each task.
Type of examination
Short response test
• Short response tests typically consist of a number of items that may include students responding to some or all of the following activities: – drawing, labelling or interpreting equipment, graphs, tables or diagrams – short items requiring multiple-choice, single-word, sentence or short paragraph responses – calculating using algorithms – responding to seen or unseen stimulus materials – interpreting ideas and information. • Short response tests occur under supervised conditions as students produce work individually and in a set time to ensure authenticity. • Questions, scenarios and problems are typically unseen. If seen, teachers must ensure the purpose of this technique is not compromised. • Stimulus materials may also be used and may be seen or unseen. • Unseen questions, statements or stimulus materials should not be copied from information or texts that students have previously been exposed to or have directly used in class.

Assessment conditions	Units 1–2	Units 3–4
Recommended duration	60–90 minutes	60–90 minutes
Short response test	50–150 words per item (diagrams and workings not included in word count)	50–250 words per item (diagrams and workings not included in word count)

Further guidance
When implementing assessment instruments for the examination technique, teachers: • format the assessment to allow for ease of reading and responding • consider the language needs of the students and avoid ambiguity • ensure questions allow the full range of standards to be demonstrated • consider the instrument conditions in relation to the requirements of the question/stimulus • outline any permitted material in the instrument conditions, e.g. one page of handwritten notes • determine appropriate use of stimulus materials and student notes; ensure stimulus materials are succinct enough to allow students to engage with them in the time provided; if they are lengthy, consider giving students access to them before the assessment • provide students with learning experiences that support the types of items, including opportunities to respond to unseen tasks using appropriate communication strategies • indicate on the assessment the dimensions and objectives that will be assessed, and explain the instrument-specific standards.

3.3 Exiting a course of study

3.3.1 Folio requirements

A folio is a collection of one student's responses to the assessment instruments on which exit results are based. The folio is updated when earlier assessment responses are replaced with later evidence that is more representative of student achievement.

3.3.2 Exit folios

The exit folio is the collection of evidence of student work from Units 3 and 4 that is used to determine the student's exit result. Each folio must include:

- four assessment instruments, and the student responses
- evidence of student work from Units 3 and 4 only
- at least one Investigation based on primary data
- a range of assessment instruments that includes no more than two instruments from any one technique
- a student profile completed to date.

3.3.3 Exit standards

Exit standards are used to make judgments about students' exit result from a course of study. The standards are described in the same dimensions as the objectives of the syllabus. The standards describe how well students have achieved the objectives and are stated in the standards matrix.

The following dimensions must be used:

- Dimension 1: Knowing and understanding
- Dimension 2: Analysing and applying
- Dimension 3: Planning and evaluating.

Each dimension must be assessed in each unit, and each dimension is to make an equal contribution to the determination of an exit result.

3.3.4 Determining an exit result

When students exit the course of study, the school is required to award each student an A–E exit result.

Exit results are summative judgments made when students exit the course of study. For most students this will be after four units. For these students, judgments are based on exit folios providing evidence of achievement in relation to all objectives of the syllabus and standards.

For students who exit before completing four units, judgments are made based on the evidence of achievement to that stage of the course of study.

Determining a standard

The standard awarded is an on-balance judgment about how the qualities of the student's responses match the standards descriptors in each dimension. This means that it is not necessary for the student's responses to have been matched to every descriptor for a particular standard in each dimension.

Awarding an exit result

When standards have been determined in each of the dimensions for this subject, Table 3 below is used to award an exit result, where A represents the highest standard and E the lowest. The table indicates the minimum combination of standards across the dimensions for each result.

Table 2: Awarding exit results

Exit result	Minimum combination of standards
A	Standard A in any two dimensions and no less than a B in the remaining dimension
B	Standard B in any two dimensions and no less than a C in the remaining dimension
C	Standard C in any two dimensions and no less than a D in the remaining dimension
D	At least Standard D in any two dimensions and an E in the remaining dimension
E	Standard E in the three dimensions

Further guidance can be found in the QCE and QCIA policy and procedures handbook.

3.3.5 Standards matrix

	Standard A	Standard B	Standard C	Standard D	Standard E
Knowing and understanding	The student work has the following characteristics:	The student work has the following characteristics:	The student work has the following characteristics:	The student work has the following characteristics:	The student work has the following characteristics:
	• comprehensive description and explanation of scientific facts, concepts and phenomena in a range of situations including some that are unfamiliar	• detailed description and explanation of scientific facts, concepts and phenomena in familiar situations	• description and explanation of scientific facts, concepts and phenomena in familiar situations	• description of simple scientific facts, concepts and phenomena	• statements about simple scientific facts and phenomena
	• coherent description and explanation of scientific skills, techniques, methods and risks.	• detailed description and explanation of scientific skills, techniques, methods and risks.	• description and explanation of scientific skills, techniques, methods and risks.	• description of scientific skills, techniques, methods and risks.	• statements about simple scientific skills, techniques, methods and risks.
Analysing and applying	The student work has the following characteristics:	The student work has the following characteristics:	The student work has the following characteristics:	The student work has the following characteristics:	The student work has the following characteristics:
	• comprehensive analysis of data, information, situations and relationships	• detailed analysis of data, information, situations and relationships	• analysis of data, information, situations and relationships	• description of data, information, situations and relationships	• statements about simple data, information, situations and relationships
	• application of scientific knowledge, understanding and skills to generate justified solutions in a range of situations including some that are unfamiliar	• application of scientific knowledge, understanding and skills to generate informed solutions in familiar situations	• application of scientific knowledge, understanding and skills to generate solutions in familiar situations	• partial application of simple scientific knowledge, understanding and skills	• superficial application of simple scientific knowledge, understanding and skills
	• clear and coherent communication using scientific terminology, diagrams, conventions and symbols.	• effective communication using scientific terminology, diagrams, conventions and symbols.	• communication using scientific terminology, diagrams, conventions and symbols.	• basic communication using aspects of scientific terminology, diagrams, conventions and symbols.	• basic communication using everyday language.

Planning and evaluating	The student work has the following characteristics:	The student work has the following characteristics:	The student work has the following characteristics:	The student work has the following characteristics:	The student work has the following characteristics:
	• considered planning of scientific activities and investigations	• effective planning of scientific activities and investigations	• planning of scientific activities and investigations	• planning of aspects of scientific activities and investigations	• statements about aspects of scientific activities and investigations
	• systematic evaluation of the reliability and validity of plans and procedures, and data and information	• detailed evaluation of the reliability and validity of plans and procedures, and data and information	• evaluation of the reliability and validity of plans and procedures, and data and information	• statements about the reliability and validity of simple plans and procedures, and data and information	• statements about aspects of reliability and validity
	• valid conclusions, decisions and recommendations justified with scientific evidence.	• informed conclusions, decisions and recommendations linked to scientific evidence.	• conclusions, decisions and recommendations using scientific evidence.	• conclusions, decisions and recommendations.	• statements of personal opinion.

4 Glossary

Term	Explanation
A	
administrative control	work procedures, including timing of work, policies and other rules and practices, that are designed to reduce the duration, frequency, and severity of exposure to hazardous chemicals or situations
analyse; analysis	consider in detail for the purpose of finding meaning or relationships, and identifying patterns, similarities and differences, e.g. distinguishing between relevant and irrelevant data when graphing results
apply; application	use, utilise or employ in a particular situation
aspects	components, elements
B	
basic	essential or elementary
C	
clear	easy to understand; explicit; without ambiguity
coherent	well-structured and logical; internally consistent relation of parts
comprehensive	thorough, including all that is relevant
concept	an abstract idea or a mental symbol, typically associated with a corresponding representation in language or symbology, that denotes all of the objects in a given category or class of entities, interactions, phenomena, or relationships between them; concepts are abstract in that they omit the differences of the things in their extension, treating them as if they were identical; they are universal in that they apply equally to everything in their extension; concepts are also the basic elements of propositions; concepts are discursive and result from reason; concepts help to integrate apparently unrelated observations and phenomena into viable hypotheses and theories
conclusion	final result or summing up; inference deduced from previous information; reasoned judgment
considered	formed after careful (deliberate) thought
D	
data	documented information or evidence of any kind that lends itself to scientific interpretation; may be quantitative or qualitative
describe; description	give an account of characteristics or features
decision	a judgment or resolution
detailed	meticulous; including many of the parts
E	
effective	meeting the assigned purpose
evaluate; evaluation	assign merit according to criteria; examine and judge the merit, significance or value of something

Term	Explanation
explain; explanation	provide additional information that demonstrates understanding of reasoning and/or application
F	
fact	an observation or explanation that is so well established there is no reason to doubt it
familiar	situations or materials that have been the focus of prior learning experiences
H	
hierarchy of control	a widely used system of prioritised control measures to minimise or eliminate exposure to hazards
hypothesis	a tentative explanation for a phenomenon in the form of a statement that can be tested through scientific investigation; a hypothesis should be stated as simply and precisely as possible, clearly defining the variables to be measured and the criteria for success
I	
informed	having relevant knowledge; being conversant with the topic
J	
justify; justified	provide sound reasons or evidence to support a statement; soundness requires that the reasoning is logical and, where appropriate, that the premises are likely to be true
M	
method	the procedure for an approach to executing a scientific investigation
module of work	a module of work provides effective teaching strategies and learning experiences that facilitate students' demonstration of the dimensions and objectives as described in the syllabus A module of work: • draws from relevant aspects of the underpinning factors • identifies relevant concepts and ideas, and associated subject matter from the core topics • provides an alignment between core subject matter, learning experiences and assessment.
P	
partial	attempted, with evidence provided, but incomplete
phenomenon (plural: 'phenomena')	an observable or detectable event
purposeful	having an intended or desired result

Term	Explanation
R	
reliable; reliability	constant and dependable or consistent and repeatable; in science reliability refers to the reproducibility or consistency of results and information (if the investigation is repeated by others, the same results should be obtained); note that validity and reliability are often conflated (see validity)
risk	identifying and managing the elements of a procedure that expose one to danger or harm; ensuring an investigation will be carried out safely
S	
scientific evidence	empirical data (primary or secondary) or scientific facts, concepts, theories or laws
simple	involving few elements, components or steps; obvious data or outcomes
skill	the ability to carry out a specific task
statement	a sentence or assertion
systematic	methodical, organised and logical
T	
technique	the particular way of carrying out a specific task
U	
unfamiliar	situations or materials that have not been the focus of prior learning experiences
unit	a unit is 55 hours of timetabled school time, including assessment. A course of study will usually be completed over four units (220 hours).
V	
valid; validity	in science, the extent to which tests measure what was intended; the extent to which data, inferences and actions produced from tests and other processes are accurate (ACARA 2015c)

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