

B O A R D O F S T U D I E S
NEW SOUTH WALES

Science

Stage 6

**Revised
Support Document**

2007

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Updated with minor amendments September 2009 (PAF #2009649)

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First published in 2007 by
Board of Studies NSW
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Internet: www.boardofstudies.nsw.edu.au

2009649

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1. Introduction

The Stage 6 Biology, Chemistry, Earth and Environmental Science, Physics and Senior Science syllabuses were published in 1999 and amended in 2002. Updated copies of the syllabuses can be found on the Board of Studies website and these include the revised assessment components and weightings (2003) and the minor amendments made in 2007.

This support document has been revised and updated and is designed to help teachers to understand key aspects of the Science Stage 6 courses in relation to:

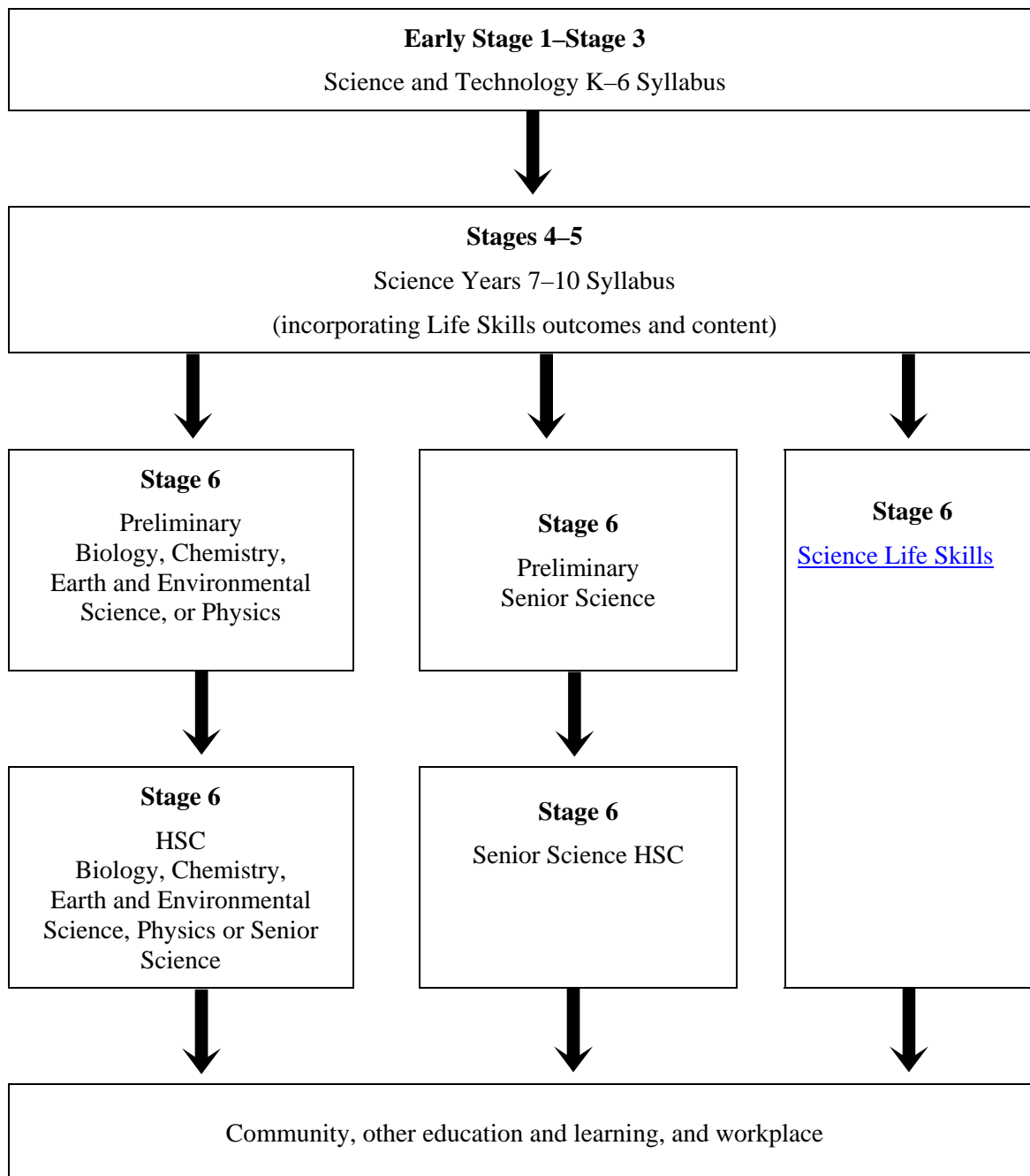
- the K–12 continuum of learning in science
- planning the teaching/learning program
- programming units of work
- assessment
- open-ended investigations.

The document shows how these aspects can be incorporated in teaching/learning programs, and how these programs are underpinned by the principles of assessment for learning.

The sample scope and sequence plan, assessment plans and program proforma provided in this document demonstrate ways in which teachers can build a teaching and learning program and develop units of work to ensure coverage of the scope of the syllabus.

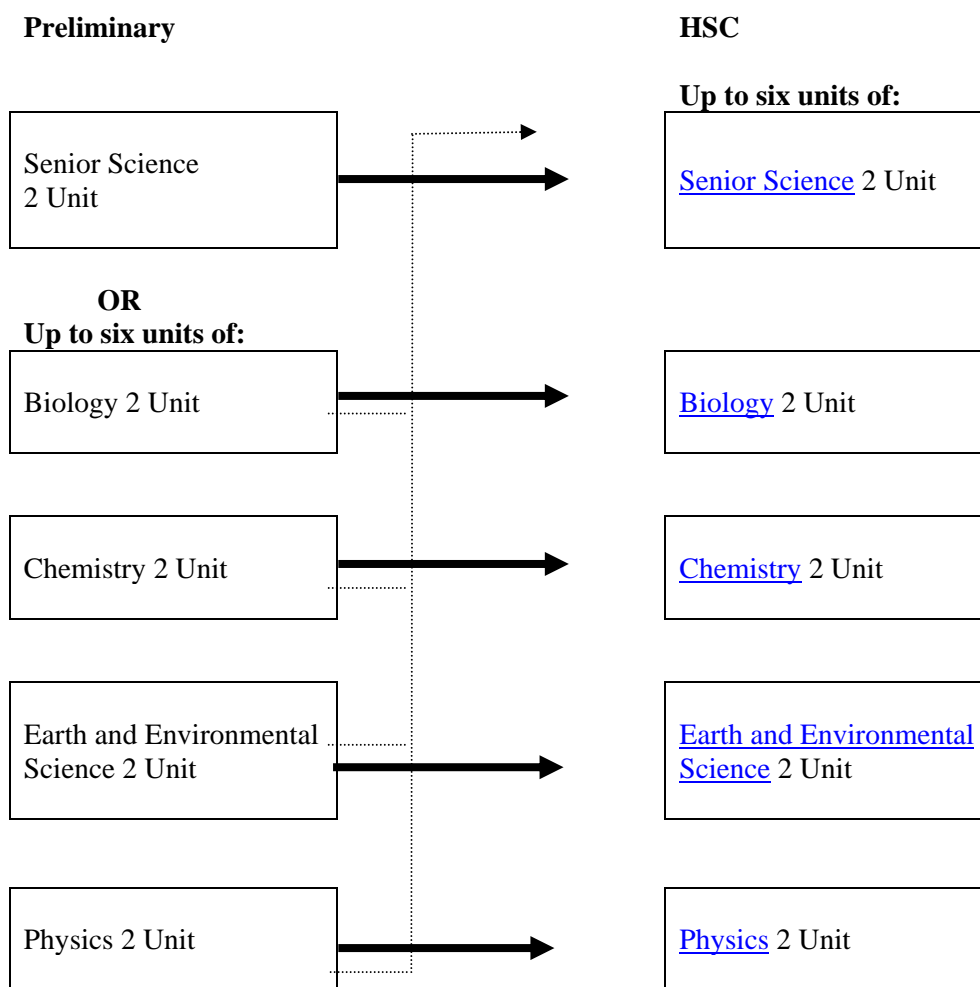
To assist in the planning process for systematic skill development, teachers should use the [Skills Module 8.1 and 9.1 Mapping Grids](#) provided on the website.

The Place of the Stage 6 Syllabuses in the Science K–12 Curriculum



The Relationship Between the Stage 6 Courses

The courses in Stage 6 and the relationship between the courses are represented in the diagram below. The links in the diagram go to the HSC Course Descriptions.



To satisfy pattern of study requirements for the award of the Higher School Certificate a student may count a maximum of six Preliminary units and six HSC units from the following courses:

- Biology
- Chemistry
- Earth and Environmental Science
- Physics
- Senior Science.

In the Preliminary study pattern, Senior Science cannot be studied in combination with Biology, Chemistry, Earth and Environmental Science or Physics.

Note also that students who are undertaking the Senior Science HSC course must have satisfactorily completed the Preliminary course in Senior Science, Biology, Chemistry, Earth and Environmental Science or Physics.

In the HSC study pattern Senior Science can be studied in combination with Biology, Chemistry, Earth and Environmental Science or Physics. (*Assessment, Certification and Examination (ACE) Manual*, p 88)

The Continuum of Learning

Each Stage 6 syllabus is part of a Kindergarten to Year 12 continuum of learning in science. The Stage 6 science syllabuses use the same model as the [Science Years 7–10 Syllabus](#) with objectives, outcomes and the content expressed in terms of Contexts, Prescribed Focus Areas and Domain. The [Science and Technology K–6 Syllabus](#), however, has three main elements, objectives, outcomes and content. It has the content organised around six Content Strands and three Learning Processes. While the syllabuses from Kindergarten to Year 12 may use different ways to organise the content, there are clear underpinnings of knowledge and understanding, skills, values and attitudes from one stage to another.

It is possible to present the Kindergarten to Year 12 continuum of learning in a number of different ways. The sample that follows, uses the model developed for the Stages 4–5 and Stage 6 syllabuses to demonstrate the K–12 continuum of outcomes of knowledge, understanding, skills, values and attitudes.

Prescribed Focus Areas (PFA)

In Stages 1–3, students develop a general awareness of the Prescribed Focus Areas (PFA) through the values and attitudes developed in the *Science and Technology K–6 Syllabus*. From Stage 4 through to the HSC courses in Biology, Chemistry, Earth and Environmental Science, Physics and Senior Science, the focus is on developing a strong conceptual understanding of each Prescribed Focus Area.

The continuum is evident across each of the stages in the ways in which students demonstrate the knowledge, understanding and skills they have developed about each of the Prescribed Focus Area outcomes.

	Stages 1–3	Stage 4	Stage 5	Stage 6: Preliminary**	Stage 6: HSC**
PFA	A student:	A student:	A student:	A student:	A student:
History	appreciates contributions made by individuals, groups, cultures and communities to scientific and technological understanding	identifies historical examples of how scientific knowledge has changed people's understanding of the world	explains how social factors influence the development and acceptance of scientific ideas	outlines the historical development of major principles, concepts and ideas (area specified)*	evaluates (discusses) how major advances in scientific understanding and technology have changed the direction or nature of scientific thinking
Nature and practice	gains satisfaction from their efforts to investigate, to design, to make and to use technology	uses examples to illustrate how models, theories and laws contribute to an understanding of phenomena	describes the processes that are applied to test and validate models, theories and laws	applies the processes that are used to test and validate models, theories and laws of science with particular emphasis on first-hand investigations in (area specified)	analyses the ways in which models, theories and laws in (area specified) have been tested and validated (applies the processes that have been used to test and validate models, theories and laws to investigations)
Applications and uses	initiates scientific and technological tasks and challenges and perseveres with them to their completion	identifies areas of everyday life that have been affected by scientific developments	evaluates the impact of applications of science on society and the environment	assesses the impact of particular technological advances on understanding in (area specified)	assesses the impact of particular advances in (area specified) on the development of technologies
Implications for society and the environment	shows informed commitment to improving the quality of society and the environment through science and technological activities	identifies choices made by people with regard to scientific developments	discusses scientific evidence supporting different viewpoints	describes (identifies) applications of (area specified) which affect society or the environment	assesses the impact of applications of (area specified) on society and the environment
Current issues, research and developments	appreciates the significance of Australian scientific and technological expertise across gender and cultural groups exhibits curiosity and responsiveness to scientific and technological ideas and evidence	describes areas of current research	analyses how current research might affect people's lives	describes (identifies) the scientific principles employed in particular areas of research in (area specified)	describes possible future directions of (area specified) research

* Area specified refers to Biology, Chemistry, Earth and Environmental Science, Physics or Senior Science.

** The outcomes for the Senior Science course may differ from those of the other Stage 6 courses. Where this is the case the outcomes related to the Senior Science outcomes or differences in the Senior Science outcomes are shown in brackets.

Domain: knowledge and understanding

In Stages 1 to 3, students develop a knowledge and understanding of the natural and made environment and apply this understanding to their everyday lives. Students research and investigate to identify phenomena and processes that have influenced Earth over time. They build on their existing understanding of forms of energy, the interactions between living things and their effects on the environment, and the processes that form and change the Earth over time. In Stages 4 and 5, students develop their understanding of models, theories and laws of science, and the systems and structures that describe the relationships between phenomena. The Stage 6 syllabuses identify, consolidate and build on the knowledge and understanding developed in the *Science Years 7–10 Syllabus* in specific content areas to provide students with a contemporary and coherent understanding of science.

Domain: skills

The K–12 continuum is also evident in the skills developed from Stage 1 through to Stage 6, and focuses on continually increasing students' expertise in planning and conducting investigations, communicating information and understanding, developing scientific thinking and problem-solving techniques, and working individually and in teams.

In Stages 1 to 3, students develop the confidence to initiate their own investigation to satisfy their curiosity, develop the concept of a fair test and undertake some analyses of data they have gathered. In Stages 4 and 5, students increase their skills in developing investigation plans, selecting and using appropriate strategies to solve problems, using appropriate forms of communication to present scientific information to different audiences, and analysing both first- and second-hand data and information to draw conclusions. In Stage 6, students develop skills in assessing whether first- and second-hand data and information is valid and reliable, processing information to assess its scientific accuracy, and applying critical thinking skills and justifying generalisations that they make in terms of scientific principles.

The continuum from Stages 1 to 3 through to Stage 6 is exemplified through the skill outcomes of each course.

	Stages 1 to 3	Stage 4	Stage 5	Stage 6: Preliminary	Stage 6: HSC
Skill	A student:	A student:	A student:	A student:	A student:
Planning investigations	...makes judgements based on the results of ... planning	clarifies the purpose of an investigation and, with guidance, produces a plan to investigate a problem	identifies a problem and independently produces an appropriate investigation plan	identifies and implements improvements to investigation plans	justifies the appropriateness of a particular investigation plan
Conducting investigations	conducts their own investigations	follows a sequence of instructions to undertake a first-hand investigation uses given criteria to gather first-hand data accesses information from identified secondary sources	undertakes first-hand investigations independently with safety and competence gathers first-hand data accurately accesses information from a wide variety of secondary sources	discusses the validity and reliability of data gathered from first-hand investigations and secondary sources	evaluates ways in which accuracy and reliability could be improved in investigations
Communicating information and understanding	...makes judgements based on the results of questioning, collecting, recording ...data...	evaluates the relevance of data and information with guidance, presents information to an audience to achieve a particular purpose	explains trends, patterns and relationships in data and/or information from a variety of sources selects and uses appropriate forms of communication to present information to an audience	identifies appropriate terminology and reporting styles to communicate information and understanding	uses terminology and reporting styles appropriately and successfully to communicate information and understanding
Developing scientific thinking and problem-solving techniques	...makes judgements based on the results of analysing data, and drawing conclusions	draws conclusions based on information available uses an identified strategy to solve problems uses creativity and imagination to suggest plausible solutions to familiar problems	uses critical thinking skills in evaluating information and drawing conclusions selects and uses appropriate strategies to solve problems uses creativity and imagination in the analysis of problems and the development of possible solutions	draws valid conclusions from gathered data and information	assesses the validity of conclusions from gathered data and information
Working individually and in teams	works cooperatively with others in groups on scientific and technological tasks and challenges	undertakes a variety of individual and team tasks with guidance	plans, implements and evaluates the effectiveness of a variety of tasks independently and as a team member	implements strategies to work effectively as an individual or as a member of a team	explains why an investigation is best undertaken individually or by a team

Domain: values and attitudes

By reflecting on the past, present and future involvement of science in society, students are encouraged to develop positive values and informed critical attitudes. In Stages 1 to 3 the main focus is developing positive values and attitudes towards themselves, others and science and technology. In Stages 4 and 5, these are broadened to include lifelong learning and the environment. Stage 6 consolidates those values and attitudes developed in earlier Stages to encourage students to justify both ethical behaviour and a desire for the critical evaluation of the consequences of applications of science.

Again, this continuum can be exemplified through the outcomes.

	Stages 1 to 3	Stages 4 and 5	Stage 6: Preliminary	Stage 6: HSC
Students will develop positive values about and attitudes towards:	A student:	A student:	A student:	A student:
themselves	demonstrates confidence in themselves and a willingness to make decisions when investigating, designing, making and using technology gains satisfaction from their efforts to investigate, to design, to make, and to use technology	demonstrates confidence and a willingness to make decisions and to take responsible actions		
others	works cooperatively with others in groups on scientific and technological tasks and challenges	respects different viewpoints on science issues and is honest, fair and ethical	demonstrates positive values about, and attitudes towards, both the living and non-living components of the environment; ethical behaviour; and a desire for critical evaluation of the consequences of the applications of science	justifies positive values about, and attitudes towards, both the living and non-living components of the environment; ethical behaviour; and a desire for critical evaluation of the consequences of the applications of science
learning as a lifelong process	exhibits curiosity and responsiveness to scientific and technological ideas and evidence initiates and perseveres with investigations, and takes tasks to their completion	recognises the relevance and importance of lifelong learning and acknowledges the continued impact of science in many aspects of everyday life		
science and technology	appreciates contributions made by individuals, groups, cultures and communities to scientific and technological understanding appreciates the significance of Australian scientific and technological expertise across gender and cultural groups	recognises the role of science in providing information about issues being considered and in increasing understanding of the world around them		
the environment	shows informed commitment to improving the quality of society and the environment through science and technology activities	acknowledges their responsibility to conserve, protect and maintain the environment for the future		

2. Interpreting the Syllabus Design

Skills Modules 8.1 and 9.1

All the Stage 6 science syllabuses involve further development of the skills students have developed in Stages 4 and 5 including:

- planning investigations
- conducting investigations
- communicating information and understanding
- developing scientific thinking and problem-solving techniques
- working individually and in teams.

The HSC skills content module 9.1 further develops the content in the Preliminary course skills module 8.1.

Planning systematic skill development

Skill development within and across the Preliminary and HSC courses needs to be carefully planned and tracked. To assist in the planning process for systematic skill development, teachers should use the [Skills Modules 8.1 and 9.1 Mapping Grids](#). The use of the mapping grids helps to ensure that all aspects of each skill have been addressed. It is also useful during the implementation of the program to alert teachers to the level of independence required for specific skills in each module.

On the [Skills Modules 8.1 and 9.1 Mapping Grids](#) the skills learning experiences could be broadly classified into one of three developmental levels. In the learning phase (L) the teacher establishes the student's skill prior learning and uses this as the basis for developing student understanding through appropriate explicit teaching of the relevant knowledge, understanding and skills components. In the practising phase (P) the student uses the knowledge, understanding and/or skills in tasks to achieve specific goals. The application phase (A) is when the student independently uses the knowledge, understanding and skills in the course of regular work and as a foundation for the development of learning. Based on an analysis of all units of work, the learning experiences in programs can be evaluated and modified to ensure that in addressing the skills content of the syllabus there is a continuum in the development within and across the modules in the Preliminary course and similarly in the HSC course.

In developing teaching/learning experiences based on the module content teachers should:

- consider the relationship between content points within and across sections of a module
- select appropriate skills content from the Preliminary (8.1) and HSC (9.1) skills modules
- provide opportunities within and across the Preliminary and HSC courses for students to develop the full range of skills.

In the syllabus skills content is signalled by the use of the terms from Skills Modules 8.1 and 9.1 and may be included in both columns 2 and 3 of the core modules.

Examples 1 and 2 focus on the relationship to Skills Module 8.1 and an application of the key words and verbs used in column 3 of the syllabus. In planning teaching/learning activities the content points would not be taken in isolation. They need to be considered within the context of the module and in relation to other content in the section and module.

Example 1

- The following extract is from the *Senior Science Stage 6 Syllabus* Module 8.2.1 – Water for Living (p23).

1. Water is essential for the health of humans and other living things

Students learn to:

- discuss ways, using examples, that animals reduce water loss, such as:
 - excrete uric acid instead of urea
 - nocturnal behaviour
 - reduced activity
 - lying in the shade
 - burrowing underground

Students:

- gather, **process** and analyse information to identify the different ways in which a range of terrestrial animals reduce water loss

12.2 gather first-hand information by:

- using appropriate data collection techniques, employing appropriate technologies, including data loggers and sensors
- measuring, observing and recording results in accessible and recognisable forms, carrying out repeat trials as appropriate

12.3 gather information from secondary sources by:

- accessing information using a range of resources, including popular scientific journals, digital technologies and the internet
- practising efficient data collection techniques to identify useful information in secondary sources
- extracting information from numerical data in graphs and tables as well as from written and spoken material in all its forms
- summarising and collating information from a range of resources

The inclusion of the requirement to *gather information* in the above extract from Module 8.2, is signalling to the teacher that the student must engage in some aspect of the skill content associated with gathering information. Since the module content does not specify whether this is from first-hand or secondary sources, the teacher can develop an activity that includes Skills Module 8.1 content from 12.2 and/or 12.3 of the syllabus. The choice will depend on the exact nature of the activity planned and students' prior experience. For the activity mentioned in this content point, an appropriate focus would be on selected content related to gathering information from secondary sources.

12.4 **process information** to:

- assess the accuracy of any measurements and calculations, and the relative importance of the data and information gathered
- identify and apply appropriate mathematical formulae and concepts
- best illustrate trends and patterns by selecting and using appropriate methods, including computer assisted analysis
- evaluate the validity of first-hand and secondary information and data in relation to the area of investigation
- assess the reliability of first-hand and secondary information and data by considering information from various sources

While the scope of the skill, as described in 8.1, includes references to calculations and mathematical formulae, the specified module content point does not lend itself to processing information in that way. The scope, however, does include assessing the relative importance of information, evaluating validity and assessing reliability. Any of these skills would be appropriate as the focus of an activity to develop students' knowledge, understanding and skills around the module content points in columns 2 and 3 of the extract.

Example 2

The following extract is from the *Physics Stage 6 Syllabus* Module 8.2.5 – The World Communicates (p25).

In planning the learning experiences to address core module content, consideration should be given to the relationship with other content within and across all sections of the module.

In each core module:

- the column 1 content provides an overview and could be used by the teacher as a contextual focus for the learning experiences for each section
- there are clear links between the content in the three columns in each section.

5. Electromagnetic waves have potential for future communication technologies and data storage technologies

Students learn to:

- identify types of communication data that are stored or transmitted in digital form

Students:

- identify data sources, gather, process and present information from secondary sources to identify areas of current research and
- use available evidence to discuss some of the underlying physical principles used in one application of physics related to waves, such as:
 - Global Positioning System
 - CD technology
 - the internet (digital process)
 - DVD technology

14.3 use available evidence to:

- design and produce creative solutions to problems
- propose ideas that demonstrate coherence and logical progression and include correct use of scientific principles and ideas
- apply critical thinking in the consideration of predictions, hypotheses and the results of investigations
- formulate cause-and-effect relationships

Through their first-hand experiences in identifying, gathering and processing information from secondary sources, students develop their knowledge and understanding of the specified content in column 2.

Possible Classroom Scenario for Example 2

Based on evidence from prior learning activities the teacher decides that the development of each of the skill content associated with *using available evidence* will occur over several modules, rather than be comprehensively treated in one module. The teacher begins by using the activity associated with this content point to discuss and model what is meant by logical progression of an idea based on the evidence that is available. This demonstrates to students how to identify the relationships between ideas and the scientific principles they have covered in the module.

By developing teaching and learning activities within and across modules 8.2–8.4 that allow students, with some teacher assistance, to practise this skill, the teacher intends that students will be able to apply these skills independently and confidently by the end of the Preliminary course.

For this class, the development of the skill content associated with 14.3 b) and c) could be summarised as follows

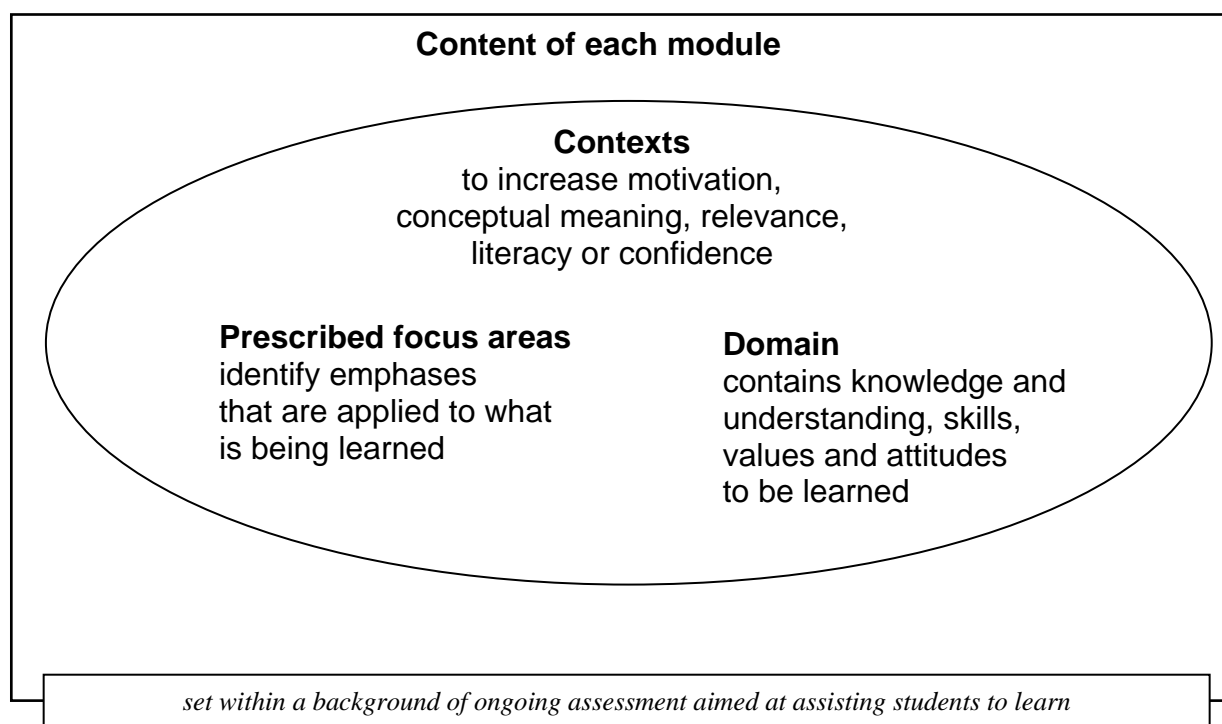
Physics Skills Module 8.1 Content	Module 8.2 The World Communicates	Module 8.3 Electrical Energy in the Home	Module 8.4 Moving About
14.3 use available evidence to:			
a) design and produce creative solutions to problems			
b) propose ideas that demonstrate coherence and logical progression and include correct use of scientific principles and ideas	Modelled by teacher and briefly practised by students	Practised by students with teacher support	Practised and/or applied by students
c) apply critical thinking in the consideration of predictions, hypotheses and the results of investigations	Modelled by teacher and briefly practised by students	Practised with teacher support	Practised and/or applied by students
d) formulate cause-and-effect relationships			

Core Modules

Content

Each core module includes content through which the Prescribed Focus Areas and Domain: knowledge and understanding, skills, values and attitudes outcomes can be achieved. In the core modules the Prescribed Focus Areas and Domain content is organised into three columns. This content has been related to the contextual outline and integrated throughout the module.

The following diagram summarises the relationship between the three content elements of the Stage 6 Science course:



Context

In the Stage 6 science courses each core module has a contextual outline which provides the framework devised to assist students to make meaning of the Prescribed Focus Areas and Domain within the module. Contexts are culturally bound and therefore communicate meanings that are culturally shaped or defined. Contexts draw on the framework of society in all aspects of everyday life. The contexts for each module encourage students to recognise and use their current understanding to further develop and apply more specialised scientific understanding and knowledge. Teachers can also use the content statements in the first column to devise a specific contextual focus within each section of the core module.

Core Module Overview

Sample introductory page

Senior Science Stage 6 Syllabus Module 8.4 – Humans at Work (p30)

Contextual Outline

The human body is structurally well-adapted to the tasks required of it. It has structures and reflexes that protect soft tissue and prevent injury. All movable joints have cartilage that acts to reduce friction, in conjunction with the synovial fluid, and as a shock absorber in those joints with extensive movement such as the backbone. The skeletal structures are composed of protein and calcium salts which provide it with both flexibility and rigidity. All these protective measures ensure that the human body can survive a multitude of hazards in the natural environment and cope with the everyday demands placed on it.

Provides the module overview but is not examinable

However, the body still needs to be protected from hazards that are part of the modern environment. A knowledge of the structure and function of the human body suggests appropriate safety measures that need to be considered and technologies that can be developed to protect the body. Legislation on occupational health and safety issues that relate to our immediate home and work environments encourages the adoption of safe practice in all aspects of students' lives.

Assumed Knowledge

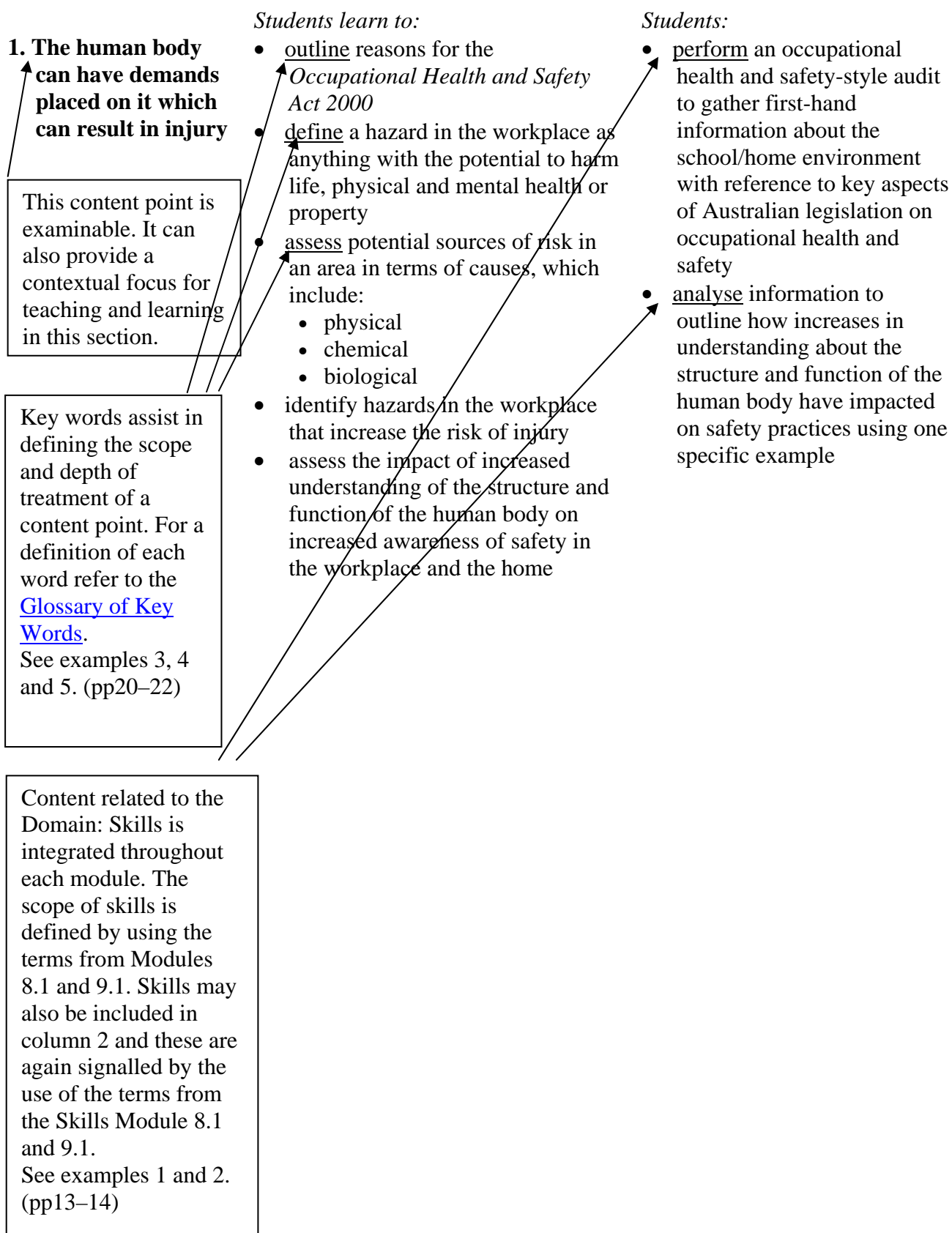
Refer to the *Science Years 7–10 Syllabus* for the following:

- 4.6.1a) identify situations or phenomena in which different forms of energy are evident
- 4.8.5a) describe the role of the digestive, circulatory, excretory, skeletal and respiratory systems in maintaining humans as functioning organisms

Identifies the major areas of Domain: Knowledge and from Understanding the *Science Years 7–10 Syllabus* that are incorporated into each Preliminary core module

Sample contents page

Senior Science Stage 6 Module 8.4 – Humans at Work



2. Potential risks to the respiratory system can be minimised by implementing protective measures

Students learn to:

- account for the moist lining of the lungs allowing oxygen to diffuse through to the blood
- outline the purpose of mucous production and the role of cilia on epithelial tissue in the lungs
- outline the effect of chronic exposure to inhaled solids on lung tissue
- identify safety procedures and equipment in the school and workplace including:
 - fume cupboards
 - filtering masks
 - filters
 - dust extractors/fans
 - adequate ventilation to reduce inhalation of harmful substances

Students:

- gather, process, analyse and present information from secondary sources on one respiratory condition caused by environmental factors and include:
 - cause
 - effect on respiratory system
 - symptoms
 - prevention
 - current directions in research to reduce the problem

Content that could be developed into an open-ended investigation: a practical experience requirement of each course

Content related to the Domain: Knowledge and Understanding is integrated throughout each module

Content related to the Prescribed Focus Areas is integrated throughout each module

Content related to the Contextual outline is integrated throughout each module

Content points in the core modules should be read literally in order to determine scope and depth. Examples 3, 4 and 5 show how the key word used helps to define the scope and depth of treatment of the content point. Definitions of the key words are provided in the [Glossary of Key Words](#).

Example 3

An extract from the *Chemistry Stage 6 Syllabus* Module 9.3.4 – The Acidic Environment (p55) is shown below.

In planning teaching and learning experiences the column 2 content needs to be considered in relation to all of the content within this section of the module. This part of the module has clear links to the contextual framework and the content in other sections of the module.

In order to determine the scope and depth of treatment of the two statements identified below, reference needs to be made to the definitions of each of the key words used.

4. **Because of the prevalence and importance of acids, they have been used and studied for hundreds of years. Over time, the definitions of acid and base have been refined**

Students learn to:

- outline the historical development of ideas about acids, including those of:
 - Lavoisier
 - Davy
 - Arrhenius
- outline the Bronsted-Lowry theory of acids and bases
- describe the relationship between an acid and its conjugate base and a base and its conjugate acid

Outline means ‘sketch in general terms; indicate the main features of’, so the minimum required is a brief overview which highlights the main features of the work of Arrhenius, Lavoisier and Davy that contributed to the development of ideas about acids. There is scope to introduce others, and the teacher would use their professional judgement to determine the depth appropriate for the group involved.

Describe means to ‘provide characteristics and features’ of the relationship between an acid and its conjugate base and between a base and its conjugate acid. It does not ask that students explain why this relationship exists.

Example 4

The following extract is from the *Chemistry Stage 6 Syllabus* Module 8.2.4 – The Chemical Earth (p26)

- **explain that** the amount of energy needed to separate atoms in a compound is an indication of the strength of the attraction, or bond, between them

Through the teaching/learning experiences students should gain an understanding of how to use the key word to clarify the scope and depth of treatment of the content statements.

The term **explain** requires a student to identify and describe the features of the concept and use cause and effect to show the relationship between the energy required to separate atoms and the attraction between them.

The table provides a scaffold to show the relationship between these key words.

Identify the amount of energy needed to separate atoms in a compound	This requires students to state the amount of energy needed to separate atoms in a compound, either in general terms or for specific examples.
Describe how the amount of energy needed to separate atoms in a compound is an indication of the attraction, or bond, between them	This requires students to provide features of the amount of energy needed to separate atoms in a compound and its relationship to the attraction, or bond, between them.
Explain that the amount of energy needed to separate atoms in a compound is an indication of the attraction, or bond, between them	This requires students to provide information on the relationship between the energy needed to separate atoms in a compound and the attraction, or bond, between them. The cause-and-effect reasons why this relationship exists need to be provided.

Example 5

The following extract is from the *Earth and Environmental Science Stage 6 Syllabus* Module 8.3.2 – The Local Environment (p26)

- **analyse** the ways in which vegetation of an area can be influenced by soil composition and climate

The key word used identifies the scope and depth of treatment of the content provided in the statement.

The term **analyse** requires a student to identify and describe how the features of the vegetation are influenced by soil composition and climate. In their explanation students should draw out and relate the implications of the relationship between the vegetation and the soil composition and climate.

The table provides a scaffold to show the relationship of these key words.

Statement	Interpretation based on the key word used
Identify the ways in which the vegetation of an area can be influenced by soil composition and climate	This requires students to state the ways that the vegetation of an area can be influenced by the soil composition and climate. This could be in the form of a list.
Describe the ways in which the vegetation of an area can be influenced by soil composition and climate	This requires students to provide features of the ways in which the vegetation of an area can be influenced by the soil composition and climate.
Explain the ways in which the vegetation of an area can be influenced by soil composition and climate	This requires students to make clear the relationship between the vegetation of an area and the soil composition and climate. The reasons the soil composition and climate affect the vegetation need to be provided.
Analyse the ways in which the vegetation of an area can be influenced by soil composition and climate	This requires students to identify the ways in which the vegetation of an area can be influenced by the soil composition and climate of a region; to describe the relationships between each of the ways identified; and to draw out the implications of the relationships between vegetation and soil composition and climate.

3. Advice on Programming and Assessment

Planning the Teaching/Learning Program

The fundamental step in the design of effective teaching and learning programs is the establishment of a program overview with a scope and sequence plan. When developing this plan and teaching/learning units teachers will have several considerations.

Syllabus requirements

The *Stage 6 Science Syllabuses* have a Preliminary course and a HSC course. The Preliminary modules consist of core content that would be covered in 120 indicative hours. The HSC course consists of core and options organised into a number of modules. The core content covers 90 indicative hours and one option covers 30 indicative hours. Students are required to cover one of the options.

The following syllabus requirements need to be addressed when developing a teaching/learning program:

- All content related to the Domain: knowledge and understanding and skills must be addressed.
- All Prescribed Focus Area outcomes must be addressed in both the Preliminary and HSC courses.
- The values and attitudes outcome must be addressed in the Preliminary and HSC courses.
- Each unit of work includes content related to the three content elements: Context, Prescribed Focus Areas and Domain.
- The modules 8.1 (Preliminary) and 9.1 (HSC) skills outcomes and content selected are appropriate for the content specified in the modules.
- Students must complete 80 indicative hours of practical/field work during the Preliminary and HSC courses with no less than 35 hours of practical experiences in the HSC course.
- Practical experiences must include at least one open-ended investigation in both the Preliminary and HSC courses.

To meet students' specific needs teaching/learning programs should:

- develop and extend students' prior learning within and across the Preliminary and HSC courses
- draw on the modules' contextual outline and the content statements in column 1 in devising the framework to assist students to use their current understanding to develop and apply more specialised scientific knowledge and skills
- integrate Modules 8.1 and 9.1 skills outcomes and content within and across modules to provide students with opportunities to develop the full range of skills by the end of the Preliminary and HSC courses.

When developing the units in a teaching/learning program sufficient information should be provided to allow OHS regulations (eg Chemical Safety in Schools) and Animal Welfare Guidelines for Teachers to be addressed.

Planning the teaching/learning program involves a number of interrelated activities including:

1. Establishing a scope and sequence plan

The [example of a Stage 6 Chemistry scope and sequence](#) details the placement, sequence and duration of possible units of work to be done and provides an example of the way in which the syllabus outcomes could be shown for each module. The Preliminary and HSC courses are organised into a number of modules, each of which has specified indicative hours.

In this example each syllabus module constitutes a unit of work and shows the targeted outcomes in the modules in the teaching/learning program.

2. Mapping the skills content for the outcomes in each proposed unit

Each syllabus module specifies content which provides opportunities for students to achieve the skills outcomes. Modules 8.1 (Preliminary) and 9.1 (HSC) provide the skills content that must be addressed within and across each course. Teachers should provide opportunities based on the module content to develop the full range of skills content identified in Skills Modules 8.1 and 9.1 ([Skills Modules 8.1 and 9.1 Mapping Grids](#)).

3. Adjusting and amending the teaching-learning program

Planning and programming is a dynamic process. During the development of the teaching/learning units there needs to be some flexibility for making adjustments to the organisation of the content. Teacher reflection and evaluation of student learning during and following teaching of lesson sequences and/or a unit of work will not only result in amendments to the program but also to the scope and sequence plan and skill content mapping grids.

Together, the scope and sequence plan and the skill content mapping grids provide a means by which teachers can ensure that the teaching/learning program established by the school addresses the syllabus requirements.

Programming Units of Work

Programming is the process of selecting and sequencing learning experiences that cater for the diversity of student learning needs in a particular stage. The program should provide the teaching/learning experiences based on syllabus content by which students are able to achieve the outcomes of the *Science Stage 6 Syllabuses*.

The [sample Stage 6 unit proforma](#) has been annotated to show the characteristics of each part of the proforma. The first page of the proforma provides an overview of the features of the unit relating to time, syllabus contextual outline, targeted outcomes and resources. The examples of formats provided on the second page show how the essential content elements of Prescribed Focus Areas, Domain: knowledge, understanding, skills, values and attitudes can be organised and integrated through the learning experiences. When planning teaching/learning sequences schools may choose to use or adapt the proforma styles provided to develop programs that best meet their needs and circumstances.

In programming units of work the following needs to be considered:

1. *Focusing on the syllabus outcomes*

The *Stage 6 Science Syllabuses* promote an approach to programming that has outcomes as the focus. During the planning process a manageable number of outcomes for each learning unit of work are identified and inform the organisation of the content and learning experiences for the units. The outcomes are also central to the decisions on the required evidence of learning.

2. *Identifying what evidence of learning will be required*

It is necessary to identify specific evidence of learning to be observed through the teaching, learning and assessment activities for the unit outcomes. The evidence of learning provides a basis for informing and adjusting the teaching/learning program. It should also enable teachers to make judgements about student achievement in relation to the outcomes and content and provide feedback to students on how to enhance their learning.

3. *Determining how evidence of learning will be gathered*

In order to collect the desired evidence of learning a range of strategies are selected that will:

- provide valid and reliable evidence of student learning
- enable students to demonstrate the extent of their knowledge, understanding and skills
- provide a balance between informal and formal evidence gathering
- support the learning process and be manageable within the time allocated to the unit.

Assessment for learning

The Board's syllabuses advocate *assessment for learning*. Assessment that enhances learning recognises that learners use their current understanding to discover, develop and incorporate new knowledge, understanding and skills. *Assessment for learning* helps teachers and students to know if their current understanding is a suitable basis for future learning.

Assessment occurs as an integral part of teaching and learning. Teacher instruction and assessment influence student learning and the learning processes. This involves using assessment activities to clarify student understanding of concepts, and planning ways to remedy misconceptions and promote deeper understanding.

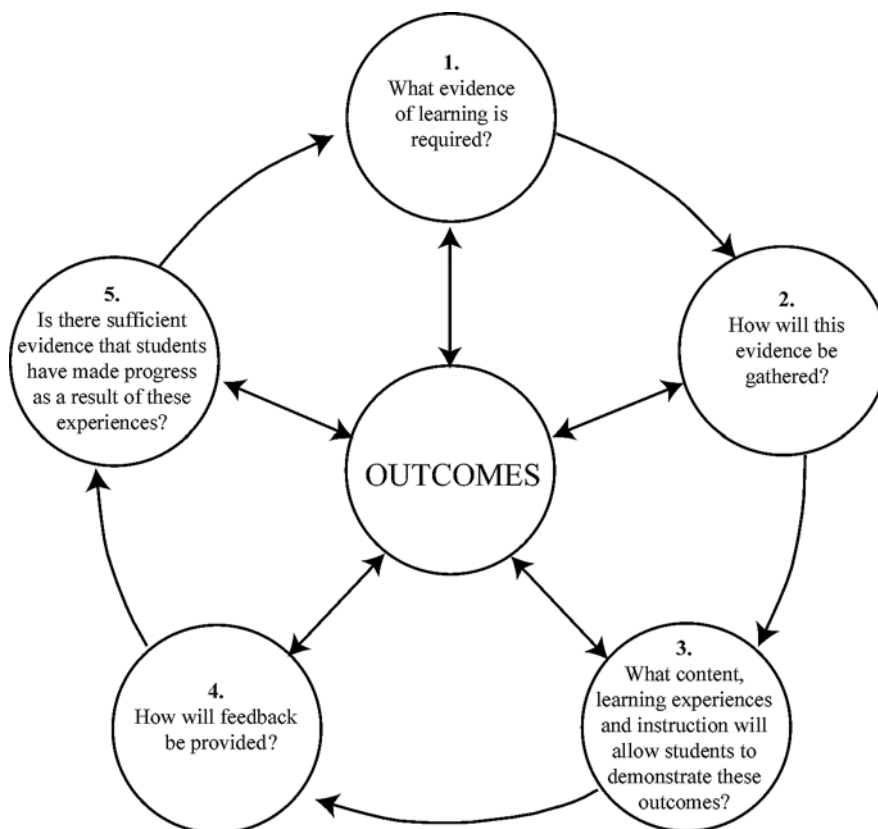
Assessment for learning encourages self-assessment and peer assessment. Students can develop and use a range of strategies to actively monitor and evaluate their own learning and the learning strategies they use.

The feedback that students receive from completing assessment activities will help teachers and students decide whether they are ready for the next phase of learning or whether they need further learning experiences to consolidate their knowledge, understanding and skills. Teachers should consider the effect that assessment and feedback have on student motivation and self-esteem, and the importance of the active involvement of students in their own learning.

By integrating learning and assessment, the teacher can choose which aspects of a student's performance to record. These records can be used to monitor the student's progress, determine what to teach next and decide the level of detail to be covered. At key points, such as the end of the year, this information is also available for the teacher to use to form a judgement of the student's achievement relative to the outcomes being assessed and, where appropriate, the performance description. This judgement can be used to inform parents, the next teacher and especially the student, of the student's progress. Consequently, teachers using their professional judgement in a standards-referenced framework are able to extend the process of *assessment for learning* into the assessment of learning.

Planning for effective learning and assessment

The diagram below summarises a model for integrating learning and assessment. It emphasises that outcomes are central to the decisions teachers make about the learning to be undertaken and the evidence of learning that needs to be collected. This evidence enables teachers to determine how well students are achieving in relation to the outcomes and to provide students with feedback on their learning. Evidence of learning assists teachers and students to decide if students are ready for the next phase of learning, or if teachers need to adapt programs to provide further learning experiences to consolidate students' knowledge, understanding and skills.



4. Designing the learning experiences

Based on the scope and sequence plan, skills content mapping grids and consideration of factors such as local resources, students' interests, learning history and cultural backgrounds, teachers design learning experiences/activities that:

- identify and build on prior learning to determine future directions for developing students' knowledge, understanding, skills, values and attitudes
- are student-centred, meaningful and stimulating, and cater for differing learning styles
- are appropriate for the contextual outline of the unit
- integrate the content selected to address the Prescribed Focus Areas and Domain: knowledge, understanding, skills, values and attitudes outcomes.
- allow students to provide the required evidence of learning in relation to the outcome being addressed
- integrate *assessment for learning* as part of the teaching/learning process
- provide opportunities for creativity, independent learning and encourage students to take greater responsibility for their learning.

An [example of part of a program](#) using the sample Stage 6 unit proforma has been provided to demonstrate how the core module content and the selected HSC (9.1) skills module content can be integrated. The lesson sequence highlights how students' knowledge, understanding and skills are developed through explicit and systematic teaching and learning selected to address the outcomes targeted in the unit. Throughout a unit the contextual emphasis should be clearly embedded in the teaching strategies. In learning sequences relating to the core module content that focuses on the targeted Prescribed Focus Areas and values and attitudes outcomes for a unit, the teaching strategies should provide a similar level of specificity to those shown in the example.

5. Planning how feedback will be provided

Feedback about student work in relation to the outcomes is integral to the teaching and learning process. A balanced approach to informal and formal feedback occurs normally through good teaching practice. In designing learning and assessment experiences, consider how the proposed feedback strategies will focus on what is expected in the activity and provide students with constructive and meaningful information and opportunities for reflection on their learning.

Feedback should:

- communicate clearly to students how well their knowledge, understanding and skills are developing in relation to the outcomes
- include opportunities for peer evaluation and self-evaluation
- enable students to reflect on and plan with the teacher the next steps in their learning.

6. Providing opportunities and strategies for teacher reflection and evaluation

Working collaboratively leads teachers to develop shared understanding of the syllabus and supports them in making consistent and comparable judgements about student learning. Throughout planning, programming and the teaching of the units it is important to reflect individually and collaboratively on the process and to evaluate the extent to which:

- the learning experiences selected to address the content are manageable in the time allocated to the unit

- learning experiences and/or the unit should be modified to enhance teaching and improve learning
- the context and integration of content assisted the students' conceptual and skill development
- the assessment activities enables teachers to gather evidence and make judgements about student achievement in relation to the outcomes
- feedback strategies enable students to improve their learning.

The [sample evaluation proforma](#) provides a template for teacher evaluation of a teaching/learning unit and is intended to be used in conjunction with the [sample focus questions](#) for discussion and consideration.

Developing an Effective HSC Assessment Program

Assessment is the process of identifying, gathering and interpreting information about student achievement. Assessment can be used for a number of key purposes including to:

- assist student learning
- provide information on student learning and progress in a course in relation to syllabus outcomes
- evaluate and improve teaching and learning programs
- provide evidence of satisfactory completion of the course
- report on the achievement by each student at the end of the course.

In this section of the Support Document some advice is provided about developing effective internal assessment programs using a standards-referenced approach. In a standards-referenced model the specific standards of achievement against which student performance is assessed remain constant and consist of what is to be learned and how well it is to be achieved.

The [*HSC assessment in a standards-referenced framework – A Guide to Best Practice*](#) provides general advice on a standards-referenced approach to HSC assessment, outlines of the Board of Studies requirements for Stage 6 assessment and checklists for the development and evaluation of a school's HSC assessment policies and procedures. More specific information on rules and procedures for the Higher School Certificate can be found in the [*Assessment Certification and Examination Manual*](#).

Designing Effective Learning and Assessment

Designing effective learning experiences requires the selection of activities that explicitly develop students' knowledge, understanding and skills and allow evidence of learning in relation to the targeted outcomes to be gathered. Assessment should be an integral part of each unit of work and should support student learning. The *Stage 6 Science Syllabuses* demonstrate standards by specifying the knowledge, understanding and skills expected to be learned by students as a result of studying the course. In school-based assessment activities student achievement is assessed against these standards. These activities should be designed to focus on outcomes and show a clear relationship to the syllabus content.

Teachers are responsible for developing effective assessment HSC programs that clearly reflect the course content and meet the mandatory components, weightings and task requirements provided in the *Assessment and Reporting in <Course> Stage 6 document*.

In designing an internal assessment program to assess student performance against standards teachers should consider whether the tasks:

- have explicitly stated purposes that address the outcomes
- are integral to the teaching and learning program
- show a clear relationship between the outcomes and content being assessed
- focus on what was taught in class and what students were informed would be assessed
- allow students to demonstrate the extent of their knowledge, understanding and skills relative to the outcomes being assessed
- provide valid and reliable evidence of student learning
- provide opportunities to gather information about what further teaching and learning is required for students to succeed.

The following principles and suggested procedures are provided to help teachers in the development of standards-referenced internal assessment programs.

Effective assessment in science occurs when:

- **it is integrated with the teaching and learning context**

Plan assessment tasks when units of work are designed so that the relationship between teaching/learning and assessment is made explicit.

- **it provides an appropriate balance of the knowledge, understanding and skills that are interdependent and integrated**

Design tasks that assess more than one skill wherever possible. Developing scientific thinking and problem solving skills, for example, can be incorporated into a number of tasks rather than being assessed as a discrete task. This allows students different opportunities and contexts for demonstrating achievement.

- **it is valid and reliable and has clear links that can be mapped between the outcomes and formative assessment activities that have been emphasised in the unit of work**

Ensure that the task instructions and questions are unambiguous and that students are aware of the outcomes to be assessed. Assessment should allow students to show what they know, understand and can do.

- **it recognises that each task can assess a number of outcomes and that over the course of the assessment program all outcomes are assessed**

Record the outcomes assessed against each task and ensure that all knowledge, understanding and skill outcomes are assessed over the program for the course.

- **it ensures comparable processes and procedures across different classes completing the same task**

Establish a clear understanding of the processes and procedures for administering each task and a shared understanding of the marking standard. This understanding comes from the use of assessment criteria and/or marking guidelines which identify the knowledge, understanding and skills that a task assesses. These are embedded in the task and have clear links to the course content and outcomes targeted in the unit of work. Including this detail in the task notification assists students to prepare effectively for the task as they have an explicit understanding of the type of assessment task and assessment criteria. The task notification should be provided at least two weeks prior to each task.

- **it indicates to students the number of tasks, the nature of the tasks, when the tasks are to take place and the weightings allocated to the tasks**

Students need to have a written copy of the internal assessment program for the course. This includes the scheduled timing, type, number, weightings, components and mark value of all assessment tasks.

The *Assessment and Reporting in <Course> Stage 6* document provides general advice on assessment in Stage 6 as well as the specific requirements for the Preliminary and HSC Science course. It is available on the Board's website with each Stage 6 Science syllabus and contains:

- suggested components and weightings for the internal assessment of the Preliminary course
- mandatory components and weightings for the internal assessment of the HSC course

- the HSC examination specifications, which describe the format of the external HSC examination.

A balance is required in the assessment program between obtaining sufficient information and overassessing. Three to five tasks, including the trial HSC, are considered sufficient to adequately assess the components of the course.

Features of Quality Assessment Tasks

Assessment task design should:

- focus on outcomes and be appropriate for the outcomes being assessed
- give students the opportunity to demonstrate what they know and can do and assist their learning
- be valid and reliable, measuring what the task purports to assess, and providing accurate information on each student's achievement
- express marks on a scale sufficiently wide to adequately reflect relative differences in student performance.

Effective marking of assessment tasks requires:

- marking criteria and/or guidelines that provide clear descriptions of the quality of response required based on the standards. Where appropriate these could include wording from syllabus outcomes and performance descriptions
- a mark range that allows for discrimination between the performances of individual students based on the standards
- a shared understanding of the demands of the tasks among the teachers responsible for the marking
- consistent application of marking guidelines.

Feedback and reporting on assessment tasks should:

- be provided in a timely manner
- be linked to the specific outcomes and marking criteria addressed by the task
- indicate the ranking and relative difference between students that result from different performance descriptions of the specified standards
- be meaningful, constructive and provide students with an indication of their performance relative to the outcomes being assessed and their general progress.

Student performance in the HSC course report includes a performance scale with levels (bands) of achievement and descriptions that summarise the attainments typically demonstrated in that band. Using the wording of these performance band descriptions in relation to individual assessment tasks can be a useful way to provide feedback to students. However teachers need to take care that students do not conclude that this is the band they will finally achieve in the HSC.

Sample Assessment Programs

The assessment weightings and components to be applied to internal assessment are identified in the document *Assessment and Reporting in <Course> Stage 6*, available with the syllabus for each Science course. They ensure a common focus for internal assessment in the course across schools, while allowing for flexibility in the design of tasks.

Internal assessment provides a measure of a student's achievement based on a wider range of syllabus content and outcomes than may be covered by the external

examination alone. A variety of tasks should be used to give students the opportunity to demonstrate outcomes in different ways and to improve the validity and reliability of the assessment.

The [sample Stage 6 HSC assessment program](#) provided shows a range of tasks that address the requirements of all the Stage 6 science courses. In developing their assessment programs, schools may choose to use or adapt the proforma style and range of types of tasks suggested. However, the final internal assessment mark should be based on a range and balance of assessment instruments. The tasks in the sample assessment program are broadly grouped into examination type tasks and non-examination type tasks.

Examination type tasks include those in which the questions or tasks are unseen such as class and topic tests, traditional half-yearly examinations and trial examinations. **No more than 50% weighting may be allocated to this type of task.**

Non-examination type tasks include:

- question(s) or stimulus material provided in advance with the task completed in class. A variation could be to inform students that they are to incorporate unseen material into their response when the task is completed in class
- first-hand practical tasks performed and assessed in the laboratory
- fieldwork studies and presentation of reports
- an open-ended research task using secondary sources with information gathered, processed and analysed over an extended period of time
- open-ended investigation including the gathering of first-hand data by planning and performing the investigation, processing and analysing the data and communicating the outcomes of the investigation
- preparation of teaching/seminar notes for teaching a topic to an audience
- oral presentations with visuals/audio.

These non-examination types of task provide opportunities to integrate a broad range of knowledge, understanding and skill outcomes that may not be able to be addressed by the external examination. They can also include activities which allow for responses to be developed over a period of time.

A best practice standards-based assessment program in science would show:

- the outcomes assessed by each task
- the mandatory course components and weightings with no more than 50% weighting allocated to examinations and topic tests
- 30% weighting allocated to tasks that assess students' abilities to plan and conduct first-hand investigations, gather and process first-hand data, and gather and process relevant information from secondary sources
- an appropriate number (between 3 and 5) and range of tasks with no individual task worth less than 10% or more than 40% of the program and tasks with greater weighting held towards the end of the course
- the scheduled timing/date of each task
- the nature of each task with a balance between the assessment of knowledge/understanding outcomes and course content and skills outcomes and course content (values and attitudes are not assessed).

Other resources and advice related to assessment in Stage 6 Science are available on the Board's website with the syllabus for each course and in the Assessment and Resource Centre.

In both the Preliminary and HSC courses at least one open-ended investigation (see pages 35–43) must be included as part of the 80 indicative hours of practical/fieldwork during the Preliminary and HSC courses. While these open-ended investigations may not be part of the assessment program they are challenging for many students. The [*HSC: All My Own Work*](#) program is a guide to help students to follow the principles and practices of good scholarship and complete non-examination type tasks, such as open-ended investigations, honestly and with confidence. It includes understanding and valuing ethical practices when locating and using information as part of their HSC studies.

The [*HSC: All My Own Work*](#) program is designed to be delivered flexibly as self-paced learning modules and is integrated with other NSW syllabuses and programs. From 2008, all students entered for one or more HSC courses with an external examination will be required to have satisfactorily completed the *HSC: All My Own Work* program, or its equivalent.

4. Open-ended Investigations

The structure for each of the Stage 6 syllabuses requires that at least one open-ended investigation be included in each of the Preliminary and HSC courses. The syllabuses state that open-ended investigations must integrate skill and knowledge outcomes.

Open-ended investigations are activities in which the students take the initiative in finding answers to problems that require the gathering of information before they can propose a possible answer. The purpose of an open-ended investigation in any form is to assist students in further development of their scientific knowledge, understanding and skills. Participation in open-ended investigations should also enhance each student's understanding of the nature and practice of science. The planning component and the problem-solving nature of an open-ended investigation distinguishes it from other types of investigations.

Not all investigations can be defined as open-ended investigations. Hegarty-Hazel classifies investigations into a number of levels over five factors depending on the choice allowed to students (Hackling, M, *Working Scientifically: Implementing and Assessing*, Education Department of Western Australia, 1998).

The factors are:

- the problem that is to be solved
- the equipment/resources needed to undertake an investigation
- the procedure planned or proposed for the investigation
- the possible answers to the posed problem
- the most common answer given to the posed problem.

In this classification, a truly open-ended investigation confronts students with a problem that has many facets, can be investigated in a number of ways using different equipment and/or resources, and does not have an expected or set answer that needs to be verified. They summarise the level of investigations from 0 to 3 in the following way.

Level	Problem	Equipment	Procedure	Answer	Common answer
0	Given	Given	Given	Given	Verification
1	Given	Given	Given	Open	Guided inquiry
2a	Given	Given	Open	Open	Open guided inquiry
2b	Given	Open	Open	Open	Open guided inquiry
3	Open	Open	Open	Open	Open guided inquiry

The amount of teacher guidance needed for the open-ended investigation will be dependent on students' prior experience in performing first-hand investigations across Stages 1–3 and with Student Research Projects in Stages 4 and 5. ([Refer to The Continuum of Learning.](#))

Students have extended their skills in working scientifically during Stages 4–5 work and will have developed confidence in selecting appropriate methodologies for conducting an open-ended investigation. An individual or a team may undertake an open-ended investigation. In any case, it should: be the students' own work; be related to some aspect of their course; and reflect their interests, skills and knowledge.

Students should be encouraged to identify, perhaps with guidance, those ways in which the investigation will enhance their knowledge and understanding of their course. In classrooms where open investigations have not been the norm, both teachers and their students will need practise in moving the students through the various levels of openness of inquiry.

The Role of the Teacher in Open-ended Investigations

The teacher must facilitate and guide students in the management of the investigation. The success of open-ended investigations depends on the skills that students have, so part of the development process must include time for teaching the skills and for practising them. Without such introductory teaching/learning strategies, students will have difficulty in progressing effectively through an investigation. While the investigation must be the work of the student and reflect his or her interests, skills and knowledge, the teacher should:

- encourage a diversity of choice of research topics within the class
- assist students to develop ideas and proposals for topic areas
- assist students to evaluate the feasibility of proposed topics
- facilitate access to resources and references
- guide students through the planning process and in particular, discuss the appropriate research methodology
- assist in the development of referencing skills
- revise note-making, summarising and collating skills
- motivate students to maintain consistency of work patterns
- validate students' work
- provide written comments, suggestions and advice on a regular and consistent basis
- assist students to evaluate the outcomes of their research
- counsel students through problems encountered.

The syllabuses are designed to allow teachers to provide students with ample opportunities for students to practise the skills needed to undertake truly open-ended investigations. Active participation in planning and performing open-ended investigations provides experiences in which students develop their understanding of the processes used to generate and test scientific ideas. Initially, the length and complexity of the investigation may depend on both the teacher's and the student's previous first-hand experiences of an open-ended investigation.

The open-ended investigations that teachers choose to include in each course can be based on any of the experiences drawn from a module, or may be entirely teacher developed drawing on any other aspects of the syllabus content.

For example, in the Module 8.3 – Patterns in Nature of the *Biology Stage 6 Syllabus*, students are required to 'perform a first-hand investigation to demonstrate the effect of surface area to volume ratio on rate of diffusion'. This is an example of a first-hand investigation where the teacher could design a teaching activity where students are given:

- the problem to be investigated
- the equipment to be used
- the procedure for setting up equipment
- the observations and measurements to be taken.

The only real ‘openness’ of this first-hand experience is, therefore, the final conclusion – ‘what is the relationship between surface area to volume ratio and rate of diffusion?’ This would therefore not be considered an open-ended investigation, but rather verification.

However, Module 8.3 also includes the requirement for students to ‘plan, choose equipment or resources and perform first-hand investigations to gather information and use available evidence to demonstrate the need for chlorophyll and light in photosynthesis’. The activity developed by the teacher could require the students (among other possibilities) to:

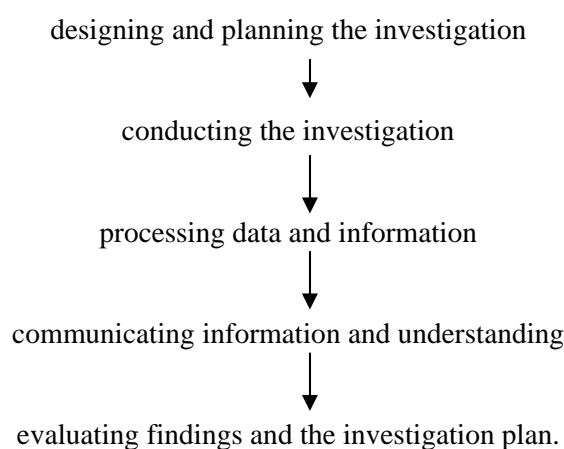
- design an investigation that allows valid and reliable data and information to be collected
- identify and/or set up the most appropriate equipment or combination of equipment needed to undertake the investigation
- carry out the planned procedure, recognising where and when modifications are needed, and analysing the effect of these adjustments
- use appropriate data collecting techniques
- apply critical thinking in the consideration of the results of investigations.

The students could learn about and practise a wide range of skills with the teacher’s role limited to identifying data to be collected and the problem to be considered. However, in this exercise, the conclusion from the investigation will be an affirmation or rebuttal of the ‘need for light and chlorophyll’ and so the openness of this investigation is still limited.

Open-ended investigations can be undertaken by teams or individuals, and could be undertaken by different students at different times during their course, with each student focusing on the area of most interest to them in the course. This could become an open-ended investigation undertaken by individuals or teams of students. In a team task different groups of material could be investigated or each student could be assigned a specific role in the investigation process.

Stages of Open-ended Investigations

The stages involved in open-ended investigations include:



Planning open-ended investigations

The question or problem identified as the focus of the open-ended investigation needs to be formalised into the hypothesis to be tested. Students, with teacher assistance if necessary, need to decide and clarify what problem they are trying to solve or what question they are asking, so that the investigation has a clear purpose. Consideration must be given to whether it will be feasible given the constraints of time, equipment and potential risks. Strategies that can assist in planning open-ended investigations include:

- drawing concept maps to identify the relationship between a possible investigation and the student's current knowledge, understanding and skills
- brainstorming possible strategies for investigating a problem and evaluating the feasibility of the strategy and/or task
- developing a timeline detailing dates and tasks covering the whole investigation
- identifying the type of data that need to be collected
- describing the strategies that will be used to collect data
- describing the analysis that will be required for these data to be useful
- determining the style of reporting to be used.

Teachers may consider asking students to keep a process diary as part of the open-ended investigation. The production of a process diary by the student can inform progress for both the student and teacher. This diary could commence during the planning process and continue through the implementation of the investigation plan. It may then become part of the final report to communicate findings and indicate areas for further research.

As a working document, the process diary can become an ongoing account of progress throughout the open-ended investigation and may include hand-written notes, annotated sketches and appropriately referenced relevant data sources and information. If a process diary is used, it should record more than superficial comments. Students could record their ideas, observations, reflections, decisions made and their reasons for those decisions. Summaries of discussions with anyone they sought advice from, such as the teacher, researchers, farm managers, scientists or technologists could also be included. The diary should provide the student with an understanding of the most significant decisions made and the problems encountered, for example, problems associated with topic choice, research methodology or experimental design, significant conversations with others, and ideas and possibilities which come to mind.

If the process diary is to be included as part of a student's report, extensive rewriting and word processing of the diary should be discouraged. Students need to see the diary as their own working document. The process diary should be presented in its original form.

Conducting open-ended investigations could include:

- trialling the procedure to be used
- modifying the procedure as a result of the trial
- performing the planned procedure
- assessing the quality of the data or information collected
- running repetitions of the procedure.

The methodology used in the open-ended investigation will depend on the type of investigation undertaken. If students are gathering first-hand data, then the methodology will be very different to those undertaking an investigation involving the collection of data or information from secondary sources. Truly open-ended investigations will lend themselves to a range of different methodologies.

Processing data and information from an open-ended investigation could include:

- assessing the accuracy of any measurements and calculations
- assessing the relative importance of the data and information collected
- trialling and choosing appropriate methods to demonstrate any trends or patterns in the information
- evaluating the validity of data and information collected and the conclusion drawn in relation to the investigation hypothesis
- assessing the reliability of data and information
- analysing the data.

The role of the teacher as guide and mentor during this stage of the investigation may be crucial in the learning process as students determine the relative accuracy and reliability of the information gathered. Students may need assistance in the selection of appropriate methods to use in their analysis of the data and information collected. They may also need assistance in learning to use data analysis software, if available and suitable, to be used in the investigation.

In presenting their results, students can be advised about the most appropriate methodology to allow meaningful comparisons to be drawn. For example, drawing or generating graphs with appropriate scales that compare three different treatments on the one set of axes may make comparison easier than three separate graphs on different scales.

In a research investigation, the results may summarise and collate information from a range of sources. Results can be presented using:

- graphs
- tables
- spreadsheets
- flow charts
- figures
- photographs.

Communicating information and understanding gained as a result of an open-ended investigation could include:

- drawing a variety of pictorial representations such as graphs, tables and diagrams to report the findings
- production of an oral or written report
- participating in a debate or class discussion on the investigation.

A summary report can assist both the teacher and student in assessing the outcomes of the investigation. The report could include:

- the research question (hypothesis)
- the contribution the investigation makes to increasing the student's own understanding

- the relationship of the investigation to the course content
- research methodology and justification
- observations and findings of the practical experiences
- conclusions and generalisations made by the individual or the team. A discussion could include reflection on the research methodology and experimental design used
- a bibliography that uses an appropriate method to acknowledge sources of information.

Evaluating findings and the open-ended investigation plan could include:

- examining the relationship between the hypothesis, the results and the conclusion of the investigation
- reaching a decision on the relevance of the findings in providing a solution to the problem, answer to the question or support for the hypothesis tested
- assessing the design of the investigation, the value of the techniques or methods used
- proposing areas for further investigation.

Where students have successfully completed an open-ended investigation during the Preliminary course that led to further areas of research, it is feasible that these further questions could be pursued in an open-ended investigation during their HSC course.

Types of Open-ended Investigations

Open-ended investigations using a range of equipment and materials to collect first-hand data and information could include:

- identification of the orders of magnitude appropriate in the measurement of data
- discussion of the uncertainty that may be present in the measurement of data
- identification of the correct units for quantitative data
- description of the strategy for data collection or gathering information
- identification of dependent and independent variables and a description of how the variables are controlled
- results of any testing of combinations of equipment that may have been needed during an investigation
- a risk assessment of intended experimental procedures and identification of strategies that address potential hazards.

Open-ended investigations involving data and information gathered from secondary sources could include:

- identification of the sources of the data or information
- discussion of the relevance of the data or information
- description of the strategy for data collection or gathering information used
- assessment of the accuracy and reliability of the data or information from a variety of sources.

There are many different types of secondary sources from which data and information could be gathered. These include media search and summary, review of an issue about science in a social content, literature review in a historical aspect of the course or

current research in the discipline being studied, or literature review on current research in the discipline being studied.

Media search and summary

Given access to a variety of media, including television and newsprint, students could identify a subject with a scientific basis and analyse the reporting of this phenomenon by different forms of media.

Module 9.2 – Tectonic Impacts from the *Earth and Environmental Science Stage 6 Syllabus* requires students to ‘gather information from secondary sources to present a case study of a natural disaster associated with tectonic activity that includes ...’. This could be developed into an open-ended investigation by including a comparison of the reporting of this disaster and the tectonic activity associated with it in both popular media and scientific journals. Depending on the availability of resources, this could be a longer-term project. By following the steps in the investigation process outlined above, students could experience most aspects of the science investigation process and could design some simple experiments to model the processes involved in the tectonic activity.

Review of an issue about science in a social context

If research is to be undertaken in the area of social contexts, then case studies or consumer attitudes/preferences investigation may be undertaken. These could involve both qualitative as well as quantitative research methodologies. This kind of open-ended investigation could include:

- observation
- action research
- questionnaires
- interviews and/or surveys
- case studies
- document analysis (newspapers, books, maps, Hansard, government policy).

Literature review on a historical aspect of the course or current research in the discipline being studied

Module 8.3 – Patterns in Nature from the *Biology Stage 6 Syllabus* requires students to ‘outline the historical development of the cell theory, in particular the contributions of Robert Hooke and Robert Brown’. This dot point could be extended into a much wider review of the history of cell theory. It could assist the development of biological knowledge and understanding by extending into research on theories of cell function in genetic activity and gene expression. Because of the potential wealth of information that is available, the teacher might limit students to a number of developments and limit the amount of information required in this investigation.

Module 8.3 – Electrical Energy in the Home from the *Physics Stage 6 Syllabus* requires students to ‘identify data sources, gather, process and analyse secondary information about the differing views of Volta and Galvani about animal and chemical electricity and discuss whether their different views contributed to increased understanding of electricity

This requires:

- identification of the type of information to be collected

- accessing information from a range of sources, which may or may not be limited by the teacher, and would be determined by school resources and student ability
- summarising and collating information from a range of sources, which may require some teacher assistance
- the identification and use of cause-and-effect relationships
- identification of the interconnectedness of ideas or scientific principles.

Teacher guidance would be critical to ensure that students doing such an investigation stayed within the parameters of the task because there is so much material available on each of these scientists that might not relate to the task. Inexperienced students will need assistance in distinguishing between the requirements of the task and the ‘write all you can find out about’ type of open-ended assignment.

Literature review on current research in the discipline being studied

Module 8.5 – The Cosmic Engine from the *Physics Stage 6 Syllabus* requires students to ‘identify data sources, gather and process information and use available evidence to assess the effects of sunspot activity on the Earth’s power grid and satellite communications’. As there are many articles related to this topic, students will probably need assistance in identifying appropriate resources, journals or internet websites.

For some students, a literature review may be an appropriate and satisfying open-ended investigation. It is a concise description of the student’s interpretation and understanding of their reading. The review should focus only on literature relevant to the research question being investigated, and avoid being a presentation of general information about the topic. The review will vary considerably depending on the available literature.

While it would not be expected that the review would be extensive, it should:

- go beyond the general information provided in two or three school textbooks
- identify the specific resources, including popular scientific journals, CD-ROMs and the internet, used to access information
- assess some of the current knowledge of the topic and research methods related to the research question and acknowledge the source of information or data
- cite some of the ideas, data and conclusions from other sources
- describe in a concise way the student’s interpretation and understanding of their reading.

Assessment of Open-ended Investigations

Assessment of an open-ended investigation could focus on:	Preliminary Outcomes	HSC Outcomes
<ul style="list-style-type: none"> quality of the background research, including appropriateness, variety of sources used, validity of information 	<p>P11 identifies and implements improvements to investigation plans</p> <p>P12 discusses the validity and reliability of data gathered from first-hand investigations and secondary sources</p>	<p>H11 justifies the appropriateness of a particular investigation plan</p> <p>H12 evaluates ways in which accuracy and reliability could be improved in investigations</p>
<ul style="list-style-type: none"> quality of the process diary (if required), including regular use, evidence of development of ideas and critical decisions 	<p>P12 discusses the validity and reliability of data gathered from first-hand investigations and secondary sources</p> <p>P14 draws valid conclusions from gathered data and information</p>	<p>P12 discusses the validity and reliability of data gathered from first-hand investigations and secondary sources</p> <p>H14 assesses the validity of conclusions from gathered data and information</p>
<ul style="list-style-type: none"> plan of investigation, including justification for methodology chosen, appropriateness, details of materials, clarity of methodology, viability of investigation 	<p>P11 identifies and implements improvements to investigation plans</p>	<p>H11 justifies the appropriateness of a particular investigation plan</p>
<ul style="list-style-type: none"> any modifications, including appropriateness and justifications 	<p>P12 discusses the validity and reliability of data gathered from first-hand investigations and secondary sources</p> <p>P14 draws valid conclusions from gathered data and information</p>	<p>H12 evaluates ways in which accuracy and reliability could be improved in investigations</p> <p>H14 assesses the validity of conclusions from gathered data and information</p>
<ul style="list-style-type: none"> the results of the research, including appropriateness of methodology chosen to present information in order to show relationships 	<p>P14 draws valid conclusions from gathered data and information</p>	<p>H14 assesses the validity of conclusions from gathered data and information</p>
<ul style="list-style-type: none"> data analysis, including discussion of the meaning of results, discussion of the relationship of data to the research question, discussion of the degree of success of the investigation, discussion of the limitations of equipment and methodology, discussion of design weaknesses, relevance and practicality of suggested improvements, and discussion of data reliability or the effect of errors 	<p>P14 draws valid conclusions from gathered data and information</p>	<p>P14 draws valid conclusions from gathered data and information</p>
<ul style="list-style-type: none"> the conclusions, including discussion of the relationship between the research findings and the research question, comparison with other findings in literature review (if relevant), and suggestions for areas of further investigation. 	<p>P14 draws valid conclusions from gathered data and information</p>	<p>P14 draws valid conclusions from gathered data and information</p>

Safety

The information provided in this section describes the legal obligations of schools in relation to safety. Teachers will need to ensure that they comply with these as well as with particular system requirements.

The *Occupational Health and Safety Act 2000* and the Occupational Health and Safety Regulation (OHS) 2001 contain provisions that require employers to consult with employees on health and safety matters. The OHS Regulation 2001 sets out requirements for workplaces related to putting into place systems to identify, assess, control and/or eliminate health or safety risks.

The OHS Regulation 2001 provides broad coverage for all workplaces along with specified control measures for particular hazards.

These relate to:

- identification of all workplace hazards
- assessment of risks arising from those hazards
- implementation of measures to control those risks
- provision of training, instruction and supervision
- workplace consultation between employers and employees
- control of specific high risk hazards such as plant, hazardous substances and hazardous processes.

Amendments to the OHS Regulation in 2005 regulate the supply, transport and storage of chemicals, whether as single chemicals or constituents in mixtures. It includes operation of dangerous goods stores in addition to labelling and packaging requirements.

The regulation under this Act has over 370 clauses and refers to several Australian standards. In addition, the Australian Code for the Transport of Dangerous Goods by Road and Rail details the dangerous goods concerned and defines the labelling (other than those covered by the *Poisons Act 1966* (NSW)) and performance specifications of the packaging.

It provides instructions on the storage, use and disposal of dangerous goods in the workplace. This includes substances used in a range of specialist subjects in schools, together with substances used for cleaning, weed control and other similar purposes.

The amendments to this legislation have three main implications for schools:

- Dangerous goods must be stored safely with consideration to their relative hazards and to their compatibility with other substances.
- Containers of dangerous goods must be labelled with the appropriate class labels once certain quantity thresholds are reached.
- Where quantities of dangerous goods stored on site exceed limits specified under the Regulations, schools will require a Dangerous Goods Licence.

It is a legislative requirement that a register of all hazardous substances stored on site be kept and be readily accessible to all staff. Schools should be familiar with the requirements and responsibilities under this Act and Regulation.

School policies and procedures should be developed, implemented and monitored to ensure compliance with the Act and the Regulation. There are various offences and penalties associated with the *Occupational Health and Safety Act* (2000) and the Regulations made under the *Occupational Health and Safety Act*. These include

penalties for organisations found guilty of breaches of the Act or the Regulations. There are also penalties for staff and other persons, even students and visitors, found guilty of breaches of occupational health and safety law.

Resources

Chemical Safety in Schools (CSIS) is a resource package for schools, developed by the Department of Education and Training (DET) to provide schools with up-to-date information on chemical safety and to assist schools meet the mandatory requirements under the *Hazardous Substances* and *Dangerous Goods* legislation.

The package addresses the *Occupational Health and Safety (Hazardous Substances) Regulation* (1996), which requires:

- training for staff in the management of risks associated with the use of chemicals
- ready access to risk and safety information on hazardous substances
- a register to be kept of hazardous substances used or stored on site
- the labelling of chemical containers with risk and safety information
- the assessment of risks to health from exposure to hazardous substances
- the implementation of control measures to protect health and safety
- the maintenance of records of training and risk assessment
- the appropriate labelling and storage of dangerous goods
- licensing by WorkCover NSW, where stocks of dangerous goods exceed storage limits.

The package also promotes best practice in the use of chemicals for teaching and learning in schools.

QStores for fact sheets on chemicals.

The National Health and Medical Research Council publication, *Code of Practice for the Safe Use of Lasers in Schools: Radiation Health Series No 36* (Australian Government Publishing Service, Canberra, 1995) is an essential guide.

Contact

WorkCover NSW, 92–100 Donnison Street, Gosford, NSW 2250, telephone 13 10 50 or fax (02) 4325 4145 for Dangerous Goods Licences.

Standards Australia, 286 Sussex Street, Sydney, NSW 2000, telephone 8206 6000, for information about or purchase of current Australian Standards.

Department of Environment & Climate Change, 59–61 Goulburn Street, Sydney South, NSW 1231, telephone (02) 9211 4723, for waste disposal regulatory requirements.

Use of Animals in Science Teaching

Teachers of science are aware of the importance of animals to teaching and learning in the school curriculum. Animals provide many opportunities for students to gain knowledge, acquire skills and develop appropriate, positive attitudes towards the welfare of animals.

The use of animals in research and teaching in NSW is regulated by the *Animal Research Act 1985* (NSW), which places the responsibility for the care and welfare of animals in schools upon the teacher involved with their use. Under the Act, an animal means, 'a vertebrate animal, and includes a mammal, bird, reptile, amphibian and fish, but does not include a human being'.

This legislation requires researchers and teachers to consider and apply three general principles (the 3Rs). They are:

- the replacement of animals with other methods
- the reduction of the number of animals used
- the refinement of techniques used to reduce the impact on animals.

Teaching activities involving animals may only be performed when a decision has been made that, after weighing the educational value against the potential negative effects on the welfare of the animal and deciding that no other non-animal or less sentient animal alternative is suitable, they are justified.

If a teacher decides that animal use is justified, they should check that the activity is included in the list of approved activities. This list is in the document *Animals in schools: Animal welfare guidelines for teachers* and on the *Animals in schools* web site at: <http://www.schools.nsw.edu.au/animalsinschools/>. This document and web site explains what to do if the activity is not included in the list of approved activities.

The Animal Research Act requires all schools to have access to an Animal Ethics Committee (AEC). In the case of Department of Education and Training (DET) schools and Catholic Education Commission (CEC) schools, this requirement is fulfilled automatically by the Schools Animal Care and Ethics Committee (SACEC). Schools that are part of the Association of Independent Schools (AIS) and other independent schools may nominate the SACEC as their AEC or set up their own AEC. The SACEC was established by joint agreement between the AIS, the CEC and the DET. Its role is to ensure that the use of animals by schools complies with the Act.

The SACEC sends annually, to all the schools it serves, an Animal Research Authority. This authorises:

- student participation for activities in categories 1–3
- teacher demonstration only for activities in category 4
- student participation for collection, observation and release of tadpoles (frogs).

This authorisation is for all activities that are carried out in accordance with the provisions described in *Animals in schools: Animal welfare guidelines for teachers*.

Animals in schools: Animal welfare guidelines for teachers is a mandatory document in all schools covered by the SACEC.

The school principal is responsible for identifying, and listing on the Animal Research Authority, all appropriately qualified teachers who have the principal's approval to use animals for teaching or research. The authority must be kept in the principal's office and be available for inspection by appropriate officers from the Animal Welfare Unit or members of the SACEC.

Using native animals for educational purposes

Teachers who wish to keep native animals for educational purposes must obtain a scientific licence. An application form for SACEC approval for this licence is available on the *Animals in schools* website at:

<http://www.schools.nsw.edu.au/animalsinschools/>

Resources

Animals in Schools: Animal Welfare Guidelines for Teachers, NSW Department of Education, 2001.

Animals in schools website:

<http://www.schools.nsw.edu.au/animalsinschools/>

Enquiries relating to the use of animals in teaching and research may be made to the Schools Animal Welfare Officer on (02) 9886 7426 or by fax on (02) 9886 7154 or by email sally.bannerman@det.nsw.edu.au

Enquiries relating to the collecting of aquatic organisms may be made to the NSW Department of Primary Industries on (02) 9527 8411.

Appendices

Sample Evaluation Proforma

Learning Unit/ Syllabus Module: _____	Number(s) _____
Name _____	
Date Commenced: _____	Date Completed: _____
Was the indicative time for the unit/module appropriate for the cohort?	
Suggestions for changes, deletions and/or additional resources to enhance teaching and learning in this unit/module.	
How well does the targeted (8.1/9.1) skills content selected for this unit address the skill development within the module and/or across the course?	
Which suggested learning experiences need to be modified or changed to enhance teaching and/or improve learning opportunities for the different types of learners?	
In what ways could the teaching-learning strategies better integrate knowledge, understanding, skills, values and attitudes in each section of the unit/module?	
Which of the targeted Prescribed Focus Area and skill outcomes need additional emphasis in the unit/module of work?	
In what ways could the assessment activities be further developed to: <ul style="list-style-type: none">• focus more clearly on syllabus outcomes• provide clearer communication to students on the task requirements and/or ways in which they could improve their level of achievement?	
Other comments:	

Teacher: _____ Date: _____

Sample focus questions for discussion and consideration in evaluation of a teaching-learning unit

Indicative timing

1. Is the indicative time for each section appropriate? If not, which areas need more/less time?

Resources identified

1. What particular difficulties or problems were there with equipment or other resources used in first-hand investigations?
2. What resources should definitely be deleted from the list?
3. What new and/or better resources have been identified?
4. In which areas of content would further/different resources be useful and/or are needed?

First-hand experiences

1. Which were the more appropriate practical experiences for the module content?
2. Which practical experiences were better for illustrating the 8.1/9.1 skills module content?

Skills development

1. Which 8.1/9.1 skills content needed more explicit teaching-learning experiences than others in this module?
2. Does the program provide adequate opportunities for students to practise and apply the targeted skills content that was the focus of learning in this unit/module?
3. Was the selection of targeted 8.1/9.1 skills content appropriate for the module content addressed?
4. In what ways does the 8.1/9.1 skills content mapping need to be modified or changed to better address skill development in the unit and/or across the course?

Teaching and learning strategies

1. Which of the teaching and learning strategies provided were appropriate in identifying and building on students' prior learning and/or determining future directions?
2. Were the suggested teaching/learning strategies effective in providing opportunities for conceptual development for all students?
3. How effective were the context(s) selected in assisting students to make meaning of the content?
4. Did this unit provide sufficient variation in learning opportunities for the range of different types of learners in the group?
5. What was the student response to the unit?

Assessment tasks

1. Do the assessment activities:
 - include a range of syllabus outcomes
 - explicitly state the outcomes being assessed and clearly articulate the assessment criteria
 - have well-constructed marking guidelines
 - allow students to provide evidence of the breadth and depth of their learning in relation to the outcomes being addressed?
2. How well do the feedback strategies communicate to students their strengths, weaknesses and areas for improvement?

Stage 6 HSC Chemistry Sample assessment grid

Component	Task 1	Task 2	Task 3	Task 4	Task 5	Weighting
	Secondary Sources Investigation	Planning and Performing a Practical Task	Term 2 Examination	Performing and Reporting a First-Hand Investigation	Examination	
	Term 4 Week 7	Term 1 Week 8	Term 2 Week 2	Term 2 Week 7	Term 3 Week 5	
	H1, H3, H12, H13, H14	H11, H12, H13, H14, H15	H4, H6, H7, H9, H12, H13, H14	H2, H9, H11, H12, H13, H14	H5, H6, H7, H8, H9, H10, H13, H14	
Knowledge and understanding of: <ul style="list-style-type: none"> the history, nature and practice of chemistry, applications and uses of chemistry and their implications for society and the environment, and current issues, research and development in chemistry atomic structure, the periodic table and bonding, energy, chemical reactions, carbon chemistry and stoichiometry 	5	–	10	5	20	40
Skills in: <ul style="list-style-type: none"> planning and conducting first-hand investigations gathering and processing first-hand data gathering and processing relevant information from secondary sources. 	5	10	–	15	–	30
Skills in: <ul style="list-style-type: none"> Communicating information and understanding Developing scientific thinking and problem-solving techniques Working individually and in teams 	5	5	5	5	10	30
Total %	15	15	15	25	30	100

Note: No more than 50% weighting may be allocated to tests and examinations

Stage 6 HSC Chemistry Sample assessment grid

Component	Task 1	Task 2	Task 3	Task 4	Weighting
	Secondary Sources Investigation	Planning and Performing a Practical Task	Performing and Reporting a First-Hand Investigation	Examination	
	Term 4 Week 7	Term 1 Week 8	Term 2 Week 7	Term 3 Week 5	
	H1, H5, H12, H13, H14	H11, H12, H13, H14, H15	H2, H9, H11, H12, H13, H14	H3, H4, H6, H7, H8, H9, H10, H13, H14	
Knowledge and understanding of : <ul style="list-style-type: none"> the history, nature and practice of chemistry, applications and uses of chemistry and their implications for society and the environment, and current issues, research and development in chemistry atomic structure, the periodic table and bonding, energy, chemical reactions, carbon chemistry and stoichiometry 	5	–	10	25	40
Skills in: <ul style="list-style-type: none"> planning and conducting first-hand investigations gathering and processing first-hand data gathering and processing relevant information from secondary sources. 	5	10	15	–	30
Skills in: <ul style="list-style-type: none"> Communicating information and understanding Developing scientific thinking and problem-solving techniques Working individually and in teams 	5	5	10	10	30
Total %	15	15	35	35	100

Note: No more than 50% weighting may be allocated to tests and examinations

Contextual Outline

Many consumer products have been developed because of increased understanding of chemical substances, chemical reactions and the biochemistry of human body surfaces. Some of these products are used as cleaning agents, while others have been developed to act as barriers against environmental factors like wind and heat. Some products are mixtures, used for medicinal purposes, and require a different understanding of body chemistry and chemical interaction. The production of these substances on a commercial scale has resulted from developments in chemical technology and an understanding of the different properties of chemicals and chemical interactions. These products include a range of different types of substances, different mixtures and various polymer molecules.

Many products are applied to the hair and skin, to keep them clean or offer some protection from the elements. The products are designed to take into account the properties of water and alcohol, as solvents, and numerous aspects of body chemistry. The different types of chemical substances and how they are combined to make mixtures depends upon their specific physical and chemical properties. The types of products used and the ways in which they are used have changed over time and are continuing to change as people become more aware of the environmental and health impacts of some of the synthetic substances produced.

This module increases students' understanding of the history, nature and practice, applications and uses of science and the implications of science for society and the environment.

(Senior Science Syllabus p 42)

Targeted Outcomes:

A student:

- H2. applies the processes that are used to test and validate models, theories and laws, to investigations
- H4. assesses the impacts of applications of science on society and the environment
- H7. identifies effects of internal and external environmental changes on the human body
- H8. relates the properties of chemicals to their use
- H11. justifies the appropriateness of a particular investigation plan
- H12. evaluates ways in which accuracy and reliability could be improved in investigations
- H13. uses terminology and reporting styles appropriately and successfully to communicate information and understanding
- H14. assesses the validity of conclusions from gathered data and information
- H15. explains why an investigation is best undertaken individually or by a team

Resources:

Selection of mixtures, eg detergents, cleaners, cosmetics, mayonnaise, milk, shaving foam, lubricants, pesticides

MSDS Sheets or <http://www.msds.com.au>

http://www.questacon.edu.au/temp_japan/story.asp?tblStories.storyNumber=83&categoryID=MI&languageID=AU

http://www.hsc.csu.edu.au/senior_science/core/life_chem/9-2-2/9.2.2.html

9.2.1 The use of a substance depends on its physical and chemical properties

Module 9.2 Content	R	9.1 Skills Content	Suggested Teaching –Learning Strategies
<p>Students learn to/Students:</p> <p>*identify that a wide range of substances are used daily as part of our food, our hygiene, and maintenance of our health</p> <p>*process and analyse information to identify the range of chemicals used in everyday living including: detergent, lubricant, pesticide, solvent, metal cleaner, body hygiene chemicals, cosmetic and outline any precautions that may be needed in the use and handling of these chemicals</p> <p>*explain that mixtures can be</p> <ul style="list-style-type: none"> - solutions that contain dissolved substances and are uniform throughout - suspensions containing particles that settle out, or form layers, quickly - colloids with particles that remain suspended for long periods of time and include: <ul style="list-style-type: none"> - liquid-in-liquid (emulsions) <ul style="list-style-type: none"> - oil-in-water - water-in-oil - gas-in-liquid (foams) <p>*identify that solutions, colloids and suspensions occur in a wide range of consumer products</p> <p>*use first-hand or secondary sources to gather, process, analyse and present information to identify examples of suspensions and colloids and outline one advantage of a mixture being in each form</p>		<p>Students:</p> <p>12.2 gather first-hand information by:</p> <p>b) measuring, <i>observing and recording</i> results in accessible and recognizable forms, carrying out repeat trials as appropriate</p> <p>12.3 gather information from secondary sources by:</p> <p>a) <i>accessing information</i> from a range of resources including popular scientific journals, digital technologies and the Internet</p> <p>d) <i>summarising and collating</i> information from a range of resources</p> <p>13.1 present information by:</p> <p>b) <i>selecting and using appropriate media</i> to present data and information</p> <p>14.1 analyse information:</p> <p>a) <i>to identify trends, patterns</i> and relationships as well as contradictions in data and information</p> <p>b) <i>to justify</i> inferences and conclusions</p>	<p><u>Practical investigation:</u> What are the safety issues connected with some substances we use everyday?</p> <p>In teams students:</p> <ul style="list-style-type: none"> - identify a range of substances used daily as part of our food, our hygiene, and maintenance of our health. -<i>outline an investigation</i> to locate and observe a variety of samples of chemicals used in everyday living including: detergent, lubricant, pesticide, solvent, metal cleaner, body hygiene chemicals, cosmetic. -<i>gather and record safety information from labels</i> and Material Safety Data Sheets (MSDS), -<i>select and use an appropriate format</i> to collate the safety data relevant to the use and handling of each chemical. -<i>analyse the information gathered</i> to justify the precautions that would be needed in the use and handling of these substances. <p>Individually students:</p> <ul style="list-style-type: none"> - review their prior learning by developing working definitions for each of the terms mixture, compound, solution, suspension, physical properties and chemical properties. - use secondary sources to refine their ideas and list the distinguishing features of each. <p>With teacher guidance, students use secondary sources to:</p> <ul style="list-style-type: none"> -define the term ‘colloid’, giving examples of emulsions and foams. -<i>summarise</i> the properties of these examples. <p><u>Practical investigation:</u> Are common consumer products solutions, suspensions or colloids?</p> <p>In pairs, students:</p> <ul style="list-style-type: none"> -collect some consumer products that are examples of solutions, suspensions and a range of colloids -<i>observe</i> the effect of filtering and centrifuging samples of these products -use labels or other secondary sources to identify components -classify these products based on the observed properties. -<i>analyse the data</i> to identify <i>patterns</i> and draw conclusions. -<i>using an appropriate medium</i> select and present information that relates the classification of mixtures to their properties <p>Through discussion of pooled class data, students outline the advantage of these mixtures being in the form of a solution, suspension or colloid.</p>

Example Scope and Sequence – Stage 6 Chemistry [insert years]

Week	Term 1 [year]		Term 2 [year]		Term 3 [year]	Term 4 [year]			
1	Preliminary Module 8.2: The Chemical Earth	HSC All My Own Work	Preliminary Module 8.3: Metals (cont)		Preliminary Module 8.4 Water	Revision for Yearly Exam			
2	Allocated Time: 30 hrs				Preliminary Assessment 2: Half Yearly Examination		(cont)	Preliminary Assessment 4: Yearly Exam	
3	Outcomes: P2, P6, P10, P11, P12, P13, P16						Preliminary Module 8.4: Water Allocated time: 30 hrs		Preliminary Module 8.5: Energy Allocated time: 30 hrs Outcomes: P2, P6, P7, P8, P9, P11, P12, P13, P14
4			Group Open-ended Investigation		Preliminary Assessment 3: Open-ended investigation: Solubility				
5					Outcomes: P3, P4, P6, P7, P11, P12, P15, P16				Preliminary Module 8.5: Energy (cont)
6			Outcomes: P1, P3, P5, P7, P10, P12, P14						
7									
8	Preliminary Assessment 1: Research Task								
9	Preliminary Module 8.3: Metals								
10	Allocated Time: 30 hrs Outcomes: P1, P3, P5, P7, P10, P12, P14								

NOTE: In all Stage 6 Science courses the Preliminary modules consist of core content that would be covered in 120 indicative hours. The example shows that, to meet the Preliminary course 120 hours time requirement, the HSC course does not commence until week 3 of Term 4.

Example Scope and Sequence (cont) – Stage 6 Chemistry [insert year]

Week	Term 1 [year]		Term 2 [year]	Term 3 [year]	Term 4 [year]
1	HSC Core	Group Open-ended Investigation	HSC Core Module 9.4: Chemical Monitoring and Management (cont)	HSC Option Module 9.5: Industrial Chemistry (cont)	Higher School Certificate Examinations
2	Module 9.3: The Acidic Environment		Assessment 3: Half Yearly Examinations		
3	Allocated Time: 30 hrs		HSC Core Module 9.4: (cont) Chemical Monitoring and Management Allocated time: 30 hrs Outcomes: H2, H3, H5, H6, H12, H13, H14, H16	HSC Assessment 5: Trial HSC Examinations	
4	Outcomes: H1, H4, H6, H8, H10, H11, H12, H14,				
5	H15				
6			HSC Assessment 4: Performing and Reporting on Fieldwork	Complete Module 9.5: Industrial Chemistry	
7					
8	HSC Assessment 2: Open-ended investigation: Galvanic cells		HSC Option Module 9.5: Industrial Chemistry Allocated time: 30 hrs Outcomes: H3, H4, H5, H7, H9, H11, H12, H16	Review	
9	HSC Core Module 9.4: Chemical Monitoring and Management				
10					

Sample Stage 6 Unit Proforma

The following sample Stage 6 unit proforma includes the features of a teaching/learning program and has been annotated to show the characteristics of each part.

Course: Preliminary/HSC	Unit title/Syllabus Module: Number and Name	Indicative Hours:	Syllabus indicative hours identify an appropriate time for content to be dealt with at the appropriate depth, and so that students have sufficient opportunity for feedback and improvement.
Contextual Outline:			
The contextual outline is stated for each module. It is provided to guide teachers in designing the teaching/learning and assessment experiences and to assist students to make meaning of their learning in relation to their past and current experiences.			
Target Outcomes:			Identifies the outcomes that are the focus of the teaching/learning sequences. The identified Prescribed Focus Area and Domain: knowledge, understanding, skills, values and attitudes outcomes will be those that reflect the explicit teaching within the unit.
Resources:			Examples would include: <ul style="list-style-type: none"> • texts/references/scientific journals/library resources • current websites/digital, audio and visual technologies • specific materials, resources, equipment (including safety equipment) that are not part of the everyday laboratory resources

Sample Stage 6 Unit Proforma continues on the next page to show some examples of how the essential content elements of the syllabus could be organised.

Sample Stage 6 Unit Proforma (cont)

Schools may choose to use or adapt the proforma style provided below to develop a program that best meets their needs and circumstances.

Example 1

Outcome	Module Content Column 1, 2 and 3	R*	Skills Module Content (8.1/9.1)	Suggested Learning Strategies	Evidence of Learning

Decide on the observable evidence resulting from the activity that will allow judgements to be made on achievement in relation to the outcomes.

Example 2

Skills Module Content (8.1/9.1)	R*	Module Content Column 2	R*	Module Content Column 3	Suggested Learning Strategies
					Module Content Column 1

Presents an overview of the context and focus of teaching/learning in the lesson sequences.

Example 3

Skills Module Content (8.1/9.1)	R*	Module Content Column 1, 2 and 3	Suggested Learning Strategies and Evidence of Learning

*Registration

Identified content from Module 8.1/9.1 and Columns 1, 2 and 3 of the core syllabus module

Describes the details of the teaching/learning activities best suited to the syllabus content. They focus on how the learning will allow students to provide the required evidence of learning in relation to the specified content selected for the targeted outcomes in the unit. Learning activities may be referenced to the resources.