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Chapter 1

Introduction

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1.1 Background


The Science Stages 4–5 Syllabus was published in 1998 and amended in 2003 as the Science Years 7–10 Syllabus. It builds on directions identified through international and national research into the teaching of science, and during wide circulation of the draft syllabus in NSW through consultation at forums with teachers, academics and science educators across all sectors. The Science Years 7–10 Syllabus has been developed within the parameters set by the Board of Studies NSW K–10 Curriculum Framework and is part of a continuum of learning from Kindergarten to Year 12 that supports sustained, sequential, high-quality learning in science.

The syllabus rationale describes in broad terms the nature of the subject and outlines its relationships with the contemporary world and current practice. It explains the place and purpose of the subject in the curriculum, particularly how it contributes to the K–10 Curriculum Framework, a key principle of which is that the curriculum must be inclusive of all students in New South Wales.

The Science Years 7–10 Syllabus provides opportunities for students through their learning in science to:

• develop through a range of contextualised learning experiences their science knowledge, understanding, skills, values and attitudes
• explore through the Prescribed Focus Areas issues related to the history of science, nature and practice of science, applications and uses of science, implications for society and the environment, and current issues, research and development
• develop scientific knowledge and understanding of the non-living world and living world using models, theories, laws, structures, systems and interactions
• develop their expertise in working scientifically through the skills of planning and conducting scientific investigations, communicating information and understanding, developing scientific thinking and problem-solving techniques, and working individually and in teams.

The Science Years 7–10 Syllabus promotes the concept that assessment for learning is integral to teaching and learning and recognises the importance of the active involvement of students in their own learning. This support document has been designed to assist teachers in planning and implementing learning/teaching programs based on the syllabus objectives and outcomes, and to show how these programs are underpinned by the principles of assessment for learning.
1.2 The place of the Science Years 7–10 syllabus in the Science K–12 Curriculum

- **Early Stage 1–Stage 3**
  Science and Technology K–6 Syllabus

- **Stages 4–5**
  Science Years 7–10 Syllabus
  (incorporating Life Skills outcomes and content)

- **Stage 6**
  Preliminary Biology, Chemistry, Earth and Environmental Science or Physics

- **Stage 6**
  Preliminary Senior Science

- **Stage 6**
  Senior Science HSC

- **Stage 6**
  Science Life Skills

Community, other education and learning, and workplace
1.3 The continuum of learning

The *Science Years 7–10 Syllabus* consists of objectives, outcomes and the content expressed in terms of Contexts, Prescribed Focus Areas and Domain. The *Science and Technology K–6 Syllabus* has the three main elements – objectives, outcomes and content – with the content organised around six Content Strands and three Learning Processes. While the syllabuses from Kindergarten to Year 12 may organise the content differently, there are clear underpinnings of knowledge and understanding, skills, and 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, and 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.
### Prescribed Focus Areas

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

* 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 1–3, 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.
### Knowledge and understanding

<table>
<thead>
<tr>
<th>Early Stage 1</th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
<th>Stage 4</th>
<th>Stage 5</th>
<th>Stage 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>A student:</td>
<td>A student:</td>
<td>A student:</td>
<td>A student:</td>
<td>A student:</td>
<td>A student:</td>
<td>A student:</td>
</tr>
<tr>
<td><strong>Models, theories and laws; structures and systems</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The outcomes of Stage 6 in Biology, Chemistry, Earth and Environmental Science, Physics and Senior Science build upon the foundations laid in Stage 5 to extend students’ knowledge and understanding in specific areas</td>
</tr>
<tr>
<td>explores and identifies ways some forms of energy are used in their daily lives</td>
<td>identifies and describes different ways some forms of energy are used in the community</td>
<td>identifies various forms and sources of energy</td>
<td>identifies and applies processes involved in manipulating, using and changing the form of energy</td>
<td>identifies and describes energy changes and the action of forces in common situations</td>
<td>applies models, theories and laws to situations involving energy, force and motion</td>
<td></td>
</tr>
<tr>
<td>identifies ways in which living things are different and have different needs</td>
<td>identifies and describes ways in which living things grow and change</td>
<td>identifies and describes the structure and function of living things and ways in which living things interact with other living things and their environment</td>
<td>describes the features of living things</td>
<td>relates the structure and function of living things to models, theories and laws</td>
<td></td>
<td></td>
</tr>
<tr>
<td>explores and identifies ways the environment influences their daily lives</td>
<td>identifies and describes ways in which people and other living things depend upon the Earth and its environments</td>
<td>identifies and describes the structure and function of living things and the ways in which living things interact with each other and their environment</td>
<td>identifies, describes and evaluates the interactions between living things and their effects on the environment</td>
<td>identifies factors affecting survival of organisms in an ecosystem</td>
<td>assesses human impacts on the interaction of biotic and abiotic features of the environment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Knowledge and understanding</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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*Science Years 7–10 Support Document 2009*
### 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 1–3, 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 1–3 through to Stage 6 is exemplified through the skill outcomes of each course.

<table>
<thead>
<tr>
<th>Early Stage 1</th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
<th>Stage 4</th>
<th>Stage 5</th>
<th>Stage 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>A student:</td>
<td>A student:</td>
<td>A student:</td>
<td>A student:</td>
<td>A student:</td>
<td>A student:</td>
<td>A student:</td>
</tr>
<tr>
<td>Interactions</td>
<td>recognises that the Earth is the source of most materials and resources</td>
<td>identifies where resources are found, and describes ways in which they are used by humans</td>
<td>analyses the impact of human resource use on the biosphere to evaluate methods of conserving, protecting and maintaining Earth’s resources</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>creates and evaluates products and services considering aesthetic and functional factors</td>
<td>creates and evaluates products and services, demonstrating consideration of sustainability, aesthetic, cultural, safety and functional issues</td>
<td>identifies, using examples, common simple devices and explains why they are used</td>
<td>relates the interactions involved in using some common technologies to their underlying scientific principles</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 1–3, 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 1–3 through to Stage 6 is exemplified through the skill outcomes of each course.
## Skills

<table>
<thead>
<tr>
<th>Skill</th>
<th>Stages 1 to 3</th>
<th>Stage 4</th>
<th>Stage 5</th>
<th>Stage 6 (Preliminary)</th>
<th>Stage 6 (HSC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning investigations</td>
<td>… makes judgements based on the results of … planning</td>
<td>clarifies the purpose of an investigation and, with guidance, produces a plan to investigate a problem</td>
<td>identifies a problem and independently produces an appropriate investigation plan</td>
<td>identifies and implements improvements to investigation plans</td>
<td>justifies the appropriateness of a particular investigation plan</td>
</tr>
<tr>
<td>Conducting investigations</td>
<td>conducts their own investigations</td>
<td>follows a sequence of instructions to undertake a first-hand investigation</td>
<td>undertakes first-hand investigations independently with safety and competence</td>
<td>discusses the validity and reliability of data gathered from first-hand investigations and secondary sources</td>
<td>evaluates ways in which accuracy and reliability could be improved in investigations</td>
</tr>
<tr>
<td>Communicating information and understanding</td>
<td>… makes judgements based on the results of questioning, collecting, recording … data …</td>
<td>evaluates the relevance of data and information with guidance, presents information to an audience to achieve a particular purpose</td>
<td>explains trends, patterns and relationships in data and/or information from a variety of sources</td>
<td>identifies appropriate terminology and reporting styles to communicate information and understanding</td>
<td>uses terminology and reporting styles appropriately and successfully to communicate information and understanding</td>
</tr>
<tr>
<td>Developing scientific thinking and problem-solving techniques</td>
<td>… makes judgements based on the results of … analysing data, and drawing conclusions</td>
<td>draws conclusions based on information available</td>
<td>uses critical thinking skills in evaluating information and drawing conclusions</td>
<td>draws valid conclusions from gathered data and information</td>
<td>assesses the validity of conclusions from gathered data and information</td>
</tr>
<tr>
<td>Working individually and in teams</td>
<td>works cooperatively with others in groups on scientific and technological tasks and challenges</td>
<td>undertakes a variety of individual and team tasks with guidance</td>
<td>plans, implements and evaluates the effectiveness of a variety of tasks independently and as a team member</td>
<td>implements strategies to work effectively as an individual or as a member of a team</td>
<td>explains why an investigation is best undertaken individually or by a team</td>
</tr>
</tbody>
</table>
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 1–3 the main focus is on developing positive values and attitudes towards themselves, others and science and technology. In Stages 4 and 5, the focus is 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.
## Values and attitudes

<table>
<thead>
<tr>
<th>Students will develop positive values about and attitudes towards:</th>
<th>Stages 1 to 3</th>
<th>Stages 4 and 5</th>
<th>Stage 6 (Preliminary)</th>
<th>Stage 6 (HSC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>themselves</td>
<td>A student: demonstrates confidence in themselves and a willingness to make decisions when investigating, designing, making and using technology</td>
<td>A student: demonstrates confidence and a willingness to make decisions and to take responsible actions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>others</td>
<td>A student: gains satisfaction from their efforts to investigate, to design, to make, and to use technology</td>
<td>A student: respects different viewpoints on science issues and is honest, fair and ethical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>learning as a lifelong process</td>
<td>A student: works cooperatively with others in groups on scientific and technological tasks and challenges</td>
<td>A student: 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</td>
<td>A student: recognises the relevance and importance of lifelong learning and acknowledges the continued impact of science in many aspects of everyday life</td>
<td>A student: 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</td>
</tr>
<tr>
<td>science and technology</td>
<td>A student: exhibits curiosity and responsiveness to scientific and technological ideas and evidence</td>
<td>A student: initiates and perseveres with investigations, and takes tasks to their completion</td>
<td>A student: recognises the role of science in providing information about issues being considered and in increasing understanding of the world around them</td>
<td></td>
</tr>
<tr>
<td>the environment</td>
<td>A student: appreciates contributions made by individuals, groups, cultures and communities to scientific and technological understanding</td>
<td>A student: appreciates the significance of Australian scientific and technological expertise across gender and cultural groups</td>
<td>A student: acknowledges their responsibility to conserve, protect and maintain the environment for the future</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 2

Interpreting the Syllabus Design

2.1 Overview of the syllabus structure ................................................................. 17
2.2 Content organisation ...................................................................................... 18
2.1 Overview of the syllabus structure

The rationale of the Science Years 7–10 Syllabus describes in broad terms the nature of science and the purpose of the subject in the curriculum. It clearly identifies the intent for students to be able to apply their knowledge of scientific concepts and processes to draw evidence-based conclusions about science-related issues when making decisions about the environment, the natural and technological worlds.

The following diagram summarises the relationship between the various elements of the Science Years 7–10 Syllabus.

- **Aim**: States the overall purpose of the syllabus by indicating the general educational benefits to students that will accrue from programs based on the syllabus.

- **Objectives**: Amplify the aim indicating in broad terms the associated knowledge and understanding, skills, values and attitudes fundamental to the subject. Objectives act as organisers of the intended outcomes.

- **Outcomes**: Express the specific intended student learning that results from the teaching of the syllabus. Outcomes are derived from the objectives and provide clear statements of knowledge, understanding, skills, values and attitudes gained by most students by the end of a stage as a result of effective learning and teaching.

- **Content**:
  - **Prescribed Focus Areas**: identify emphases that are applied to what is being learned.
  - **Contexts**: are chosen by the teacher to assist students make meaning of the Prescribed Focus Areas and the Domain.
  - **Domain**: contains knowledge, understanding, skills, values and attitudes to be learned.
Key features of the *Science Years 7–10 Syllabus* include:

- three major elements of content: Contexts, Prescribed Focus Areas (PFAs), Domain
- the essential content of the PFAs and Domain (knowledge, understanding and skills) that should be able to be realistically addressed by typical students in an indicative time of 400 hours
- the Domain: knowledge and understanding essential content that must be addressed in each of Stage 4 and Stage 5
- the Domain: skills essential content for working scientifically through: planning and conducting investigations; communicating information and understanding; developing scientific thinking and problem-solving techniques; and working individually and in teams
- **cross-curriculum content** embedded in the essential content of the PFAs and Domain which assists students to achieve the broad learning outcomes defined in the Board of Studies *K–10 Curriculum Framework*. The cross-curriculum content areas in the syllabus include: Information and Communication Technologies (ICT); Work, Employment and Enterprise; Aboriginal and Indigenous; Civics and Citizenship; Environment; Gender; Key Competencies; Literacy; Multicultural; and Numeracy
- some suggested examples of additional knowledge and understanding content (pp 30–39 of the *Science Years 7–10 Syllabus*) which is not prerequisite knowledge for Stage 6 science courses have been identified for students who have addressed the outcomes in less than the indicative time
- **Life Skills** outcomes and content which is provided for those students with special education needs for whom it has been determined that the outcomes and content found in the syllabus (sections 6 and 7 of the *Science Years 7–10 Syllabus*) are not appropriate
- a **K–12 continuum of learning** in science that provides an overview of the outcomes showing the underpinning knowledge, understanding, skills, values and attitudes from one stage to another across Stages 1–6.
- stage statements for Stages 1–6 which are summaries of the knowledge, understanding, skills, values and attitudes that have been developed by students as a consequence of achieving the outcomes for the relevant stage of learning
- advice on assessment and reporting including assessment strategies
- glossary of terms, many of which have specific relevance for science teaching or the interpretation of the syllabus.

### 2.2 Content organisation

The *Science Years 7–10 Syllabus* comprises three content elements: Contexts, Prescribed Focus Areas (PFA) and Domain: knowledge and understanding, skills, values and attitudes. The essential content is prescribed for the PFA and Domain: knowledge, understanding and skills. The *sample content page* provides an overview of how the syllabus organises the PFA and Domain essential content.

Each unit of work the teacher develops must include the selected PFA, knowledge, understanding and skills essential content relevant to the stage outcomes and appropriate to the chosen context. It would be expected that the learning experiences within the teaching program provide opportunities to assist students to work towards the achievement of the values and attitudes outcomes. The syllabus does not include essential content for the values and attitudes outcomes but teachers may develop their own and some suggestions are provided in the *Science Years 7–10 Syllabus Advice on Programming and Assessment* (p 47).
Contexts

Contexts are the framework that teachers devise to assist students to make meaning of the Prescribed Focus Areas and Domain essential content. Contexts are culturally bound and therefore communicate meanings that are culturally shaped or defined.

The Science Years 7–10 Syllabus does not specify the contexts as the choice of these will depend on the societal context of the students. Teachers need to consider carefully their choice of contexts after considering factors such as local resources and students’ interests, learning history and cultural backgrounds. In developing learning experiences the contexts should be used to enhance one or more of the following:
• motivation
• conceptual meaning
• scientific literacy
• communication skills
• personal and societal power.

The choice of appropriate contexts by teachers for scientific learning should draw on the framework of society in all aspects of everyday life. The contexts selected should encourage students to recognise and use their current understanding to further develop and apply more specialised scientific understanding and knowledge.

Prescribed Focus Areas (PFA)

Prescribed Focus Areas are the emphases that are applied to what is being learned in each unit of work that the teacher develops. The selected PFA essential content should clearly relate to and complement the science understanding and skills being developed in the learning/teaching unit. The PFAs are designed to increase students’ understanding of: science as an ever-developing body of knowledge; the provisional nature of scientific explanations; the complex relationship between evidence and ideas; and the impact of science on society. The PFA essential content should not be taught in isolation to the appropriate knowledge, understanding and skills content for the stage. It must be clearly related to the concepts, ideas and understanding in the syllabus.

The syllabus identifies that each of the following PFAs must be addressed each year:
• the history of science
• the nature and practice of science
• applications and uses of science
• implications for society and the environment
• current issues, research and development.

The syllabus describes the essential content that reflects the PFA knowledge and understanding that students should be able to demonstrate by the end of Stage 5.

Teachers will select the appropriate essential content relevant to the Stage 4 or Stage 5 PFA outcome. Each unit of work in the school program must address at least one of the PFAs. As each PFA has a different curriculum emphasis it will be more suitably addressed in some contexts than in others. Decision about the choice of the context will influence and inform the PFA and values and attitudes outcomes selected for a learning unit.
Domain: knowledge and understanding, skills, values and attitudes

Science presents a distinctive view and way of thinking about the world. In the syllabus the Domain is a conceptual framework of knowledge and understanding about phenomena, skills related to carrying out investigations, and values about, and attitudes towards, science.

Knowledge and understanding

The knowledge and understanding essential content must be addressed within the identified stage. For each stage the Domain: knowledge and understanding essential content is organised as models, theories and laws, structures and systems, and interactions.

1. Models, theories and laws

Science attempts to explain phenomena or predict events by identifying consistent trends and patterns that can be used to generate:

- a *model*: mathematical, physical, experimental or logical representation based on a simplified set of assumptions. Models are often elaborated to develop theories
- a *theory*: a coherent explanation of a body of experimental evidence, based upon a small number of assumptions. A theory provides predictions that can be tested against observations
- a *law*: a simple and precise statement that has, at one time, been regarded to be universally valid. It describes phenomena that occur with unvarying regularity under the same conditions.

2. Structures and systems

Science attempts to provide explanations for phenomena in terms of:

- *structures*: where the focus is on the organisation of parts into a whole (eg atoms in molecules, organs in bodies, genes in chromosomes)
- *systems*: where the focus is on the function of a structure and on the interactions which take place within it (eg chemical reactions, bodily processes, reproduction).

3. Interactions

Scientific concepts do not exist in isolation from each other. Science involves the identification of interactions between and within simple and complex systems that leads to a greater understanding of how our world works. An understanding of natural complex systems or the development of successful technologies requires the integration and application of concepts from more than one science discipline.

Depending on the context and PFA emphasis selected for a unit of work, teachers will choose appropriate essential knowledge and understanding content for the appropriate stage from models, theories and laws, structures and systems, and interactions.

Skills

The Domain: skills provides students with the opportunity to develop the skills of working scientifically. Developing the skills of working scientifically provides a focus for the questions that students ask based on existing understanding and observations. Working scientifically provides a methodology for testing the validity of those questions, and uses critical thinking skills in evaluating information and drawing conclusions.
The syllabus emphasises that in developing the skills of working scientifically students should be active participants in a variety of types of hands-on practical experiences (pp 21–22 of the Science Years 7–10 Syllabus). Through these learning experiences, and working individually and in teams, they engage the processes related to planning and conducting investigations; gathering and processing data, drawing conclusions, communicating information and understanding.

The Domain: skills essential content described in the syllabus reflects the skills that students should be able to demonstrate by the end of Stage 5. It is expected that students undertake a range of hands-on practical experiences to provide the opportunity for the development and application of the range of skills of working scientifically described in the syllabus.

Practical experiences must occupy a minimum of 50% of allocated course time for students to demonstrate achievement in relation to the outcomes of the syllabus. In developing units of work depending on the context, PFA and Domain: knowledge and understanding content chosen, teachers will select the appropriate skills essential content to achieve the relevant Stage 4 or Stage 5 outcomes.

As well as undertaking practical experiences conducted in class time students are to undertake a variety of research projects. All students are required to undertake at least one substantial student research project during each of Stage 4 and Stage 5. At least one project must involve hands-on practical investigation. At least one Stage 5 project must be an individual task.

The investigations undertaken in the student research projects should relate to one of the topics/units of work studied or to an area of interest. When the student research project involves an open investigation students are engaged creatively in the problem-solving processes of planning and carrying out the procedure for setting up equipment, making observations and measurements and drawing conclusions. They would communicate their ideas and findings and seek constructive evaluation by peers during the course of their learning.

Values and attitudes

The syllabus identifies that through their experiences in science in Years 7–10 students develop positive values about and positive attitudes towards themselves, others, lifelong learning, science and the environment. By reflecting on the past, present and future involvement of science with society, students are encouraged to develop informed values and critical attitudes.

Their first-hand experiences of working scientifically should encourage students to develop attitudes upon which scientific investigations depend, such as curiosity, honesty, flexibility, persistence, critical-mindedness, willingness to suspend judgement, tolerance of uncertainty and acceptance of the provisional status of scientific knowledge. They need to balance these with commitment, tenacity, occasional inflexibility and a willingness to take risks and make informed judgements. As well as knowing something about science, students need to value and appreciate science and its achievements if they are to become scientifically literate.
Chapter 3

Developing a School Science Program

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3.1 Introduction

The *Science Years 7–10 Syllabus* provides schools with the flexibility to develop a learning/teaching program to meet the needs, interests and circumstances of their students. The following checklist identifies the syllabus requirements that must be addressed in planning the school learning/teaching program.

**Syllabus requirements checklist**

The science school program should address the following:

- the timetabling of an indicative time of 400 hours for Years 7–10
- a minimum of 50% of course time allocated to practical experiences
- an allocation of time for students to undertake at least one substantial *student research project* (SRP) during each of Stage 4 and Stage 5. At least one SRP should involve a hands-on practical task and at least one Stage 5 SRP should be an individual task
- a variety of relevant contexts that encourage students to recognise and use their current understanding to further develop and apply more specialised knowledge and understanding
- all *Prescribed Focus Area* (PFA) outcomes for the stage in *each year*. The syllabus essential content reflects the PFA knowledge and understanding that students should be able to demonstrate by the end of Stage 5
- all *Domain: knowledge and understanding* outcomes *within the stage*. The Stage 4 knowledge and understanding essential content must be completed before commencing Stage 5
- all *Domain: skills* outcomes for the stage in *each year*. The syllabus essential content reflects the skills that students should be able to demonstrate by the end of Stage 5
- all *values and attitudes* outcomes across stages
- explicit and systematic learning experiences within and across the units of work in the program to develop the full range of Prescribed Focus Area (PFA) and skills essential content by the end of Stage 5
- each learning unit should include:
  - all three syllabus content elements: Context, Prescribed Focus Area (PFA) and Domain
  - an appropriate context that is relevant to the students and gives coherence to the knowledge, understanding, skills, values and attitudes
  - a selected range of Domain: knowledge, understanding, skills, values and attitudes outcomes appropriate to the stage
  - essential content from *at least one* PFA. The selected PFA essential content should be appropriate to the targeted Stage 4 or Stage 5 outcomes
  - selected appropriate Domain: skills essential content that is relevant to the targeted Stage 4 or Stage 5 outcomes
- compliance with:
  - mandatory safety requirements
  - regulations related to the use of animals in teaching.
3.2 Establishing an overview in a scope and sequence plan

Planning the learning/teaching program involves a number of interrelated activities. The fundamental step in the design of effective learning/teaching programs is the establishment of a program overview with a scope and sequence plan. The scope and sequence is an overview of the learning program that demonstrates that the program is based on the syllabus outcomes and that the course requirements are being addressed within the year and across the stage(s).

The example of a Year 7 Scope and Sequence plan shows an overview of the sequence of possible units of work. It uses the Science Years 7–10 Syllabus Mapping Grids as an example of the way in which the scope of syllabus outcomes could be shown for the year and/or stage. The elements shown in this overview of the program include:

- the sequence and title of each learning unit for the year
- the time in weeks allocated to each learning unit
- the placement of class time for at least one Student Research Project in the stage
- a mapping of the scope of the targeted outcomes in each unit in each year and across the stage which identifies that:
  - all PFA outcomes are addressed at least once each year
  - a range of selected Domain: knowledge and understanding outcomes are targeted in each unit
  - all of the knowledge and understanding outcomes are addressed across the stage
  - all skills outcomes are addressed at least once in each year
  - values and attitudes outcomes are addressed across the stages

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

The Science Years 7–10 Syllabus Mapping Grids provide a proforma with the syllabus outcomes and essential content arranged in tables and columns that can be adjusted to allow for the number of learning units in each year of the school program. The content mapping grids provide a useful tool for planning where the PFA and Domain: knowledge, understanding and skills essential content will be explicitly addressed in a year/stage. These grids can also be used to demonstrate the development of the syllabus essential content (Student ‘learn about’ and ‘learn to’) across a stage in relation to the scope of targeted outcomes identified for each unit in the sequence.

In the learning program, skill development within and across Years 7–10 needs to be carefully and systematically planned and tracked. The use of the content mapping grids helps to ensure that all aspects of each skill have been addressed by the end of Stage 5. It is also useful during the planning and implementing of the program to alert teachers to the level of student independence required in performing the specific skills in each unit of work.

On the sample Year 7 content mapping grids the learning experiences are broadly classified into one of three developmental levels. In the learning phase (L) the teacher establishes the student’s 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 the learning experiences in all units of work the school program can be modified to ensure that there is a continuum in the development the syllabus skills content within each Year and across Years 7–10.

By using the syllabus mapping grids, a clear overview is provided that identifies where the learning experiences are located that specifically target the syllabus essential content in each unit of work. The mapping provides a means of evaluating whether the learning/teaching program provides a comprehensive and balanced development of all knowledge, understanding and skills essential content within each Year and across each stage.

### 3.3 Programming the learning units

The sample unit proforma shows the major components of a learning unit with descriptions of the features annotated. Schools may choose to use or adapt the proforma styles provided to develop the learning units in their program so that they best meet their students’ needs, interests and circumstances.

The first page of the unit proforma provides an overview of the features relating to time, context, targeted syllabus outcomes and resources. The second page provides some examples of formats to show how the syllabus content elements of Prescribed Focus Areas, Domain: knowledge, understanding, skills, values and attitudes can be organised and integrated through the learning experiences.

It is suggested that when planning a learning unit a backward mapping strategy be used. This process begins with identifying the intended or targeted syllabus outcomes for each unit and includes the following interrelated steps.

1. **Focusing on the syllabus outcomes**

During the planning process a manageable number of outcomes for each learning unit are identified on the scope and sequence and these will be the focus of the organisation of the essential content and learning experiences within the units. The targeted outcomes in the unit 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 and that will be gathered for the targeted outcomes that are the focus of learning in each unit. In order to collect the desired evidence a range of assessment 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.

The identified evidence of learning provides the basis for informing the development of contexts, selection of essential content and the planning of the learning experiences within the units of work in the school program.
3. Designing the learning experiences

Programming is the process of selecting and sequencing learning experiences that cater for the diversity of student learning needs in a particular year and/or stage. Each learning unit in the school program should provide a range of suggested explicit learning/teaching experiences best suited to the selected contexts, knowledge, understanding and skills content. The learning experiences should provide sufficient detail of how the suggested strategies will assist students to gain the knowledge, understanding, skills, values and attitudes required to demonstrate their level of achievement of the outcomes of the Science Years 7–10 Syllabus.

Based on the overview in the sequence plan of the units of work, the mapping of the outcomes and essential content, consideration of factors such as local resources, students’ interests, learning history and cultural backgrounds, teachers design learning sequences in the units of work that:

• identify and build on prior learning to determine future directions for developing students’ knowledge, understanding, skills, values and attitudes
• are student-centred, stimulating, meaningful and cater for differing learning styles
• are developed around appropriate contexts relevant to students’ everyday lives
• integrate the essential content selected to address the knowledge, understanding, skills, values and attitudes outcomes
• integrate assessment for learning as part of the learning/teaching experiences
• allow students to provide the required evidence of learning in relation to the outcome being addressed
• provide opportunities for creativity and independent learning, and encourage students to take greater responsibility for their learning.

When developing learning experiences, it is important to consider the principles of learning, the nature of the learner, the learning environment and how these learning experiences apply to the Science Key Learning Area.

Assessment is the process of identifying, gathering and interpreting information about student achievement. It occurs as an integral part of teaching and learning and involves using assessment activities to assist students in understanding their learning and the learning processes.

The Board’s syllabuses advocate assessment for learning which focuses on the syllabus outcomes and clearly express for the student and teacher the criteria by which learning will be assessed. By integrating assessment for learning activities in the learning/teaching sequences, teachers are able to gather evidence of learning and make judgements about student achievement in relation to the outcomes. Assessment for learning enables teachers to plan ways to remedy students’ alternative conceptions and/or misconceptions, promote deeper understanding, and encourage the development of positive values and informed critical attitudes.

The following diagram summarises in a model how, in programming the units of work, learning and assessment can be integrated. 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. The 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. An example of how this process can be applied is provided on page 15 of Science Years 7–10: Advice on Programming and Assessment.
An example of part of a Year 7 program using the sample Years 7–10 unit proforma has been provided. The assessment for learning activities are integrated within the Suggested Learning Strategies and shown in italics. The example demonstrates one way in which a student’s prior learning could be identified and how within a contextual framework the selected essential content covering knowledge, understanding and skills can be integrated. The lesson sequence highlights how students’ knowledge, understanding and skills are developed through explicit and systematic teaching and learning experiences selected to address the targeted outcomes in the unit.

The Prescribed Focus Area(s) content provides opportunities to make links to the targeted values and attitudes outcome(s). These outcomes do not have essential content, but the Appendix of the Science Years 7–10 Advice on Programming and Assessment provides some examples of suggested additional content. Teachers may use this suggested content or develop their own content to assist their students to work towards achievement of the values and attitudes outcomes.

4. Planning how feedback will be provided

Evidence of learning should 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. 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. 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.

In designing learning and assessment experiences, teachers should consider how the proposed feedback strategies will focus on what is expected in the activity and provide students with constructive, meaningful information and opportunities for reflection on their learning.

Rubrics are a useful tool for providing feedback to students about how they can improve their level of achievement. The sample feedback template for student research identifies the performance criteria based on the syllabus outcomes and/or content and describes the quality or development of the elements of performance of each criterion along a continuum of levels.

3.4 Adjusting and amending the learning/teaching program

Throughout the development of the school program there needs to be some flexibility for making adjustments to the outcomes and content organisation within and across the learning units. If the syllabus requirements and/or students’ needs are not being addressed it is necessary to review and evaluate the school program to determine where changes should be made. This may involve:
• adjusting the focus of existing units
• modifying the content of a unit
• designing a new unit.

During the implementation of a learning unit a useful strategy for teachers is to not only register that the essential content has been addressed but also to annotate the suggested learning and assessment experiences. On completion of a unit these annotations provide an important source of information for evaluation of the content, teaching strategies, lesson sequences and/or a unit of work that will inform decisions about future adjustments and amendments to enhance the quality of learning and teaching.

When evaluating learning units, a chosen context may need to be revisited to determine:
• whether the intended purpose of the context is achieved
• the breadth of outcomes achieved within that context
• the balance between and integration of Prescribed Focus Areas and Domain content
• the quality of motivation and relevance for the students
• the flexibility provided for additions and alterations to learning/teaching strategies
• its contemporary nature
• the range of supporting resources available.

The above features of the context(s) should be analysed in relation to the opportunities they provide for developing students’ science capabilities. Contexts may require modification and/or replacement where it can be identified that the learning-teaching strategies developed within those contexts limit students’ understanding of and about science. Reflecting on the suitability of chosen contexts contributes to maintaining science programs that are dynamic and responsive to the changing needs, interests and cultural backgrounds of students in the school.
The sample evaluation proforma provides a template for teacher evaluation of a learning/teaching unit and is intended to be used in conjunction with the sample focus questions for discussion and consideration. It is important for teachers 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 assist the students’ conceptual and skill development enabling them to make meaning of their learning
- the assessment activities enable teachers to gather evidence and make judgements about student achievement in relation to the outcomes
- feedback strategies provide students with clear guidelines to assist/improve their learning.

Planning and programming is a dynamic process and may include student feedback. This may be gathered informally or more formally using a questionnaire such as that shown in the example of a student feedback proforma. Student feedback together with teacher evaluation of a unit of work may result in amendments to the sequence plan, mapping of the outcomes and content and to the program in a Year or stage.

### 3.5 Students with diverse learning needs

**Students with special education needs**

A key principle of the K–10 Curriculum Framework that guides K–10 syllabus development is that the curriculum must be inclusive of all students in New South Wales. The rationale, aim, objectives, outcomes and content of the Science Years 7–10 Syllabus have been designed to accommodate teaching approaches that support the learning needs of all students. The Board of Studies recognises that all teachers have students in their classrooms with a range of needs and abilities. The Stage Statements and the Continuum of Learning in the syllabus can help teachers identify the starting point for instruction for the students in their class.

Students with special education needs build on their achievements in K–6 as they progress through their secondary study and undertake courses to meet the requirements for the School Certificate. It is necessary to continue focusing on the needs, interests and abilities of each student when planning a program for secondary schooling. The program will comprise the most appropriate combination of courses, outcomes and content available.

Most students with special education needs will participate fully in learning experiences and assessment activities provided by the outcomes and content in sections 6 and 7 of the Science Years 7–10 Syllabus, although they may require additional support, including adjustments to teaching and learning activities and/or assessment. However, for a small percentage of these students, particularly those with an intellectual disability, the Life Skills outcomes and content in section 8 of the science syllabus can provide a more relevant, accessible and meaningful curriculum option.
Collaborative curriculum planning

All students with special education needs should be encouraged to choose the most appropriate curriculum options. This process involves a team of people meeting to discuss and make decisions about curriculum options and adjustments that will enable a student with special education needs to access the curriculum. These decisions need to involve the student, parent/carer and those who have significant knowledge and understanding of the student (eg teachers, learning support personnel and community service providers as appropriate).

When making decisions about curriculum options it is important to consider:
• the student’s interests, strengths, goals and learning needs
• the support and/or adjustments that may be necessary for the student to fully access the curriculum
• the transition needs of the student from school to adult life.

Curriculum adjustments

Most students with special education needs will participate fully in learning experiences and assessment activities provided by the regular syllabus outcomes and content. A range of curriculum adjustments should be explored before a decision is made to access Life Skills outcomes and content. These adjustments will vary according to the needs of the individual student.

Decision to access Life Skills outcomes and content

For some students with special education needs, particularly those with an intellectual disability, the collaborative curriculum planning process may determine that a pattern of study based on Life Skills outcomes and content in the Science Years 7–10 Syllabus is appropriate. In coming to this decision, the planning team members should:
• consider carefully the student’s priorities, competencies and learning needs
• establish that the regular outcomes of the science syllabus are not appropriate to meet the needs of the student (eg note the curriculum adjustments that have already been implemented for the student and why these alone are not appropriate to meet the student’s present and future needs)
• record the adjustments to instruction, teaching strategies and assessment practices that are still required in those subjects in which the student undertakes regular syllabus outcomes and content
• demonstrate that the student’s pattern of study will meet the requirements for the School Certificate.

School planning to implement Life Skills outcomes and content

When it has been decided that a student should undertake a science course based on Life Skills outcomes and content, school planning to support the student in the learning process should:
• involve appropriate personnel in the design and implementation of the student’s overall study pattern for the School Certificate
• select the Life Skills outcomes and content for each course that will be accessed by the student on the basis of the student’s learning needs
• identify the most appropriate settings (eg school, community or workplace) for the student to demonstrate achievement of outcomes
• estimate the time needed to address the selected outcomes and content in each course
• identify the resources required to assist the school in meeting the needs of the student
• plan teaching strategies that are appropriate to the age and abilities of the student
• identify curriculum adjustments that may be required to enable the student to access the Life Skills outcomes and content and demonstrate achievement of outcomes
• identify strategies for monitoring the student’s progress
• include ongoing collaborative planning to assist the student’s successful transition from school to adult life.

Access to Life Skills outcomes and content in Years 7–10

As part of the decision to allow a student to access the Science Years 7–10 Life Skills outcomes and content, it is important to identify relevant settings, strategies and resource requirements that will assist the student in the learning process. Clear time frames and strategies for monitoring progress, relevant to the age of the student, need to be identified and collaborative plans should be made for future needs. It is not necessary to seek permission from the Office from the Board of Studies for students to undertake the Science Years 7–10 Life Skills outcomes and content, nor is it necessary to submit planning documentation. More specific information can be found in the Assessment Certification and Examination Manual.

Assessment of Life Skills outcomes

Students undertaking Years 7–10 Life Skills outcomes and content in science will be assessed on their achievement of the outcomes identified in the planning process. Students can demonstrate achievement of outcomes in a number of ways and across a range of environments including the school, home and community. Evidence of achievement of outcomes can be based on ongoing observations during teaching and learning or from assessment tasks specifically designed to assess achievement at particular points in the course of study.

Students may require support to achieve Life Skills outcomes. The type of support will vary according to the particular needs of the student and the requirements of the task. Examples of support may include:
• extra time
• verbal, visual and/or physical prompts and/or physical assistance from others
• technological aids
• adjustments to the environment based on the specific needs of individual students including modifications to equipment and furniture.

Developing a whole-class program that meets the needs of all students

Teachers may need to consider:

1. Environment factors
   • Limit distractions within the classroom to ensure that students are best able to focus on the activities in hand.
   • Ensure that students can clearly view demonstrations and relevant resources.
   • Ensure access to rooms and equipment for all students.
   • Provide modifications and additions to equipment, eg adjustable height benches to accommodate wheelchairs, non-slip mats, electric hotplates instead of Bunsen burners, equipment with large grips and computer simulations on CD-ROM.
   • Establish a few very clear and simple rules for behaviour in the classroom and laboratory.
   • Plan fieldwork activities and assessment tasks well in advance to ensure that they are accessible to all students.

2. Syllabus factors
   • Explicitly teach the specific terminology and concepts associated with the activities within Science Years 7–10.
   • Choose contexts that cater for individual interests and experiences.
   • Use more systematic and explicit teaching procedures to:
     – review previously learned work
     – demonstrate and model new information
     – provide opportunities for guided and independent practice
     – provide appropriate scaffolding
     – encourage generalisation and maintenance of skills through practice
     – monitor progress and give student feedback.
   • Make informed decisions about the timing of activities to allow students the best opportunity to absorb new, difficult and critical ideas.
   • Allow students to show achievement of outcomes in a variety of ways other than tests and examinations.
   • Structure the Student Research Project component so that it can be broken down and completed in smaller stages with regular guidance and feedback.

3. Assessment factors
   • Have an understanding of the students’ prior learning experiences in order to establish levels of knowledge and skills and to determine a starting point for instruction.
   • Assess students’ entry knowledge and skills in science to provide a clear indication of what specific teaching is required to address any gaps.
   • Use alternative assessment strategies when necessary.

4. Learning/teaching factors
   Use a variety of learning/teaching strategies for practical experiences such as:
   • teacher demonstrations and group work
   • organising students with special education needs for small group work, paired or shared work
   • negotiating the expectations of the work tasks
• individualising the tasks or activities where necessary
• providing structural scaffolding of information by adding cues, highlighting specific sections or key words
• reviewing and rehearsing knowledge and skills in different contexts to encourage generalisation to new topics and tasks
• sequencing the knowledge and skills from easy to more difficult where possible
• developing preliminary units of work in cases where students seem to lack prior knowledge
• using a range of resources to accommodate students’ varying literacy levels.

Gifted and talented students

Gagné (1995) developed definitions that distinguished gifted students from talented students in terms of their potential and performance:

... a gifted child is one who has outstanding potential, in this case in science, beyond what we would expect from his or her age peers. Talent is defined here as superior achievement in science.

Gifted and talented students are a diverse group. Boys and girls with high intellectual potential are found in all cultures, geographic locations and socio-economic levels. Within the gifted and talented population students vary in terms of the nature and level of their abilities. The further the student’s ability or potential is from his/her age peers, the greater the need will be for enrichment of the curriculum for that student.

An underachieving child of high potential can be acknowledged as a gifted student whose abilities have not yet developed as talents. The translation of giftedness into talent can be either facilitated or impeded by variables including the student’s motivation and self-esteem, socioeconomic and cultural factors, and the school’s capacity to identify and foster his or her gifts (Gagné, 1995).


Identifying gifted and talented students

The Board’s document Guidelines for Accelerated Progression (revised 2000) lists not only some typical attributes and characteristics of gifted and talented students but a list of objective and subjective approaches to assist with the assessment of a student as gifted and/or talented. These include:
• professional observation of performance
• parent observation
• peer observation
• checklists of traits and characteristics
• cumulative school history
• anecdotal evidence
• interviews
• interest surveys
• standardised achievement tests
• tests of cognitive/intellectual ability
• teacher-devised tests.
In accordance with the *K–10 Curriculum Framework*, the *Science Years 7–10 Syllabus* takes into account the diverse needs of all students. The *K–10 Curriculum Framework* is a standards-referenced framework that describes, through the syllabus and other documents, the expected learning outcomes for students. Teachers are able to use syllabus standards as a reference point to assist them in identifying talented students in science and in adopting special provisions such as differentiation within the classroom, as a means of meeting the needs of these students.

A tool that may also assist in identifying students who would benefit from differentiation is pre-testing, used at the beginning of a learning unit or teaching sequence to determine the student’s prior knowledge and skills. This form of diagnostic assessment should examine similar subject matter to that which would be assessed at the end of a learning unit. Students who display a high level of prior knowledge could undertake a differentiated unit on the same topic, or negotiate work in another area of interest. The differentiated unit might build on the knowledge and skills already demonstrated and/or expand knowledge and skills into a complementary area.

It is important that gifted and talented students are recognised early as these students frequently learn to conceal their abilities (Tannenbaum 1983; Harrison 1999). This may occur across subject areas or within specific classes. Reasons behind underachievement can include boredom due to lack of challenge and variety in the curriculum, fear of failure, the need for peer acceptance and systematic decline of ‘academic stretch’, that is, a student not wanting to reach beyond his or her present level in order to learn new material. This is particularly the case with students for whom no previous modifications have occurred. Whitmore (1980) provides an excellent reference on underachievement and lack of motivation among gifted students and identifies a number of characteristics associated with gifted underachievers. (This table may be found on p 50 of the previous 1999 Stage 4/5 support document.)

**Catering for the gifted and talented student in science**

Social, emotional, affective and motivational needs must be recognised, acknowledged and considered in designing educational programs and options for gifted and talented students. Research findings (Silverman 1993, Gross 1994) suggest that intellectually gifted students differ from age peers in their emotional and social development as much as in their intellectual and academic characteristics. Social and emotional development in children is more highly correlated with mental age than with chronological age (Tannenbaum 1983, Janos & Robinson 1985). Along with high intellectual capacity, gifted students may be more sensitive, more empathetic, more affected by the comments of others, including teachers, than other students of their age group. They may have a more highly developed sense of moral reasoning or tend to associate with older students (Silverman 1993). These students may experience unusual ‘awareness, perceptions, emotional responses and life experiences’ throughout their life span (Morelock 1992).

The following are examples of some of the strategies available to assist teachers to meet the needs of gifted and talented students.

**Differentiating the curriculum in the regular classroom**

The term *differentiation* when applied to curriculum simply means providing different work to suit individual needs. In the case of gifted and talented students, this differentiation should allow scope for not only remembering, understanding and applying the material being covered but also for analysing, evaluating and creating from it (Anderson & Krathwohl 2001).
The work presented and/or negotiated with gifted students should require higher-order thinking skills including analysing, evaluating and creating beyond the interest and ability of the majority of age peers.

The distinction between essential and additional content in the Science Years 7–10 Syllabus recognises that some students will need all of the available time (400 indicative hours) to focus on the essential content, while others will extend their learning by engaging with content beyond the syllabus. The additional content suggested in the syllabus can be addressed in either Stage 4 or 5 and is not prerequisite knowledge for the Stage 6 Science courses. It should not be considered to be an exhaustive list and schools may select other content appropriate to the interests of the student. However, this must not include the mandatory content from any of the Stage 6 Science courses. Additional content may be selected and incorporated into units of work to extend gifted and talented students’ learning into areas of specific interest. In a differentiated unit it may also be used to broaden and deepen their knowledge, understanding and skills. Open-ended investigations in teams could be used to provide gifted and talented students with greater responsibility for managing the group and analysing, synthesising and evaluating the group’s findings.

A model proposed by Maker (1982) maps identified characteristics against teaching experiences that may challenge the gifted and/or talented student. The model provides a basis for identifying possible program modifications. By assessing whether a number of statements are true for any one child the teacher can identify possible starting points for modifying activities in science in relation to content, process, product and learning environment. The lesson modification worksheet can then be used to identify the strategies most recommended for each student and as the basis for planning learning experiences.

Curriculum compacting
This option is used in conjunction with other modifications such as extension work or as part of the process of acceleration. The regular curriculum is designed to meet the needs of the majority of students in a particular age group. A great deal of material may be repeated, both within topic areas and from year to year. Gifted and talented students need:
• less repetition
• to work at a faster pace
• work that is intellectually challenging.

Close examination of the school’s Science program may reveal a number of areas that may be covered in less time or removed completely from a modified program for gifted learners. Some of the areas that could be compacted or modified could be identified by above-level testing. The earlier the compacting of the curriculum and accelerated progression occur for these students, the greater the opportunity for them to broaden and deepen their learning and interests beyond the core curriculum.

Personal interest research
In conjunction with other forms of curriculum modification, personal interest research based on higher-order questions devised by the teacher in collaboration with the student can provide him/her with time to explore aspects of science not covered in the regular curriculum. This further motivates students for whom science holds a personal interest. This option can of course be used with the whole class, providing all students, as well as the gifted and/or talented student, with the opportunity to work at their own level of ability and interest.
The Prescribed Focus Areas (PFA) in the *Science Years 7–10 Syllabus* could be used as a starting point to help students develop ideas for personal interest research. The PFAs provide opportunities for students to broaden their understanding of the contribution and relevance of science to their own lives and society, the developmental nature of scientific knowledge and processes and how science has been influenced and constrained by societies.

The **Student Research Project** provides opportunities for all students, including gifted and talented students, to engage in a scientific investigation in which they apply their problem-solving and critical thinking skills, creativity and imagination over an extended period. Students can use this opportunity to investigate a particular area of interest or extend their understanding of a topic they have studied. These open-ended projects would enable gifted and talented students in particular to demonstrate critical thinking, analytical skills and their ability to synthesise and evaluate. By active involvement in planning and conducting scientific investigations, students develop their skills in working scientifically, their understanding of the provisional nature of scientific explanations and of the complex relationship between evidence and ideas.

It is recommended that students present the results and analysis of this type of research to a real audience. Presentations may be made to small groups of students, class groups, groups of students and staff or larger groups such as school assemblies, parent groups or even local council or government, eg results and interpretation of research undertaken in the local environment could be presented to the council with suggestions for improvement. A product such as this should have a context that is relevant to the lives of the student and in communicating with an appropriate audience, provides a focus for consolidation of the research itself and recognition of the student’s abilities and effort. Within the area of independent projects students may be given the opportunity to enter some of the many subject-related competitions available throughout the year. These competitions are often flexible in terms of content and may provide further opportunities for gifted and talented students to collaborate with mentors and peers and to further develop areas of interest.

**Mentoring**

Mentoring links a student with community members who share a fascination or expertise in the student’s particular field of interest (Forster 1992). Mentorships offer gifted and talented students a level of expertise not usually available in the regular school setting. These programs need careful coordinating and monitoring and must address all school policies and procedures relating to student safety and welfare. It is also important that appropriate protocols are in place and adhered to by students when they are communicating with mentors and peers using ICT.

There are many benefits to mentoring as a provision for gifted and/or talented students. Autonomous behaviour is fostered (Betts 1991) and the process leads to high task interest, creativity, cognitive flexibility and positive feelings of self-worth (Reilly 1993). Mentorships may be arranged as an extracurricular activity or as part of a modified program for gifted students.

**External courses**

Most major universities in New South Wales offer some form of program in science for gifted and talented students. These opportunities allow gifted high school age students to work with a university faculty member in their area of expertise, usually over a couple of days. They also provide an opportunity for gifted students to meet, work and socialise with age peers who have
similar interests and ability. Information on these courses is usually sent to schools or is available from the universities. Some schools also offer weekend or holiday courses or camps that are open to students from other schools. These are often advertised in the magazine Gifted, published by the New South Wales Association for Gifted and Talented Children Inc. four times a year.

### Acceleration

If a student demonstrates ability well above age peers across subject areas and indeed the whole cohort, acceleration is an option. Acceleration acknowledges the rapid rate of a child’s cognitive development and involves delivering appropriate curriculum and services at a level commensurate with a gifted child’s demonstrated readiness and needs (VanTassel-Baska 1992). It permits students to move through the essential content at a faster rate.

Early identification of students for whom acceleration may be an appropriate option is essential. The Board of Studies’ [Guidelines for Accelerated Progression](#) (2000) includes a detailed discussion of the general principles, types of programs, selection of students and policies related to acceleration. Psychometric testing and, if appropriate, self, peer, parental and teacher nomination may form part of the identification process.

In science there are two main options for a student who demonstrates that acceleration is required:

1. The student remains in age cohort grouping for all other subjects and moves into a higher cohort group for classes in science. This may be possible if:
   (a) classes for science for the year above are timetabled at the same time as the cohort from which the student is moving, or
   (b) the student attends science classes at the level above and completes work in subjects missed during that time when age cohort has classes for science.

2. A student is given work at an accelerated level within their age cohort science class. This option would also require the student to work independently at least some of the time. This work would be completed instead of, not in addition to, the regular class work given.

To be successful both of these options require long-range planning, financial commitment and a school timetable that accommodates the accelerants in the school community. Working with the accelerants is essential and of vital importance. Catching up on work missed with peers can often be difficult, especially if it is not in the student’s area of ‘talent’. While many gifted and talented students are able to learn faster and have a higher capacity for complex thought, they may need help with basic skills, processes and procedures (such as organisation, methods and scaffolds), particularly if they have moved into a higher cohort group.

### References


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Harrison, C 1999, Giftedness in early childhood, Gifted Education Research, Resource and Information Centre (GERRIC), Sydney.


Maker, CJ 1982, Curriculum development for the gifted, Pro-Ed, Austin TX.


Whitmore, JR 1980, Giftedness, conflict and underachievement, Allyn & Bacon, Boston, MA.
**Further reading**


Kanevsky, L 1993, ‘Lesson modification sheet, curriculum modification’ in course notes for Certificate of gifted education, University of NSW, Australia. See also Kanevsky L, Tool kit for curriculum differentiation, Faculty of Education, Simon Fraser University, Burnaby, Canada.

**Websites**


Illinois Mathematics & Science Academy

IMSA delivers enrichment programs to stimulate the interest, motivation and achievement of elementary, middle school and high school students in mathematics, science and technology, [www.imsa.edu](http://www.imsa.edu)

IMSA Problem-based Learning Network

Helpful ideas and resources for using problem-based learning as a way of extending gifted students in Mathematics and Science, [http://pbln.imsa.edu](http://pbln.imsa.edu)


NSW Department of Education 2004b, *Guidelines for the use of strategies to support gifted and talented students*, NSW DET, Sydney.


# Chapter 4

## Practical Experiences In Science

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</table>
4.1 Introduction

The *Science Years 7–10 Syllabus* identifies in the objectives, outcomes and content the skills of working scientifically to be developed as:

- planning investigations
- conducting investigations
- communicating information and understanding
- developing scientific thinking and problem-solving techniques
- working individually and in teams. (*Science Years 7–10 Syllabus*, p 21).

Practical experiences in Years 7–10 Science must occupy a minimum of 50 percent of allocated course time for students to demonstrate achievement in relation to the working scientifically skills outcomes of the syllabus. In developing the units of work the practical experiences based around appropriate skills essential content should be the central to the learning sequences. The nature and variety of these hands-on practical experiences within and across the learning program should provide opportunities for students to continually develop their expertise in each of the working scientifically skill areas.

The *Science Years 7–10 Syllabus* identifies that practical experiences should emphasise hands-on activities and include:

- undertaking laboratory investigations
- undertaking field work
- using a range of data collection technologies and strategies
- researching by using the library, internet and CD-ROMs (ICT)
- using models
- using or reorganising second-hand data including those in spreadsheets and databases
- extracting information and reorganising information in the form of flow charts, tables, graphs, diagrams, prose, keys, spreadsheets and databases.

Practical experiences may also incorporate activities such as:

- using computer animations and simulations, video and film resources to capture and analyse information not readily available as a primary source
- using data loggers to collect and record data.

Hands-on practical experience should be selected to provide opportunities for students to address a range of knowledge, understanding and skill outcomes. In planning learning units careful consideration should be given when selecting the types of practical experiences to be used, to their purpose, the targeted working scientifically skills and the intended results of learning within and across the stage(s).

4.2 Developing the skills of working scientifically

In the *Science Years 7–10 Syllabus* there are working scientifically outcomes for each stage but the essential content is not stage specific. The content identifies the skills of working scientifically that students should be able to demonstrate by the end of Stage 5. It would be expected that in the units of work there would be explicit teaching and learning experiences that are appropriate to the types of hands-on practical experiences selected to address the targeted skills content and the stage outcome.
Students need not only to master the set of working scientifically skills described in the syllabus but also develop an understanding about what these skills are for, and when and how to use them in their own investigations. In planning units of work there should be careful integration of relevant science ideas/concepts within the hands-on practical experiences so that students are able to make meaningful links between what they are doing and how this learning relates to their knowledge and understanding of science.

The selection of a variety of types of practical experience within each unit of work provides the opportunity to target different syllabus outcomes. Within and across stage(s) of the learning program, the range of syllabus skill outcomes should be addressed.

Students entering Year 7 bring with them understanding and skills from their prior learning experiences in K–6 Science and Technology. The K–12 continuum shows the overview of the development of skills of working scientifically from Stage 1 through to Stage 6. Within each year and across the Stages 4 and 5 Science program, the emphasis in learning would progress towards students practising and applying their skills in working scientifically in new and increasingly complex situations as independent learners.

To assist teachers in planning the skill development within and across the stages of the syllabus the content mapping grids could be used as a planning tool. The skills learning experiences can be broadly classified into one of three developmental levels. In the learning phase (L) the teacher establishes the student’s skill level and uses this as the basis for developing student understanding through explicit teaching of the relevant skills component. In the practising phase (P) the student uses the skills in tasks to achieve specific goals. The application phase (A) is when the student independently uses the 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 Stages 4 and 5.

The learning/teaching program should include a balance between the different types of practical experiences such as demonstrations, research activities, field work, closed practical exercises and open-ended investigations. Recipe-style, worksheet-based laboratory exercises may be helpful in illustrating some concepts, assisting students to develop their skills in manipulating scientific equipment or in gaining skills in using and understanding techniques. However, when the learning experiences are dominated by these types of activities, students are provided with few opportunities to gain the range of hands-on experiences needed to develop all aspects of the skills of working scientifically. In particular these types of activities have limited scope for students to engage in scientific investigations in which they identify the question or problem to be investigated, the procedure to be used and apply critical analysis, creative thinking and problem-solving in seeking answers or solutions.

All learning units should include a range of types of hands-on practical experiences through which students are actively engaged in practicing and applying a variety of techniques to gather, process and present first-hand data/information and that from secondary sources. When structuring the learning sequences in the units of work, opportunities for students to engage in team, group and class discussion should be included. This provides time for the students to share their ideas and develop the reasoning patterns central to thinking scientifically. The teacher’s role is to facilitate learning by engaging and stimulating the students in actively thinking and talking about their understanding and in thinking about their learning.
4.3 What do investigations mean in science?

Science is a distinctive view and way of thinking about the world that is embedded in the culture of its times. Science has many methods of investigation, but central to all scientific inquiry is the notion that evidence forms the basis for defensible conclusions. Scientific inquiry is the variety of procedures that are creatively and flexibly used by scientists to find answers to questions about the natural world. As well as the valuing of evidence, scientific inquiry should encourage students to be curious and willing to speculate about and explore the natural world. Science attitudes include objectivity to reduce bias in interpretation of findings, openness to new ideas and willingness to modify explanations in light of new evidence, scepticism that seeks evidence before making decisions, respect for reason, and honesty.

Science education should challenge students to be questioning, reflective and critical thinkers. It does this through their active engagement in hands-on practical experiences involving scientific investigations that test interesting, authentic questions relevant to their real world, challenge their ideas and understanding and emphasise the importance of evidence in forming conclusions. The Science Years 7–10 Syllabus clearly identifies that it is through their active participation in planning and conducting a range of first-hand investigations in a variety of situations that students develop their understanding about science and scientific inquiry.

Students apply thinking and problem-solving in investigations to answer questions about the natural and technological world. They use their working scientifically skills to plan and conduct their investigation; to collect, process and interpret data/information; to communicate their conclusions; and to review and evaluate their plan, procedures and findings in order to pose more questions. Through their hands-on practical experiences they develop their understanding of the nature and practice of science and its importance and significance to their lifeworld.

As shown in the following model, in practice these processes are adaptive and may not take place in the strict order of: Planning – Conducting – Processing – Evaluating. For example, at some point in the conducting phase it may be identified that further planning is needed and therefore a more recursive model may more accurately represent the investigation process. The model also identifies where these processes link to the working scientifically outcomes and content of the Science Years 7–10 Syllabus.
Processing data and information

In the Science Years 7–10 Syllabus it is expected that hands-on practical experiences will provide opportunities for extracting information from graphs, flow diagrams, text and audio/visual resources. Students are required to organise data and/or information into flow charts, tables, graphs, diagrams, spreadsheets and databases to show trends, patterns and relationships. They should also be able to construct a variety of specified types of graphs to clearly and succinctly present information. The understanding of data organisation in science and the level of skills in graphing required at each stage is consistent with that for the same stage in Years 7–10 Mathematics.

Data handling skills in Science

Different types of investigation will provide opportunities for students to practise and apply different approaches to the collection and analysis of data. In planning and evaluating Science learning units teachers should check that the data handling skills required are consistent with those identified for Stages 4 and 5 in the Mathematics Years 7–10 Syllabus.
Observations and measurements of variables can be presented as discrete or continuous.

- Discrete data are in categories such as gender, type of animal, brand of paper towel, colour.
- Continuous data are associated with measurement involving a standard scale with equal intervals such as height of plants in centimetres, the amount of fertiliser in grams and the length of time in seconds.

Data may be represented in tables or graphs. A table emphasises the absolute value of the component data while a graph emphasises the relative value of the data and is a visual representation of comparative data.

**Tables**

Information is presented in tabular form to facilitate access to the information and to identify any distinguishing patterns. Tables give information in a matrix, ie columns and rows, organised for easy comparison. The deciding factor in the organisation of information in tabular form should be whether it assists the reader or viewer to access or interpret the information.

When presenting information in a table the following features would be considered good practice:

- the table should have a title
- every column should have a heading
- the units of measurement should be identified in the column heading
- figures in each column or row should be aligned
- a zero should only be used when a measurement of zero was obtained – use a dash when no reading was recorded
- identical results should be written again, not shown with ‘ditto marks’
- the same item should not appear in more than one category
- show totals, subtotals, and/or percentages where relevant.

**Graphs**

Graphs are a convenient method of displaying data. Graphs can be used to:

- present and interpret data
- present the results of an experiment
- monitor the progress of an experiment
- make a comparison with theory
- investigate whether data fit the mathematical model
- indicate the degree of reliability of the data
- determine the value of some quantity
- identify an empirical relationship between two quantities or help in the derivation of empirical equations
- serve as visual aids.

Students should be able to distinguish between, draw and interpret column graphs, histograms, divided bar, sector and line graphs. They should be able to select and use appropriately these graph types to display and represent particular data. The type of graph chosen should be the one that best allows the information presented to be interpreted and explained.
Column graphs

This graph type may be used to display discrete data (data which consist of separate or distinct parts). In this graph type the horizontal axis is marked in equal intervals and vertical columns of equal width are drawn to the appropriate height of the vertical scale.

Histograms

This graph type may be used to display frequency distributions. In this graph type the horizontal axis is marked in equal intervals and columns are drawn for the relevant frequency. Adjacent columns in a histogram have a common edge.

Bar graphs and sector graphs

These graph types may be used to display the component parts of a total. A simplified way of displaying this type of data is by the division of a rectangle (bar) into the proportions of the component parts. In a sector graph (pie chart) a circle is divided into sectors where the angles at the centre are in the same proportion as the component parts.

Composite graphs

Students in Stages 4 and 5 are NOT required to be able to draw composite graphs; however, they should be able to extract information from and interpret these types of graphs. Composite graphs may be used to display complex data, make comparisons of large quantities of data or enhance clarity, eg a composite column/bar graph is one in which each column is itself a bar graph.

Line graphs

This graph type may be used to display the relationship between two variables for which the obtained data are samples of a continuum (continuous data). Drawing a line of best fit is NOT addressed in the Mathematics or Science syllabuses until Stage 6. The Science Years 7–10 Syllabus does NOT require this skill for students in Stages 4 or 5.

When presenting information graphically the following features would be considered good practice:
• the graph should have a title
• the x-axis should display the independent variable; the y-axis should display the dependent variable
• axes should be clearly labelled to indicate the relevant variable, including units (where applicable)
• there should be a linear or logarithmic scale, clearly marked with at least three or more points on each scale
• scales should be selected which allow the range of data displayed to extend over most of the available grid
• the axes need not be continuous if a discontinuity marker is shown
• the axes need not start from zero
• there should be accurately plotted data points
• extrapolations, if used, should not be joined to the origin or axes unless this is given in the data or can be reasonably assumed
• a key should be given where there is more than one line shown on a graph, or if symbols are used so that each line or symbol is readily identifiable.
Presenting information

The Science Years 7–10 Syllabus requires students to select and appropriately use specified types of texts to present information. The texts identified include discussion, explanation, procedure, exposition, recount, report, response or experimental record for oral or written presentation. In presenting observations, results and findings from their hands-on practical experiences the format and medium selected should be appropriate to the type of practical experience and the purpose for which it has been included in the unit of work.

It is NOT a syllabus requirement that the procedure for practical experiences be written using the third person, past tense and passive voice: eg ‘the celery stem was cut and the stem was placed in a beaker containing dye solution’. In recording their practical experiences students should write in their own words using clear, correct, concise plain English. It should be a stage-appropriate record of why and how the practical experience was undertaken, and their results and findings.

Presenting information using the headings, Aim, Method, Results, Discussion and Conclusion is not appropriate in practical experiences such as simple experiments to develop skills in using science equipment or those involving the verification of concepts. These headings are more helpful as a way of reporting about controlled experiments and open-ended investigations. The students’ records of these activities should enable them to make meaningful links between the question/problem raised, what they did in seeking evidence, further questions that they identified and how their learning relates to their knowledge of and understanding about science.

4.4 Types of practical investigations

A review of the literature presents reasons for the inclusion of practical experiences in the learning program. Depending on students’ understanding and skills, practical experiences provide opportunities for:

- motivation and enjoyment of science
- language development
- learning to work cooperatively
- providing concrete experiences of natural phenomena
- stimulating curiosity and creativity
- developing techniques and manipulative skills associated with using scientific equipment
- developing investigation and problem-solving skills
- experiencing and developing an understanding of the nature and practice of science
- conceptual development
- developing positive attitudes towards and values about themselves, others, learning as a lifelong process, and science and technology.

The reason for including the practical experience in a learning sequence will determine the type of practical investigation that is selected. In the research literature science investigations have been classified in different ways. One classification is based on the methods of data collection or the design of the investigation. These methods include:

- survey research where populations are sampled to investigate the relationship between variables
- comparative or descriptive studies typical of field biology and the earth sciences
• researching, analysing and explaining data collected and reported by other scientists
• testing types of materials, eg strength of steel, durability of paint etc
• chemical analyses
• investigating a relationship between two variables where repeat trials can be used
• investigating a relationship between two variables where replication can be used
• investigating the effect of several independent variables on one dependent variable (often associated with a design problem).

The following table summarises classifications other researchers have proposed that are based on the types of questions that are central to the investigations.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Information-seeking</td>
<td>‘Find the effect of’ … problems</td>
<td>How does the depth of water in a container affect the rate at which water runs out of a hole in the bottom?</td>
</tr>
<tr>
<td>These are investigations carried out to see what happens either as a natural process unfolds or when some action is taken. They do not usually involve comparisons and are useful in developing students’ learning to enable them to make sense of future experiences. The information-seeking may be an end in itself but may be a forerunner for hypothesis-generating investigations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How-to-do-it investigations</td>
<td>‘Decide which’ … problems</td>
<td>Separate a mixture of sand, salt and water in order to retrieve all three substances.</td>
</tr>
<tr>
<td>These investigations relate to problems of a technological nature though they may involve many scientific process skill and ideas.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comparing or fair testing</td>
<td>‘Find a way to’ … problems</td>
<td>Decide which brand of paper towel is best for absorbing spilt water.</td>
</tr>
<tr>
<td>In these types of investigations students engage with real-world questions relevant to their lives and gain ownership of the problem. Such investigations involve manipulation of variables, yet care must be taken not to present these questions in isolation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pattern-finding investigations</td>
<td>‘Find a way to’ … problems</td>
<td>Find a way to measure the weight of a suitcase when existing equipment is not adequate.</td>
</tr>
<tr>
<td>These investigations provide experiences that distinguish between an association between things and a cause-and-effect relationship. They involve the same skills as ‘comparing’ investigations but there is an additional emphasis on interpretation of findings. They also provide opportunities for developing skills in presenting data and for consideration of the extent to which conclusions about cause and effect can be drawn.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypothesis-generating investigations</td>
<td>‘I wonder why?’ questions where the first step is to consider possible reasons why and then to test them. These are often open-ended investigations that may involve some fair testing and result in further questions being raised regarding the testing of these.</td>
<td></td>
</tr>
</tbody>
</table>

I wonder why potatoes can start growing stems while they are stored in a dark cupboard.
Within and across stage(s) of the school learning/teaching programs students should be provided with opportunities to undertake different practical experiences that extend their working scientifically skills in undertaking independently investigations of an increasingly complex nature, individually and in teams.

**Open-ended investigations**

Many science educators argue that students need the opportunity to do open-ended investigations if they are to develop the working scientifically, critical thinking and problem-solving skills that lead to a more scientific understanding of their world and the way scientists work. In open-ended investigations students need to be involved in selecting the problem or variables to be investigated. Student choice enhances ownership, motivation and persistence in the face of difficulties.

Open-ended investigations are activities in which students take the initiative in finding answers to questions or problems that they have identified themselves. The problems should be relevant to their lives and related to situations that are familiar to them. The question or problem chosen should require a scientific investigative approach to generating information that will provide evidence for the answer. For open-ended investigations to be meaningful learning experiences, and for students to successfully participate, they need to have an appropriate level of skills in working scientifically.

Not all investigations can be defined as open-ended investigations. Hegarty-Hazel (Hackling 1998) classified investigations into a number of levels over five factors depending on the choice allowed to students. 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. The level of investigation is summarised from 0 to 3 in the following way.

<table>
<thead>
<tr>
<th>Level</th>
<th>Problem</th>
<th>Equipment</th>
<th>Procedure</th>
<th>Answer</th>
<th>Common answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Given</td>
<td>Given</td>
<td>Given</td>
<td>Given</td>
<td>Verification</td>
</tr>
<tr>
<td>1</td>
<td>Given</td>
<td>Given</td>
<td>Given</td>
<td>Open</td>
<td>Guided inquiry</td>
</tr>
<tr>
<td>2a</td>
<td>Given</td>
<td>Given</td>
<td>Open</td>
<td>Open</td>
<td>Open guided inquiry</td>
</tr>
<tr>
<td>2b</td>
<td>Given</td>
<td>Open</td>
<td>Open</td>
<td>Open</td>
<td>Open guided inquiry</td>
</tr>
<tr>
<td>3</td>
<td>Open</td>
<td>Open</td>
<td>Open</td>
<td>Open</td>
<td>Open guided inquiry</td>
</tr>
</tbody>
</table>

The planning component and the problem-solving nature of open-ended investigations distinguish them from other types of hands-on practical experiences.

Through their experiences in performing different types of hands-on practical experiences students should develop a range of skills and gain an understanding of the purposes for and processes involved in investigations in science. To effectively undertake open-ended investigations they need to have skills and experience in analysing problems, formulating a
testable question or hypothesis, and planning and conducting their own experiments. Those students who are passive followers of instructions in practical experiences will find it difficult to become autonomous decision-makers when attempting open-ended investigation tasks.

The scaffold provided later in this section provides a guide for students in planning and conducting their open-ended investigation. The amount of teacher guidance needed for the open-ended investigation will depend on students’ prior experience and skills in performing first-hand investigation (refer to The Continuum of Learning). Across Stages 4 and 5 the students would be expected to develop and extend their skills in undertaking open-ended investigations. By Stage 5 they should need less teacher guidance and demonstrate greater independence in their learning.

Models for structuring learning/teaching sequences involving practical experiences

In planning units of work careful consideration should be given to the reasons for the inclusion of different types of practical experiences and their purpose. The intended outcomes of learning should be explicit in the learning sequences. Students should have a clear understanding of the purpose for undertaking the practical experiences and how these experiences relate to and contribute to their knowledge and understanding of science.

The 5Es instructional model

The 5Es instructional model is derived from constructivist learning theory. This model is based on the constructivist premise that students learn best when allowed to work out explanations for themselves over time through a variety of learning experiences structured by the teacher.

<table>
<thead>
<tr>
<th>Phase of instructional model</th>
<th>Purpose</th>
<th>Role of reading, writing, practical work and discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engage</td>
<td>• Create interest and stimulate curiosity</td>
<td>Motivating/discrepant demonstrations to create interest and raise questions. Open questions and individual writing to reveal students’ beliefs.</td>
</tr>
<tr>
<td></td>
<td>• Raise questions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Reveal student ideas and beliefs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Compare students’ ideas</td>
<td></td>
</tr>
<tr>
<td>Explore</td>
<td>• Experience the phenomenon or concept</td>
<td>Open-ended investigation work to experience the phenomenon, observe, test ideas and try to answer questions.</td>
</tr>
<tr>
<td></td>
<td>• Explore questions and test students’ ideas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Investigate and solve problems</td>
<td></td>
</tr>
<tr>
<td>Explain</td>
<td>• Compare ideas</td>
<td>Small-group discussion to compare ideas and construct explanations.</td>
</tr>
<tr>
<td></td>
<td>• Introduce definitions and concept names</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Construct explanations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Justify them in terms of observations and data</td>
<td></td>
</tr>
<tr>
<td>Elaborate</td>
<td>• Use and apply concepts and explanations in new Contexts</td>
<td>Further practical activities or problems that provide an opportunity to apply, extend, compare and clarify ideas.</td>
</tr>
<tr>
<td></td>
<td>• Reconstruct and extend explanations to new Contexts</td>
<td></td>
</tr>
<tr>
<td>Evaluate</td>
<td>• The teacher looks for evidence of changes in students’ ideas, beliefs and skills</td>
<td>Write answers to open-ended questions to reveal conceptions. Reflect on any changes to explanations.</td>
</tr>
<tr>
<td></td>
<td>• Students review and evaluate their own learning</td>
<td></td>
</tr>
</tbody>
</table>
The 5Es model provides a framework for structuring a sequence of lessons consistent with a constructivist approach.

- The **Engage** lesson sets the Context, raises questions and elicits students’ existing beliefs.
- The **Explore** lesson(s) involves investigation work in which students gain first-hand, and where possible, concrete experience of the phenomenon of interest.
- The **Explain** phase draws on students’ beliefs from the Engage lesson. Concepts introduced by the teacher or from text reading are used to construct explanations for the experiences of the Explore phase.
- Further practical work provides more experiences of the phenomenon, this time in a different Context, so that the **Elaborate** lesson(s) can involve students in applying conceptions developed in the Explain lesson(s) to new Contexts, thus extending and integrating learning.
- The **Evaluate** lesson provides an opportunity for students and teachers to assess developed conceptions and compare them to original beliefs.

**The cognitive apprenticeship approach to teaching and learning of investigation competencies**

It may be helpful to conceptualise the teacher’s and the student’s roles in learning the complex craft skills of science as being analogous to that of the tradesperson and apprentice.

- The teacher models strategies for the students, making explicit their problem-solving processes.
- The teacher provides scaffolding to structure the work of the students.
- The teacher works alongside students coaching them on specific skills and strategies.
- Students are encouraged to discuss and reflect on their decision-making and strategies. Articulation of tacit knowledge helps make it explicit.
- As students gain competence some of the scaffolding is faded away.

**Supporting student learning in investigations**

**Using planning and recording proforma**

Depending on their experience, students may need a framework to support them in making decisions about planning and conducting investigations. Planning and recording proforma are useful tools to lead students through a sequence of decision-making steps as they plan and conduct their investigation, process their data and evaluate their investigation. The support provided by these reduces the students’ dependence on the teacher for instructions. These proforma provide a mechanism for the students to record their thinking and doing at the various phases of the investigation and help them to gain experience and confidence in designing and conducting investigations, giving them greater autonomy in the decision-making process.

The outline shown below provides an example that could be used to guide students in planning and conducting their open-ended investigation.
The Five Steps of Investigation

First
Write a short statement that makes clear what the problem is that you have to solve. Also write a research question or hypothesis, and then a prediction. Give a reason for your prediction.

Second
Write a plan which says what you intend doing. Say what you will do to make any tests fair. Explain what measurements are to be made and how they will be made. Draw a diagram to show how the equipment will be used to conduct your tests.

Third
Carry out your investigation and record all your observations and measurements. If you found that you needed to change your plan write down what changes were made and why they were necessary. Present your data in a way that helps show the patterns or trends in your results.

Fourth
Write a couple of paragraphs in response to these questions: What patterns or trends were present in the results? How do you explain the patterns? What did your results show you about the question or hypothesis that you were investigating?

Fifth
Write a paragraph that evaluates your investigation. Were your findings what you expected? To what extent did you reduce the errors associated with measurements, controlling variables and sampling?


Scaffolding tools
Students often need additional guidance and support to help them write a question for investigation or with planning the design of the investigation by controlling variables. It is important for teachers to model the use of these strategies so that students understand how they are used to make tests fair. Three examples of tools that address these problems are described here.

The testable-questions algorithm
In the general structure of a testable question below, the gaps correspond to the dependent variable (DV) and the independent variable (IV). This strategy, without naming the types of variables, can be used to help the student write their own questions for an investigation.

What happens to ______________ when we change ______________?

eg What happens to the growth of wheat when we change the salinity of the water? From testable questions students can learn to write hypotheses. Hypotheses are statements of tentative ideas to be tested expressed in the form of a relationship between an independent and dependent variable. The general structure of an hypothesis is:

This change in the independent variable + will cause this to happen to + the dependent variable.
Using the example relating to the growth of wheat, the following hypothesis can be developed: Increasing the salinity of water (IV) will reduce (relationship) the growth of wheat plants (DV).

Testable questions tend to be used to increase students’ skills, when
• the independent variable is discrete
• there is little prior knowledge and experience of the phenomenon to guide the writing of an hypothesis.

To write an hypothesis the students must have sufficient observations, experience and knowledge of the phenomenon to state the expected relationship between the variables.

Cows moo softly
This is a useful scaffold to remind students how to plan a fair test
Change something Measure something and Keep everything else the Same

Variables tables
Variables tables are a useful planning tool to help students plan controlled experiments and develop an understanding of the three types of variables that need to be considered in the planning phase. The following is a completed variables table for an experiment to investigate the question:

How does the amount of light affect the growth of seedlings?

<table>
<thead>
<tr>
<th>What will I keep the same?</th>
<th>What will I change?</th>
<th>What will I measure?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of seeds</td>
<td>The amount of light:</td>
<td>The height of the seedlings</td>
</tr>
<tr>
<td>Type of soil</td>
<td>Dark</td>
<td></td>
</tr>
<tr>
<td>Amount of water</td>
<td>Partial shade</td>
<td></td>
</tr>
<tr>
<td>Amount of fertiliser</td>
<td>Full sun</td>
<td></td>
</tr>
<tr>
<td>Size of container</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planting depth of seeds</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Controlled variables Independent variable Dependent variable

References

Hackling, MW 1998, Working scientifically: implementing and assessing. Open investigation work in science, Education Department of Western Australia, Perth, WA. A resource book for Primary and Secondary teachers of Science, prepared for the Education Department of Western Australia, Perth WA.


4.5 Student research project (SRP)

The *Science Years 7–10 Syllabus* requires the completion of at least one substantial student research project (SRP) in both Stage 4 and Stage 5. At least one SRP will involve a hands-on practical investigation and at least one in Stage 5 will be an individual SRP.

The SRP involves students in an open-ended investigation which provides them with opportunities to engage in scientific inquiry. In undertaking open-ended investigations students should be involved in planning and conducting the investigation, gathering and processing data and information, communicating their ideas and findings and seeking constructive evaluation by their peers. The SRP provides learning experiences for students to apply their scientific thinking and problem-solving skills over an extended period of time. In undertaking these types of investigations students should also apply and further develop a range of working scientifically skills identified in the syllabus outcomes and related content.

The SRP should be set within a fixed timeline within the scope and sequence of work units in each stage. SRPs require students to actively engage in inquiry-based learning and include:

- hands-on laboratory and fieldwork investigations involving controlled experiments, gathering and processing first-hand data that may require only limited background research
- research activities involving gathering and processing data from secondary sources with discussion of viewpoints about issues with a major scientific component relating to the applications and implications of science for society and the environment or current research and developments in science.

Students should choose investigations related to an area of interest or one of the topics they have studied. They should identify problems and develop questions for their investigation that are relevant to their own lives, the immediate environment and the wider community. In conducting their investigations and research, students should use readily available materials and be encouraged to collaborate with people who use science in their work life. Apart from the mandatory Stage 5 individual student research project, SRPs may involve collaboration with peers and teamwork.

While students will have undertaken investigations in Stages 1–3, they may need considerable support in Stage 4 as they are apprenticed into independent time management and planning and performing first-hand investigations in laboratory and fieldwork situations. Students will be at various levels with respect to skill development in using laboratory equipment and will therefore need teacher assistance at times. Careful guidelines and monitoring to assist students may need to be provided on the questions/problems to be investigated, the procedures and the materials used, and appropriate risk assessment and hazards minimisation.

Additional support for students can be provided by linking the SRP directly to the unit of work being covered in class. Class time can be allocated to assist students in clarifying their question, developing the hypothesis, planning their investigation, identifying and accessing sources of data and/or information, selecting methods of collecting, displaying and organising data, and analysing and communicating their findings. The balance between teacher-guided and independent work would be expected to shift towards more independent work as students move into Stage 5.
The opportunity exists for students to complete at least one SRP as part of a team. Each student member of a team should keep a journal of the process, their roles and responsibilities and those of other team members in planning, conducting and completion of the SRP. Peer review is a valuable learning experience for students as it models the collegial nature of scientific work. A sample feedback template, ‘Working in a team’ is an example of one way that students could be assessed and provided with feedback on their progress in achieving outcomes related to teamwork.

Students need to recognise self-assessment and peer assessment methods as part of everyday learning. If students have little experience with the process of self- and/or peer assessment they will need time and teacher guidance to develop the necessary skills. While self- and/or peer assessment are excellent ways to empower and extend student learning, teachers should make the final judgement about student achievement. Assessment for learning can be achieved by monitoring the SRP journal/diary kept by the team or the individual.

**Organising the SRP**

By providing students with clear criteria on what is required and setting deadlines to be met, teachers are modelling the processes used by scientists in their research and apprenticing students in the world of the scientist. When the steps in the processes are explicitly modelled, students are more able to learn, practise and apply these to their own investigations. In the same way, revision of strategies for recording and analysing data should be included in the lessons set aside for SRP discussion.

Where mixed-ability classes are involved, it may be useful to organise the work so that each team/group can have instruction on the SRP commensurate with their level of ability or to encourage some students with a higher level of knowledge and/or skills to mentor others. A SRP feedback sheet that is to be submitted with the completed SRP, provides a guide not only to the processes involved and skills to be developed during the SRP but also identifies for students what will be assessed.

Samples of SRPs from previous years should be kept and displayed so that students can see examples of the range and type of SRP completed and the variety of presentation methods appropriate for Stages 4 and 5. As part of the introduction to the SRP the students and/or the teacher could suggest some criteria that could be used to assess the displayed SRPs. Students could move around individually or in pairs and record their comments about the samples using the agreed criteria. This could be used in class discussion to assist students to understand the task requirements and the outcomes they are to achieve.

**Timelines and journals**

Students can be assisted with the SRP by developing a timeline. Negotiations between the student and teacher should fix a timeline that both agree to be realistic. At a number of predetermined points during the SRP, the teacher should monitor student progress to ensure that the schedule is being maintained. If a student has difficulty meeting the deadline, this would be discussed and the teacher and student could identify strategies to solve the problem and revise the timeline. A student reflection sheet is a useful tool once the SRP is under way and together with the SRP timeline can be used to help the student work within the identified milestones of the project.
Students should keep a journal about their research project to record their planning, background research, how their ideas develop, strategies and possible solutions to identified problems, resources accessed, findings from and evaluation of their investigation. Journal records aid students in thinking about what they do and why, and gives teachers specific discussion areas with their students. In addition, journals are a tangible record of the SRP’s history, the regularity with which they work on the SRP and evidence of a student’s ability to work regularly at a task over a period of time.

By incorporating the assessment criteria that will be used to provide feedback to students into the SRP information, assessment for learning opportunities can be included following the regular journal monitoring undertaken over the period of the SRP. A sample SRP journal information sheet provides a guideline to students.

**4.6 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 on 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* website at: <www.schools.nsw.edu.au/animalsinschools>. This document and website 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 <www.schools.nsw.edu.au/animalsinschools/>.

Inquiries 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>.

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

### 4.7 Safety in science

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* (NSW) and the *Occupational Health and Safety Regulation 2001* (NSW) (the OHS Regulation) contain provisions that require employers to consult with employees on health and safety matters. The OHS Regulation 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 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. This 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 that Act. These include penalties for organisations found guilty of breaches of the Act or the Regulation. 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 to 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 Code of practice for the safe use of lasers in schools (NHMRC 1995) is an essential guide.

Contacts
Dangerous goods licences
WorkCover NSW
92–100 Donnison Street
Gosford NSW 2250
Tel: 13 10 50
Fax: (02) 4325 4145

Information about or purchase of current Australian Standards
Standards Australia
286 Sussex Street
Sydney NSW 2000
Tel: (02) 8206 6000

Waste disposal regulatory requirements
Department of Environment and Climate Change
59–61 Goulburn Street
Sydney South NSW 1231
Tel: (02) 9211 4723
Example of a possible accident report

<table>
<thead>
<tr>
<th>SCHOOL ACCIDENT REPORT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of school: ____________________________</td>
</tr>
<tr>
<td>Full address: ______________________________</td>
</tr>
</tbody>
</table>

**About the injured or ill person:**

Family name ________________________________
Given name(s) ________________________________
Home address ________________________________
Date of birth (dd/mm/yyyy) ________/_______/_______
Country of birth ________________________________
Was the injured person your employee?  Yes/No

**About the injury:**

When did it happen? (dd/mm/yyyy) _______/_______/_______
Time _______________ am/pm
Where did it happen? (Give exact details, eg Room 6, soccer field)
______________________________________________
What was the injury as reported to you? (Give full details including the part or parts of the body affected, eg cut on second finger on left hand)
______________________________________________
______________________________________________
What led up to the injury? (see examples) ________________________________
______________________________________________
How exactly was the injury or dangerous occurrence caused? (see examples)
______________________________________________
______________________________________________
______________________________________________
Give details of any particular chemical, product, process or equipment involved. Be specific – include brand name, model licence number, etc. What led up to the injury?

**Examples**
- beaker cracked and broke when heated
- water spilt on floor
- 0.1M hydrochloric acid stored in damaged container

**How exactly was the injury caused?**
- cut hand on glass while cleaning up
- slipped and fell to floor
- acid burn on hand

**About the witnesses:**
1. Name of witness ______________________________________________________
2. Name of witness ______________________________________________________

Teacher(s) present ______________________________________________________

Give details of any action that has been or can be taken to prevent the accident from happening again

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Parent/guardian notified: _________________________________________________

Other comments: _________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Signature of Deputy/Principal: ____________________________________________

Date: (dd/mm/yyyy) _______/_______/_______

**References**


Chapter 5

Cross-curriculum Content

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5.1 Introduction

Cross-curriculum content assists students to achieve the broad learning outcomes defined in the Board of Studies K–10 Curriculum Framework. It is incorporated in the content of the Science Years 7–10 Syllabus in the following ways:

- Information and Communication Technologies (ICT)
- Work, Employment and Enterprise
- Aboriginal and Indigenous
- Civics and Citizenship
- Environment
- Gender
- Key Competencies (Employability Skills)
- Literacy
- Multicultural
- Numeracy.

The cross-curriculum content is embedded in the syllabus essential content. Pages 24–25 of the Science Years 7–10 Syllabus outline these links to the essential content. By explicitly addressing all of the syllabus essential content in the learning units of the school science program the cross-curriculum content will also have been addressed. Teachers should also be aware of and address any system and/or school policies and procedures relating to the cross-curriculum areas when developing their Science learning units.

The Science Years 7–10 Support Document 2009 includes additional information on only six of the 10 cross-curriculum content areas identified in the syllabus. These six areas were those included in the previous 1999 Stage 4/5 Support Document. The text has been reviewed and revised to provide support for teachers in implementing the Science Years 7–10 Syllabus.

5.2 Information and communication technologies (ICT)

ICT is integrated within the outcomes and content of all of the mandatory NSW Years 7–10 syllabuses. The inclusion of ICT across the mandatory syllabuses has increased the opportunities for students to further develop ICT knowledge, skills and understanding related to their studies. Mapping of information and communications technologies in revised mandatory Stages 4 and 5 syllabuses provides an overview of specific ICT references to each of the mandatory syllabuses. The purpose of this mapping is to assist schools in planning the integration of ICT across their learning/teaching program.

The basic aims of ICT across the curriculum are to ensure that all students have the opportunity to become competent, discriminating and creative users of ICT, and that they are better able to achieve syllabus outcomes through effective use of ICT for enhanced learning.

While all syllabuses make explicit statements about the ICT that is to be incorporated into teaching and learning, in the Science Years 7–10 Syllabus ICT is addressed through students:

- performing first-hand investigations, gathering first-hand data, and accessing and collecting information from secondary sources using a variety of technologies, including databases, CD-ROM and the internet
- researching using the library and a range of digital media, including the internet
• using a range of data collection technologies and strategies independently
• extracting, reorganising, formatting and reporting information in the form of spreadsheets, databases, flow charts, tables, graphs, diagrams, prose and keys using appropriate technologies
• developing and using ethical practices in their use of ICT.

In planning learning units in science involving the use of ICT it is important to identify:
• students’ prior learning and current experiences across the school program
• the intended learning outcomes, the purpose for which ICT will be used and student learning styles.

Students and teachers have access to a range of software applications that can be used to support teaching, learning and assessment in Science. In making decisions about the selection of the most appropriate software for the intended purpose of the learning experiences consideration should be given to the type of thinking each ICT application supports. Typical software applications include word processors, spreadsheets, databases, presentation and multimedia, media players, web browsers for internet access and email.

Word processors are major communications tools. They allow students to plan and record their investigations, put forward and accept ideas, knowing that what is on the screen can easily be revised or changed. ‘Equation Editor’ is an additional application which is useful for science teachers, especially in chemistry and physics. It is a standard application of Microsoft Word and can be accessed when working in a Word document via Insert → Object → Microsoft Equation. Equation Editor enables fractions, equations with subscript, superscript and states to be inserted very easily and quickly into text.

Spreadsheets and graphing tools allow students to organise and clearly present data for analysis. A spreadsheet facilitates discussion and provides instant feedback on the selection of the type of graph to use in a given situation, how to format the graph to usefully present the information (eg selection of scale values) and the effect of changing a value might have on the graph. Spreadsheets and graphs provide opportunities for students to explain trends, patterns and relationships and use critical thinking skills in evaluating data and/or information.

Databases are tools for storing, organising and presenting data. They are one of a range of secondary sources which students should use to access information. In appropriate situations databases should be used by students to show trends, patterns and relationships in data and/or information. In Science the learning experiences should provide opportunities for the extraction, analysis and evaluation of the data and/or information and in drawing conclusions based on the information available.

Information resources such as CD-ROMs and the internet (including email and discussion groups) give students access to authentic data. School networks and the internet can provide access to learning resources outside of school hours and enable students to collaborate with both peers and scientists.

The use of interactive whiteboards provides opportunities for the enhanced use of multimedia resources in the classroom. ICT provides students with the flexibility to present their work using a variety of formats and media. Using presentation technologies such as PowerPoint enables students to communicate their work to their peers. This reinforces learning and raises self-confidence.
Schools may also use other ICT to facilitate learning in Science. Examples of these include:

- technology such as computer simulations for modelling to test hypotheses
- computer animations and simulations, video and film resources to capture and analyse information not readily available as a primary source
- data loggers to collect and record data.

Simulations and modelling tools, including animations and virtual environments (e.g., plant and animal cells, natural selection, electric circuits, Earth’s structure), enable students to undertake investigations that may not otherwise be possible in a school situation or are conceptually difficult. However, to realise the full potential of simulations they need to be interactive. Providing students with opportunities to make predictions, test hypotheses and receive instant feedback helps develop their knowledge, understanding, and investigative and higher-order thinking skills. The use of the internet in the student research project has significant motivational potential as students are able to access simulations and virtual environments.

Modelling tools provide opportunities for students to understand models, processes and scenarios that are difficult to access in the physical world or are abstract and therefore more difficult to visualise.

Dataloggers are tools that record and store measurements electronically. They provide quicker and more accurate data collection in a wider range of investigation settings. The most important application of dataloggers is in supporting hands-on practical experiences where these devices offer a range of possibilities for students to collect data more quickly and accurately, improving the quality and quantity of results. Data logging increases not only efficiency but also provides flexibility by allowing data to be collected within and/or outside the laboratory over extended periods.

Combining data logging with word processing, spreadsheet and graphing software makes it easier for students to organise, present and analyse data and/or information and therefore provides more time to explore and discuss the underlying scientific ideas and concepts.

ICT provides the tools for teachers to engage and motivate students and provides opportunities for independent, self-directed learning. ICT may help give students more control over their learning and allow them to investigate topics relevant to their own lives. ICT provides a variety of formats (spreadsheets and quizzes) by which student achievement and progress may be monitored by both the students and their teachers. For examples, refer to HSC and SC Test Yourself and Assessment Resource Centre.

Through their learning experiences in science students need to gain information literacy skills so they can evaluate the reliability of information they locate and gather from a range of secondary sources. Accessing and using information from any secondary source, including CD-ROM and the internet, requires students to develop and use ethical practices in relation to acknowledgements, copyright and plagiarism. The HSC: All My Own Work program is a guide to help students follow the principles and practices of good scholarship.

### 5.3 Aboriginal and Indigenous perspectives

Opportunities to develop understanding of aspects of Aboriginal and Indigenous culture are provided for students as they:
• identify some of the scientific ideas that different cultures (including those of Aboriginal and other Indigenous people) have contributed to science throughout history
• give examples to show that different cultures or groups within a society (including Aboriginal and other Indigenous people) may use or weight scientific data and evidence differently to make a decision about an issue involving a major scientific component.

The syllabus also provides opportunities in teaching and learning programs for the inclusion of Aboriginal and Indigenous contexts relevant to areas such as ecology, the environment and astronomy.

Aboriginal students

Aboriginal or Torres Strait Islander people are those who are of Aboriginal and/or Torres Strait Islander descent and who identify themselves as such and are accepted by the Aboriginal and/or Torres Strait Islander communities with which they are associated.

Teachers need to be aware of the diversity of Aboriginal communities in NSW: diversity due to variations in geographic location, language and customs, socioeconomic conditions and historical experience. Because of the cultural diversity of Aboriginal Australia, Aboriginal people have no one word for Indigenous people that can apply to the whole of Australia. Aboriginal people in NSW use terms such as Koori, Goori and Murri to refer to themselves but these terms differ in other states. They are also likely to refer to themselves as belonging to specific language groups. This will indicate where people feel they ancestrally belong. Local Aboriginal groups should be consulted to determine acceptable local usage.

Aboriginal people’s experience of schools and schooling in NSW has often been negative and in conflict with the values and attitudes of their culture. The Aboriginal family is usually extended and community-based. Consequently, Aboriginal children may come to school with different views on sharing personal property, individualism, competition and group relationships. Teachers should be sensitive to these cultural differences while recognising that Aboriginal students are as diverse a group of learners as any other. They should also have high expectations of Aboriginal students as learners.

Communication

Aboriginal children have a high incidence of hearing impairment caused by middle ear infections, in particular otitis media, the effects of which may be intermittent and difficult to detect. The impact of hearing loss and the delayed acquisition of language skills cannot be overestimated and teachers should always be aware of the possibility of hearing impairment in Aboriginal children.

Many Aboriginal students speak Aboriginal English as their first or home language. Superficially, Aboriginal English is similar to Standard English but it differs in significant ways. Pragmatic differences between Standard English and Aboriginal English – such as use of silence, ways of information seeking, body language and pause time, as well as differences in semantics, use of words and grammatical structure – can lead to serious misunderstandings between teachers, parents and Aboriginal students.

Teachers need to be sensitive to the subtleties of nonverbal communication used in Aboriginal communities. They also need to be aware that their own body language is easily read by most
Aboriginal students and that their own attitudes and hidden curricula will have an effect on Aboriginal students in their classes.

Aboriginal perspectives

Aboriginal students, in common with all students, need to have their identity and culture recognised and valued by their school. It is important that teachers evaluate their own attitudes and seek to learn about Aboriginal cultures and history and that schools consult with their Aboriginal communities in developing culturally appropriate learning environments for Aboriginal students. Schools should consult Working with Aboriginal Communities: A Guide to Community Consultation and Protocols. Schools will be guided by Board syllabuses and support documents that have been developed to include Aboriginal perspectives. Further information is available on the Aboriginal Educational Contexts website: http://ab-ed.boardofstudies.nsw.edu.au/go/secondary-7-10/science

Support and consultation

Teachers must recognise that they may not automatically receive respect by virtue of their position. Rather, respect is earned as a person, through positive and genuine relationships with students and their community. It is therefore vital for all teachers to be aware not only of the importance of appropriate, effective and ongoing consultation, particularly at the local level, but also community involvement.

A wide range of personnel, support structures and resources are available to assist teachers in both improving the educational outcomes of Aboriginal students and educating all other Australian students about Aboriginal heritage and culture. The role of the Aboriginal Curriculum Unit (ACU) of the Office of the Board of Studies is to provide advice and support to all education providers in matters of curriculum.

The ACU consults closely with Aboriginal communities through the NSW Aboriginal Education Consultative Group Inc. (AECG). Another role of the ACU is to help include Aboriginal content and perspectives in all key learning areas so that all syllabuses have coherent and appropriate Aboriginal perspectives and content. The ACU currently runs a variety of syllabus support programs including Aboriginal Perspectives.

Local, regional and executive levels of the AECG provide support for Aboriginal education. Teachers might also consult with other specialist service providers such as Aboriginal Education consultants and advisors and Aboriginal Community Liaison officers, who will provide valuable guidance in contacting care givers and can facilitate communication between the school and its Aboriginal communities.

Teaching implications

Aboriginal cultures regard the nature and quality of relationships between people as very important. Working on these relationships is the key to gaining the trust and respect of Aboriginal community members. After relationships are established, knowledge will be shared. Aboriginal communities must be fully acknowledged with reciprocity as part of the protocol. Permission to use community information in any way must be sought.

It is best practice to try to involve Aboriginal people directly in the curriculum program wherever possible. Once teachers have established a relationship with members of the local
Aboriginal community, they can negotiate a community role in the planning, delivery and assessment of education programs with an Aboriginal perspective. The local AECG should be the first ‘port of call’ for local Aboriginal involvement, participation and support. The incorporation of Aboriginal perspectives in all teaching programs is essential to promote self-esteem and prevent the possible alienation of Aboriginal students, and to educate all students about the culture and heritage of Aboriginal Australia. In schools where there is no nearby Aboriginal community or where there are few, if any, Aboriginal students, Aboriginal perspectives must be acknowledged in and be woven through Science programs. This can be done by using Aboriginal voices in all forms of media on aspects of land management and ecological practice and examining the science behind traditional Aboriginal practices, eg removing toxins from cycad fruit.

**Some inclusive teaching strategies**

In meeting the learning needs of Aboriginal students in Stages 4–5, it would be beneficial for teachers to:

- assess teaching programs for incorporation of Aboriginal perspectives and enterprises relevant to Science
- ensure that Aboriginal perspectives and resources are accurate and do not reinforce stereotypes and ethnocentrism (the best resources and activities will be those which have a local perspective and are supported by the local Aboriginal community)
- recognise and respect the diversity, complexity and distinctiveness of Aboriginal cultures, such as traditionally orientated communities, contemporary communities including remote, rural and urban communities
- encourage Aboriginal community members to participate in school and classroom activities
- relate the content of lessons to the local Aboriginal area where possible
- establish a learning environment that is sensitive to, and supportive of, Aboriginal culture and heritage
- have high expectations of all students; recognise the knowledge and talents of all students
- use a variety of teaching strategies, including cooperative learning, in the classroom
- accept and encourage lateral and unconventional ways of thinking and problem-solving
- provide opportunities for students to gain competence in standard English in Science lessons while still accepting work that reflects students’ use of Aboriginal English demonstrating the correct context for both
- provide opportunities for students to demonstrate knowledge and skills through a variety of media, both verbal and nonverbal
- be aware that many Aboriginal people may regard direct questioning as impolite and confrontational and that some Aboriginal students may not reply to direct questions from the teacher, particularly if the student perceives that the teacher knows the answer
- be aware that many Aboriginal people and students may avoid eye contact as a sign of respect and this is often misinterpreted as avoidance, etc
- allow Aboriginal students time to respond to questions; pausing before responding is considered polite and appropriate in Aboriginal cultures
- ensure that assessment techniques are inclusive of all preferred learning styles.

The *Aboriginal Educational Contexts* website includes teaching and learning resources and covers specialist areas such as Aboriginal Languages and current research on Aboriginal education. It showcases examples of school-developed, context-based teaching and learning projects created in collaboration with Aboriginal elders, teachers from a number of areas within NSW, Aboriginal education consultants and science consultants.
5.4 Gender and Science education

Gender consists of a complex mix of norms, values, assumptions and expectations about almost every aspect of human behaviour and personality. In order to achieve widespread and fundamental gender equity and allow each individual the full range of options for education, career and life, schools need to assert and reinforce the commitment to gender equity. They need to have an awareness of all of the factors underlying gender issues, in order to develop an understanding of how these issues influence both community life and individual development.

Gender issues are addressed in the *Science Years 7–10 Syllabus* through the inclusion of Prescribed Focus Areas and the flexibility provided in allowing teachers to choose contexts and additional content that stimulate student interest and take account of their learning needs. Thus opportunities are provided for teachers to structure gender-neutral or gender-specific contexts depending on the needs and development of their students, both intellectually and socially.

The syllabus also requires students to examine the roles and contributions of women and men in science, providing an opportunity to break down many of the traditional stereotypes.

Certain social and religious aspects of culture may contribute to the loss of interest in science and to some students not continuing with science in the post-compulsory years. Strategies to change school culture and approaches to teaching science can be effective in encouraging both boys and girls to continue. Such changes in Years 7–10 may attract students who have shown an apparent lack of interest in and understanding of science at the beginning of secondary school.

Even though considerable progress has been made in the last decade, there is still evidence (AAUW 1998, Fensham 2004, Guzzetti 2004) that women and minority groups are under-represented in the sciences, particularly at the career level. Science educators should continue to be concerned about this because it suggests that input into decisions made about future directions for science and technology will be limited, if significant sectors of society are not represented at the decision-making level.

Girls, more than boys, continue to reject careers in mathematics, engineering and technology (AAUW 1998, NSF 2008, Fensham 2004). Many factors contribute to gender expectations, including the power of the peer group, the school culture and parental and societal expectations. Schools must be prepared to express alternative views to counter the impacts of these factors.

Several studies have shown that the social reactions of children are influenced by peers of the same sex and there is often little awareness that these influences are operating. By becoming informed about gender, gender development and gender issues in society, students and teachers gain a language that facilitates talking and thinking reflectively about this issue (Guzzetti 2004).

Teachers can begin to address gender concerns by providing supportive forums for exploring gender issues and concerns, and creating policies and practices which promote equity in boys’ schools, in girls’ schools, and in co-educational schools.
Rethinking the ways in which scientific concepts are presented in schools will benefit both girls and boys. Examples of potential improvements include school learning programs that stress the use and development of relational and connected ways of thinking, an emphasis on problem-solving in social and cultural contexts and allowance for creativity, insight and intuition.

Differences in their experiences inside and beyond school will affect how boys and girls respond to the world and make sense of it, influencing how and what they learn. Girls tend to value the circumstances in which tasks are set and take account of them when constructing meaning in a task. They consider context and content. In general, boys tend to consider tasks in isolation and judge the content and context to be irrelevant. The consequences are that girls and boys may perceive problems differently given the same set of circumstances. Current research identifies that Science learning programs need to provide experiences for all students to develop the knowledge, understanding and skills to become scientifically literate citizens. The willingness of students to engage in Science is enhanced if problems are based firmly in a ‘real world’ context. Some boys, quite likely those who are currently successful in Science, might well find such changes difficult and this issue must be considered when choosing the combination of context, Prescribed Focus Areas and Domain material to be incorporated into each teaching unit.

Surprisingly, research has shown that teachers of both sexes, often unknowingly, have lowered expectations for females, interacting very differently with their male students and their female students. Teachers at all levels can develop strategies of encouragement and inclusion. In the classroom, especially in the upper grades, teachers need to listen to the quiet voices or those who lack confidence as well as the more vocal and assertive class members.

Studies have shown that there are gender differences in communication styles in the classroom (Guzzetti 2004). In general, boys tend to respond to questions more confidently, aggressively and quickly, regardless of the quality of their responses. They speak more freely and spontaneously in class, formulating their answers as they speak. Girls, on the other hand, tend to wait longer to respond to a question in class, choosing their words carefully, reflecting on the question and constructing an answer before they speak (Brown University 2005). Students who do not feel entitled to be ‘doing’ and ‘knowing’ about Science, frequently withdraw and do not express themselves in class. All students should be actively engaged in classroom conversations, and all students need to be provided with opportunities to hear about both male and female scientists.

Other studies have found that girls’ and boys’ goals for learning differ in Science. In general, girls prefer to understand as much as possible of the task, whereas boys tend to value the accumulation of knowledge. Boys may thrive on competing to see who can finish the problem first, whereas girls prefer and perform better in situations where everyone wins. As a result of their interest in relationships and interdependence, girls will be more attracted to Science and its methods when they perceive its usefulness in other disciplines (Brown University 2005).

The preferences girls have for working collaboratively and through discussion with others have been widely noted. Collaboration is an important learning mechanism that is valued in our society and a central practice among groups of scientists. Boys and girls should be both encouraged and given opportunities to work in teams to experience the benefits of collaboration in solving problems. Studies (Fensham 2004, Seymour 1995) have shown that
many students who are strongly motivated leave the sciences because they are discouraged by the competitive atmosphere in which they work.

While in some instances learning experiences may be designed to set students in competition, students usually respond more positively to an atmosphere of cooperative learning (Guzzetti 2004). This type of learning encourages small groups of students to work together to solve problems, complete a task or accomplish a common goal. Small groups provide the opportunity for students to ask questions, discuss ideas, make mistakes, learn to listen to the ideas of others, offer constructive criticism and reflect on thinking and learning.

Science education that enables students to address scientific issues that are directly related to their lives provides them with the skills and understanding they need to think through these issues and explore the values and attitudes associated with them. The inclusion of the Prescribed Focus Areas in learning units will offer opportunities for changing the way in which many students view science, thus promoting a ‘science for all’ environment.

**Specific teaching practices that encourage gender equity in Science**

- **Set science in a real-world context by:**
  - permitting students to bring life experiences into the Science learning environment
  - considering and discussing relevant social and ethical issues
  - incorporating guest speakers who can serve as mentors and role models
  - encouraging students to participate in science-related activities inside and outside of school
  - discussing the value of science education as preparation for a variety of academic and non-academic careers.

- **Use a variety of teaching techniques that:**
  - cater for different learning styles
  - include cooperative as well as competitive learning, structuring cooperative learning groups in a way that facilitates participation
  - allow longer periods of time for making more careful observations and answering questions
  - counter the gender or experiential gaps in the use of scientific equipment and experimental materials by providing more hands-on experiences
  - use gender-neutral language
  - encourage the use of writing and drawing to help students communicate.

- **Reduce bias by:**
  - presenting Science as a subject that everyone can learn
  - giving all students an equal amount of help and feedback, recognising effort as well as accomplishment
  - acknowledging the contributions of both men and women to science, providing role models from a range of societal groups
  - choosing Science curriculum materials that do not contain bias associated with gender, race, class, sexual orientation or religious affiliation.
5.5 Multicultural perspectives

Multicultural content assists the development of students’ skills, knowledge and understanding applicable to the multicultural and multilingual nature of Australian society. It includes designing culturally sensitive curriculum that acknowledges multicultural viewpoints and histories and the application of instructional strategies that encourage all students to achieve, regardless of race, ethnic heritage or cultural background.

In science, students explore some of the different perspectives of individuals, groups, events and issues, identifying examples that show how different societal groups may use or weight criteria when making decisions about issues with a major scientific component. Through the study of both the history of science and recent scientific developments, including some by Australian scientists, students become aware of the broad cultural character of scientific endeavour.

Language background

In any science classroom there will be students with differing language abilities: native speakers of English who will have different levels of spoken and written English and reading skills, and speakers of other languages who are in various stages of learning English. Other students may identify English as their mother tongue but be culturally distinctive from other English speakers and speak a variety of English, which may have different grammatical constructions or pronunciations. Other students may speak a different social dialect to standard Australian English such as Aboriginal English or ‘inner city’ English.

Teachers must be sensitive to their students’ use of these varieties of English and appreciate that linguistically they are fully formed languages able to fulfil all the purposes of language but may be less acceptable for educational purposes or mainstream communication. These varieties of English are the mediums of communication in the students’ communities, and teachers need to accept these as legitimate while at the same time developing the students’ command of the standard dialect that is used for educational assessment in the Australian culture.

It is the teacher’s responsibility to assist all students to develop literacy skills, including those students who speak English as a second (or additional) language (ESL). Section 5.6 Literacy in Science provides a range of strategies for supporting literacy development that are appropriate to second language learners. Teachers can assist the development of literacy skills in their students by being aware of the extra demands that learning Science can place on students who are still learning English, and by developing some additional strategies specifically for (ESL) learners in the classroom.

ESL students can be broadly divided into three groups: first phase learners, second phase learners and third phase learners.

• **First phase learners** are those students whose understanding and production of spoken and written English is obviously limited in all social and educational situations. Some first phase learners may be students who have studied English in their country of origin and whose reading and writing skills have been developed but whose oral skills are very limited. First phase learners of secondary school age undertake their initial learning of English at Intensive Language Centres and enter high school as second phase learners.
• **Second phase learners** are those students whose understanding and production of spoken and written English is progressing but is still limited in some social and educational settings. Their fluency ranges from the ability to participate and meet the demands of some class activities to the ability to meet the language demands of most class activities.

• **Third phase learners** are those students who generally function fluently and effectively in English but who may occasionally need assistance in coping with the demands of English in specific situations.

It must be remembered that there is still a wide range of literacy skills within these groups. Students may, for example, have well-developed oral skills but poorly developed reading or writing skills or read and write well but be very difficult to understand orally. Others may function very well with social and schoolyard English but find it difficult to understand when speaking the language of the classroom. Others may be able to read magazines and newspapers but not be able to read textbooks.

There are many factors which affect the rate at which ESL students acquire English. These include the student’s age, first language, gender, culture, socioeconomic background, parental involvement, self-esteem, attitude to their migration to Australia and acceptance of English as the language of instruction. Factors which contribute to a student’s success in acquiring English include literacy in their first language, particularly if it is in Roman script, and the length of time they have had access to English. Many students who have English as a second language have achieved native language proficiency, both spoken and written. Teachers therefore should not make assumptions about what proficiency a student should be expected to have. Two students from the same language group who have been in Australia for the same amount of time may not have the same level of English competence because of these other variables.

The Science Years 7–10 Syllabus provides students with the opportunity to develop hands-on skills in planning and conducting investigations, communicating information and understandings, developing scientific thinking and problem-solving techniques, by working individually and in teams. The development of these skills requires spoken and written language. The situations in which these skills are presented should provide the ESL student with the opportunity to learn and practise new language both with the teacher and other students. Language learning is most effective when students are motivated by a need to communicate in a meaningful context and the learning experiences in the science classroom can provide this meaningful context.

**Features of the language of science**

The language and the written resources used by the teacher in the Science classroom differ from those the ESL student encounters in the playground and in other subject areas. The science teacher therefore needs to develop strategies and resources which will enable ESL students to recognise differences in scientific language and master the language needed to learn in science.

Some features of the language of science, which may cause difficulty for second language learners, are vocabulary, passive voice, tenses, modifiers, prepositions, reductions, conditionals and modals.
Vocabulary

Science has an ever-increasing specialised vocabulary. Words such as ‘xylem’ and ‘methane’ are almost exclusive to science. Other words such as ‘gas’ and ‘state’ are used in everyday contexts but have a specific meaning in science. It is important to check that the meaning of these words in the science context is understood.

There are also many non-technical words used in science as part of the explanation of technical terms, but which are unfamiliar to students. These words, not common in everyday speech, are often referred to as ‘educated language’. At home, for example, a student may be asked to ‘work out how fast the car is going’. In the Science classroom the student may be asked to ‘calculate the speed of the car’.

Some words are common in verbal as well as written instructions and if the student is unfamiliar with them they will have difficulty in carrying out procedures. The teacher can assist the student by putting the explanation into a physical context. For example, when discussing the water cycle and giving explanations and definitions of the processes, the teacher could demonstrate evaporation while modelling language, using sentence patterns such as, ‘I am evaporating this water. It is now evaporated. This means the water has turned into water vapour. It has turned from a liquid into a gas. Can you describe any examples of evaporation in your home?’

Setting the language into a meaningful context gives the student a number of opportunities to hear the word in various forms and the opportunity to use the word in context. The teacher could then provide a definition in the language of science: for example, ‘the process of a liquid becoming a gas is called evaporation’.

The students could then write the definition. To further assist the students’ understanding they could be asked to discuss other sentence patterns that they might use to give the same information, such as: ‘Evaporation is the process in which a liquid becomes a gas. When a liquid becomes a gas the process is called evaporation’.

This provides the student with the opportunity to listen to, speak, read and write the sentence patterns. The teacher could reinforce these patterns with individual students and in other processes of the water cycle and in later units of work with other processes eg rock cycle. Students need to be reminded of the definition patterns and the teacher can elicit the different sentence patterns by asking students to say or write a definition ‘another way’.

Teachers should preview texts to see what language demands they place on the student in terms of vocabulary as well as grammatical patterns and means of organisation (see Section 5.6 Literacy in Science for further strategies).

The following example, which could be found in a Year 7 text, shows how the teacher could assess the difficulties a student may have with vocabulary.

*Every material has certain properties. These properties can be described by words such as weight, colour, strength, hardness and melting point. The state of most materials is either solid liquid or gas.*

This piece of text at first glance looks simple; the sentences are short and there do not appear to be any difficult words. For the student the following problems may arise:
• **every** – do they know that this word signals a generalisation? Are they familiar with other ways of generalising? All materials have a set of properties. Materials have a set of properties. A material has a set of properties. Each material has a set of properties.

• **material** – specific meaning in science, not just material in clothing, curtains etc

• **properties** – specific meaning in science not houses, etc. Do they know the difference between ‘properties’ and ‘characteristics’?

• **weight** – everyday usage: ‘How much do you weigh?’ ‘How heavy are you?’

• **strength** – everyday usage: ‘Is it strong?’

• **hardness** – do they recognise that ‘-ness’ can be added to other words to show properties and characteristics, eg soft, softness?

• **melting point** – a demonstration and explanation that ‘point’ can be used in this way with other words, eg ‘saturation point’

• **state** – specific meaning in science

• **solid, liquid, gas** – do they have an understanding of these as a general class, eg not just the gas that we cook with?

As well as helping students to build up their science vocabulary teachers can help students understand some grammatical structures which are infrequent in everyday language or other school subjects.

**Passive voice**

The passive voice is used much more in science than in everyday language. Science is more interested in ‘what happened?’ than ‘who did it?’ Science is concerned more with processes and procedures than with who performs them.

The passive voice causes difficulty because the normal English pattern of subject + verb + object is not followed. In the passive voice the object occupies the first position in the sentence (usually occupied by the subject) and the subject is either missing or placed at the end of the sentence, for example:

• the teacher heated the water (active)

• the water was heated (passive).

Students will need to use this construction, for example, in recounting procedures in investigations.

**Tenses**

The most common tense used in science is the present tense. It is used for:

• regular actions and processes, eg food passes down the oesophagus

• general statements, eg air occupies space

• factual statements and observations, eg the mixture looks cloudy.

Students may need help to recognise general statements.

**Modifiers**

These are used frequently in science, often in instructions, and qualify the meaning. For example the frequency of an action or event can be modified, such as ‘measure the temperature periodically/often/occasionally/frequently’. What is the student’s concept of these durations?

The teacher can provide exercises ranking these words from less frequent to most frequent with a range of frequency words such as *always, generally, seldom, occasionally, usually, often,*
frequently, often as, from time to time, never, hardly ever. This exercise emphasises how personal experience (the context in which we learn language) can shape our meanings. Similar exercises can be done when the teacher is expressing degree or approximation.

Prepositions
Students may need help in recognising that prepositions often have more than one meaning, eg ‘put the glass jar over the sample’. In this instance ‘over’ means ‘invert’, other meanings are ‘on top of’, ‘down’, ‘past’ and ‘too much’. Students will often need help in understanding the function of prepositions. For example, in the sentence ‘Food passes from the mouth to the stomach through the oesophagus’ a student may misinterpret this sequence by just referring to the nouns ‘mouth’, ‘stomach’ and ‘oesophagus’.

A cloze activity of processes in which only prepositions have been deleted would be a useful exercise. Similar activities could be used for various types of connectives:
• time indicators in processes, eg then, firstly, after that
• causal relationships indicators, eg because, as, as a result of, therefore
• opposition or contrast indicators, eg although, but, on the other hand.

Reductions
Many science sentences are complex sentences, containing a number of clauses. This means there are many ideas in the one sentence. To put more information into a sentence the clauses are reduced resulting in the deletion of words which signal a clause. For example:
• A whale is a mammal which is adapted for an aquatic environment.
• A whale is a mammal adapted for an aquatic environment.

This reduction now allows other clauses to be added.

A whale is a mammal adapted for an aquatic environment, which is able to stay under water for long periods and communicate over long distances.

Conditionals
Science uses conditionals frequently in predicting, hypothesising and expressing universal statements. Students may need help to understand that the sequence of tenses signals the degree of likelihood.
• An event which always happens, a universal – If you heat water to boiling point it evaporates (present + present).
• An event likely to happen in the future – If it rains it will flood (present + will [future]).
• An event unlikely to happen in the future – If I added the water it would overflow (past + would + subjunctive after ‘if’).
• An event never likely to happen – If I had added the water it would have overflowed [subjunctive/conditional after ‘if’] with had [pluperfect conditional after ‘if’] + would have [subjunctive/conditional after ‘if’])

Modals
In addition to their other functions the modals can, could, may, might, ought to, express possibility and probability.
• ‘Might’ and ‘could’ express a tentative possibility – I think the substance might/could mix with the water.
• ‘May’ and ‘can’ express possibility – *The substance may dissolve when added to the water.*
• ‘Should’ and ‘ought to’ express probability – *These two substances should dissolve.*

**Language functions and science**

An understanding of the particular features of the language of Science can help the teacher plan how to assist the student to participate fully in class discussion and group work in which the student needs the language of describing, classifying, predicting, instructing, summarising, discussing, arguing, explaining, recounting and hypothesising.

Before expecting students to participate fully the teacher should observe to what extent students have command of these language functions. In discussing what they know about a particular topic with their group the teacher may need to check whether or not the students have the language skills to enable them to:

• agree and disagree
• make suggestions
• ask for suggestions
• accept a suggestion
• reject a suggestion
• agree in part with a suggestion
• interrupt.

While these are not specific to Science they are needed as the means by which the student can express their background information on the topic and elicit information from the group. In addition the teacher can use discussion and group work as a means of introducing the language of science or extending the students range of language for science. For example in a classifying activity students may be able to say ‘*these belong together*’ or ‘*these are the same*’ but need help to form sentences such as, ‘*These are both mammals. These can be classed as mammals. These can be classified into the group mammals.*’

It is important that students be able to use their familiar language at the beginning of activities to relate their own experiences about the context. However, to introduce and extend language, students will need specific language teaching. The teacher can model this language of science by recasting student sentences. After a student says, for example, ‘*Whales, bats and cows are all mammals*’, the teacher can reply: ‘*Yes that’s correct – whales, bats and cows are classified as mammals.*’

The teacher can check on the student’s progress by asking open-ended questions such as, ‘*Tell me why you decided to classify bats as mammals?*’ Students also need practice in formulating questions, eg ‘*If you had to classify a newly discovered organism, what questions would you ask?*’

The language introduced by speaking and listening can be reinforced by written activities such as mix and match, dictagloss and cloze exercises (see Section 5.6 Literacy in Science).

In general, good teaching practice in science, such as group work that encourages the development of speaking and listening skills, and strategies and activities which support literacy, will also promote the acquisition of English.
The teacher can also draw on the student’s first language for learning Science. Many students will have studied Science in their first language, and while concepts may be known in that language students will be unable to express them in English. There is a place for allowing students to use their first language to bridge the gap by asking speakers of the same language to explain or by using dictionaries in their first language. However, translation is only a starting point and students must be provided with the opportunity to place concepts in an English-speaking context. Teachers need to be aware of the language used in assessment to ensure that it is Science content being assessed and not language skills. Examples of the language of test items can be pretested and if necessary taught in class before assessment.

Cultural background

As well as the different language needs in the culturally diverse classroom the teacher needs to take account of how different cultural backgrounds can affect learning style. However, it must be acknowledged that there is diversity within any culture and that while generalisations may provide some useful information for teachers, not all students from particular groups may behave in the same way.

The teacher cannot possibly know every cultural trait of every cultural group in the classroom and must avoid stereotyping. However, the teacher can observe if a student is uncomfortable or not performing well in different tasks and sensitively elicit what the problem may be. The student, the ESL teacher and other support staff, as well as the student’s community, are the best resources for this information. While helping students to be comfortable with the learning/teaching style which predominates in the Australian classroom the teacher also needs to vary some of the tasks for individual students.

Cultural differences may also be noticed in group work. Not only may some students not have the full range of English language required for the tasks but they may also have a different understanding of the nonverbal clues, eg touching, interpersonal space, eye contact, and laughter. Smiling may mean different things in different cultures; it could mean that the student is pleased but it might also mean that the student is embarrassed or uncomfortable. Lowering the eyes could be a sign of respect or it could mean the student is avoiding the issue. Differences in what is considered polite or impolite are important if groups are to function well. It is here that language and culture meet. A student, for example, may not have the language to interrupt politely, eg ‘Would you mind if I asked a question? I was wondering if you could add dragonflies to that web.’ They may not understand the body language required to show support for an argument, by nodding and leaning forward. The teacher needs to discuss these aspects of group work to promote intercultural understanding among all the cultural groups.

Religious as well as cultural differences may also need to be accounted for in the formation of groups; gender may be an issue in some religions and cultures, and the mixing of sexes in groups may not be appropriate in some cases.

When developing communicative activities, to promote learning in Science through group work and discussion, the teacher must ascertain whether or not there is common ground before asking students to discuss issues. If there is no shared understanding or experience there can be no real exchange of information. Pollution and ecology, for example, are well known subjects in the Australian context. This is not so in all cultures and the experience of newly arrived students in these areas may be negligible. The teacher may need to provide these students with background information through video or reading, or use field work to
create a shared experience. In adapting teaching and learning strategies to account for language and cultural background the teacher demonstrates that they acknowledge the values, attitudes and beliefs of all students. This raises the self-esteem of students and encourages a positive attitude towards learning and science.

**Addressing multicultural perspectives in Science**

The *Science Years 7–10 Syllabus* provides opportunities to reinforce the contributions of human diversity to our understanding and development of scientific concepts, in the Prescribed Focus Areas and the choice of appropriate contexts.

The Prescribed Focus Areas identify the contributions of races and cultures. The histories and contributions of various ethnocultural groups can be incorporated into lessons that can allow students to:

- identify some of the scientific ideas in which different cultures have contributed to science throughout history
- use examples to identify how different cultures have developed ideas to explain the world around them
- discuss examples where societal, religious or ethical values have had an impact on scientific developments
- describe historical cases where developments or improvements in technology have transformed science
- recognise that different societal groups may use or weight criteria differently to make a decision about an issue with a major scientific component
- analyse why different cultures or groups within a society may have different views in relation to scientific issues
- describe some recent scientific contributions made by male and female scientists, including Australians, and discuss the impact of their contributions.

Science and technology are a part of daily life. The Prescribed Focus Areas allow aspects of social and historical concern, as well as the applications and implications of science, to reflect the realities of our culture and the world.

Religious and other cultural beliefs may be in opposition to material presented in a Science lesson. Teachers should allow students to present their different or potentially conflicting points of view in a safe and non-judgemental atmosphere.

There may be conflicts of interest because of cultural or religious beliefs with the following:

- evidence supporting theories about the evolution of the universe
- evidence supporting theories about the evolution of life forms
- medical and industrial uses of energy
- genetic technology in developing different strains of plants and animals
- social, ethical and moral issues surrounding the manipulation of human genetic material
- issues and discussions involving human reproduction
- combating diseases in humans
- impact of the search for renewable and non-renewable resources.

Developments in science arise from the universal and collaborative enterprise of many cultures and the recognition of this fact should feature prominently in the Science classroom. This can be achieved by:
• creating a ‘famous scientists calendar’ which highlights the birth and death of famous
scientists (including women scientists) from all cultures
• hanging pictures with culturally relevant scientific information around the room
• identifying the origins of some scientific words, eg ‘malaria’ from the Latin (Italian)
‘bad air’
• asking students to give a presentation about famous scientists and their culture
• using a variety of learning activities that reflect the students’ cultural diversity
• designing collaborative activities to enable students from different cultures to work
together towards a common goal
• fostering a classroom atmosphere that is open and encourages mutual tolerance and
respect.

5.6 Literacy in science

The development of students’ literacy skills and understanding is the responsibility of all
secondary school teachers as different subjects and learning areas make particular demands on
students’ literacy. The Science Years 7–10 Syllabus provides opportunities for students to
engage in the ongoing development of broad literacy skills as well as more science-specific
literacy.

Literacy is the ability to communicate purposefully and appropriately with others in a wide
variety of contexts, modes and mediums. Literacy incorporates not only the fundamental
skills of speaking, listening, reading and writing but also skills in visual literacy that are
developed through viewing and representing a wide range of texts.

The essential content of the syllabus provides opportunities for students to:
• use the language of science in both oral and written communication of their knowledge
and understanding via a range of media
• extract, summarise, collate and critically evaluate information for a range of purposes and
audiences
• debate, discuss and evaluate the impact and applications of science in a range of contexts.

This section of the Support Document has been organised under three headings.
• The language of science
• Listening, speaking, reading and writing in science
• Text types and the domains of language in science: apprenticing students into reading and
writing scientific texts.

The language of science

The study of science can facilitate the development of language skills that will assist students
in all areas of everyday life. However, it needs to be stressed that science has its own specific
literacy demands that need to be met by students if they are to engage successfully with the
world of science. To understand and communicate scientific concepts well, students need to
develop their language skills in the context of science. Achievement of the outcomes of the
Science Years 7–10 Syllabus is enhanced by the systematic and explicit teaching of literacy in
science.
Words and phrases in science have meanings that are often quite different both from ‘everyday’ meanings for words and from the meanings produced in other disciplines, such as history, English and mathematics. To use obvious examples, when a science teacher discusses a ‘change of state’, students need to know that the discussion is not about moving from NSW to Victoria! ‘Conductor’ is another word where meaning can vary greatly according to the context in which it is used.

If students are to develop a good understanding of scientific meanings, teachers must be explicit in the introduction, explanation and use of scientific terminology, as very few students are able to discriminate meanings intuitively. As with other aspects of learning, the context of the language influences the meaning and structure of texts. With this in mind, teachers are encouraged to model the use of new texts and to give students opportunities to use new vocabulary and sentence and text structures in their appropriate contexts.

Strategies for increasing understanding of the language of science

Finding definitions

During the reading of a textbook, alert students to the structure of paragraphs and the introductory sentences of paragraphs. If they are looking for definitions or meanings of words, they will often appear in the first sentence of a paragraph, eg:

Gravity is a force that every object exerts on every other object. Weight is the measure of the force of gravity that the Earth exerts on objects near its surface. Since weight is a force it should be measured in newtons. When you stand ...


Definitions usually give the name of the concept and then talk about its nature.

A (= thing to be defined) is B (= definition).
For example: Mammals are another class of warm-blooded vertebrates.
A is B which has C (characteristic).

In a definition, the word ‘is’ or ‘are’ may also be represented by the following phrases:
• can be seen as
• refers to
• is defined as.

Examples are signalled by:
• for example/eg
• these include/including
• such as, as in, is one such
• illustrates/can be illustrated by
• these are.

Often the word to be defined is highlighted in the text, eg ‘Marsupials are mammals that raise their young in a pouch. This subclass includes kangaroos, possums, koalas and wombats.’
Unpacking the terminology used in science texts

Consider this extract from Watson (1992, p 79):

One of the most commonly used thermosoftening plastics is polyethylene. Polyethylene comes in two forms, high density and low density. Each type is useful because they can be made either flexible or rigid, transparent or opaque. They can be dyed different colours and resist wear.

High density polyethylene is stiffer and softens at high temperature; low density polyethylene softens at a low temperature. High density polyethylene has closely packed linear chains, while low density polyethylene has short branched chains as shown in Figure 6.9. (Figure 6.9 shows the difference between irregular packing in low density polyethylene and regular packing in high density polyethylene.)

These paragraphs are quite typical of science textbooks and of the language of science itself which is, generally, lexically dense, containing long complex sentences with many technical words used to describe scientific processes and states. Many students will need help in unpacking these sentences if they are to gain full meaning of the text.

Look at one of the above sentences again:

Premodifier Noun Verb

High density polyethylene has closely packed linear chains

‘High density polyethylene’ is the noun group that is the subject of the sentence. ‘High density’ is an adjectival phrase or a ‘premodifier’; it comes before the main noun and modifies it. The modification tells what particular kind of polyethylene is described.

When students are shown how to analyse and break up the sentence into its component parts, they will be more able to extract meaning from the text. This is because they will be able to use the syntax of sentences to assist in gaining meaning from the text. Remember that English as a second language support teachers, learning difficulties teachers and English teachers have the skills to assist in the analysis of texts proposed for use in the science classroom.

Matching words to meanings

The teacher needs to decide why a textbook is to be used before the lesson begins. The purpose may not be achievable if the language of the text is beyond the level of language development of the students.

Examine this extract from De Vreeze et al (1993, p 37):

About 20 thousand years ago, humans first began trapping young wolves and raising them in captivity. As wild wolves are naturally distrusting of
humans, however, our ancestors would only have kept those few pups that would readily take to human handling. From these pups, they selectively bred the loyal companion we know today as the dog.

The first domesticated dogs would have looked much like wolves but their temperament would have been different. They trusted people, followed migrating tribes and thus began to spread across the Earth with humans. At this stage the domesticated wolf that returned to the wild probably would have been able to survive as a wild wolf, depending on how much of its wild nature had been bred out of it.

The language of these paragraphs is fairly dense lexically, but not many technical words have been used. Yet, if students do not understand much of the vocabulary, the whole purpose of the reading exercise could be lost. A quick check of certain words before the reading exercise is completed can aid student understanding of a text. This can be done by using the following method which is useful for both specific science content and everyday terms. One column has the word or phrase, the other a meaning that is appropriate in the context that it is used. Students match the terms with the correct meaning. This helps move students away from the notion that any meaning in the dictionary will do.

<table>
<thead>
<tr>
<th>Term</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>captivity</td>
<td>living with humans; tame</td>
</tr>
<tr>
<td>ancestors</td>
<td>friend, mate, partner</td>
</tr>
<tr>
<td>selective breeding</td>
<td>the natural environment without humans</td>
</tr>
<tr>
<td>loyal</td>
<td>disposition or nature; reaction to humans</td>
</tr>
<tr>
<td>companion</td>
<td>forefathers, family relatives from long ago</td>
</tr>
<tr>
<td>domesticated</td>
<td>groups of people moving from one place to another</td>
</tr>
<tr>
<td>temperament</td>
<td>allowing only those animals with the desired traits or characteristics to reproduce</td>
</tr>
<tr>
<td>migrating tribes</td>
<td>kept with humans; stopped from running with wild animals</td>
</tr>
<tr>
<td>the wild</td>
<td>prevent the inheritance of undesirable characteristics from being transferred to the next generation</td>
</tr>
<tr>
<td>breed out</td>
<td>faithful, staying with, standing by</td>
</tr>
</tbody>
</table>

A strategy that has a similar outcome is the use of crosswords. A crossword on a unit is a useful pre-test or revision exercise to firm up understandings of definitions and the relationships between words used in a science context. There are computer software programs that simplify the preparation of crosswords for class work.

Sentence beginnings and endings
This can be useful for revision where students need to check their understanding but also helps with improving understanding of sentence construction.

Example from Shadwick and Barlow (1992):

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple sugars and …</td>
<td>… proper growth and body functioning.</td>
</tr>
<tr>
<td>Water is the …</td>
<td>… are needed for growth and health.</td>
</tr>
<tr>
<td>Proteins are essential …</td>
<td>… stored as fats for a long-term energy supply.</td>
</tr>
<tr>
<td>Lipids are …</td>
<td>… starches are needed for short-term energy supply.</td>
</tr>
</tbody>
</table>
Minerals are needed for … for building body tissue, growth and repairing damaged tissue.
Vitamins … … solvent for many chemicals in the body.

By checking the construction of each potential sentence, students, possibly with help from their teacher, reconstruct the original. This can be done even without prior knowledge of the subject material relying on their understanding of sentence construction. The beginning of the sentence from Column A leads to only a limited choice from Column B to complete each sentence. For example, if the students know that the beginning ‘Simple sugars and’ is the subject made up of an incomplete noun group, the subject needs to be completed and then the sentence needs a verb and an object to become complete. So the only choice to complete the sentence is ‘starches are needed for short-term energy supply’.

Tables constructed in this format are useful for assisting language development. However, if this table was used as a revision exercise, the language clues would need to be removed and the table could be rewritten as below.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple sugars and starches are needed for …</td>
<td>… proper growth and body functioning.</td>
</tr>
<tr>
<td>Water is the solvent for …</td>
<td>… growth and health.</td>
</tr>
<tr>
<td>Proteins are essential for …</td>
<td>… long-term energy supply.</td>
</tr>
<tr>
<td>Lipids are stored as fats for …</td>
<td>… short-term energy supply.</td>
</tr>
<tr>
<td>Minerals are needed for …</td>
<td>… building body tissue, growth and repairing damaged tissue.</td>
</tr>
<tr>
<td>Vitamins are needed for…</td>
<td>… many chemicals in the body.</td>
</tr>
</tbody>
</table>

**Dictagloss**

The dictagloss is a form of dictation based on meaning rather than accuracy of transcription.

For this type of exercise students should work in pairs or small groups. The teacher reads out a short passage at normal speed on a topic in which students are familiar with the content. During the first reading of the text, students listen for the meaning of the text. The text is read again and students take down the key words. Then the group tries to reconstruct the passage. This will involve students drawing on their knowledge of the topic and their knowledge of linguistic features. They will have to negotiate with their fellow students about the final text to be submitted or recorded. The original text can then be displayed on an overhead transparency and students can check their version against it. Using dictagloss in this way means that students are revising information as well as focusing on the language used in science.

**Cloze passages**

A cloze is an activity where parts of the text have been deleted. Students have to fill in the missing parts using clues from the text and their understanding of the topic. This actively involves the student in reading the texts and practising the skill of predicting. It can also be used as a method of providing notes. As the students are actively engaged in the process of note-making, they are more likely to cognitively process the information than in a simple note copying or dictation episode where the end result is still ‘notes in the book’.

In preparing cloze passages and using them in the classroom, it is worth remembering the following points. It is not necessary that the exact missing word is supplied by the student; the
supplied word is good as long as the meaning is the same. Cloze passages can be used to check grammar or meaning of scientific terms. The general principles for the construction of cloze passages are:

- the first and last sentences should not have deletions (this gives students a context for the text)
- decide on the class of words to be deleted from the text, eg verbs, conjunctions, nouns, scientific terms
- if the purpose of the cloze passage is to reinforce or assess the students’ understanding of technical vocabulary specific to the topic, delete only these words.

For example, the use of the following paragraphs focuses on reinforcing scientific definitions or principles:

*The Earth’s revolution around the sun is the main cause of our four seasons: summer, autumn, winter and spring. These seasons are marked by differences in _______ conditions and in the length of day and _______.*

*Because the Earth’s orbit is ____________, at some time of the year the Earth is ________ to the sun than at others. As the Earth moves around the sun, its ________ stays tilted in the same direction. These factors also cause the seasons.*

The following use of the same paragraphs removes words in a definite spacing (every seventh word) and assists development of overall language skills in a science context (Watson 1995, p 139).

*The Earth’s revolution around the sun is the main cause of our four seasons: summer, autumn, winter and spring. These seasons are marked by differences _____ weather conditions and in the length _____ day and night.*

*Because the Earth’s ____ is elliptical, at some times of ______ year the Earth is closer to _______ sun than at others. As the ________ moves around the sun, its axis ________ tilted in the same direction. These factors also cause the seasons.*

The deleted words can sometimes be given to the students in a list. This can help students in the initial stages of learning vocabulary for a new topic.
Using flow diagrams
Consider the diagram below of the rock cycle:

The flow chart is used frequently in a science context to summarise the processes in quite complex cycles and to provide a more visual record. To ensure understanding of both the processes and the words used to describe and explain the process, it is a useful exercise to ask students to write the information provided into a text.

For example, in the rock cycle, the words ‘magma’ and ‘igneous rocks’ are connected by an arrow labelled with solidification. Can each student rewrite this section of the cycle as ‘Magma forms igneous rocks by the process of solidification’ or as ‘Magma solidifies into igneous rock’? Perhaps it would be better to modify the language to ‘Magma cools to form igneous rocks’. Not every student finds this easy to do. Using this strategy very easily identifies misunderstandings of the purpose of flow charts and the information that they provide.

Construction of flow charts is also a very useful summarising tool which will allow students to verify their understandings. For example:

*When water evaporates from lakes and oceans it rises in the atmosphere as invisible water vapour (gas). High in the atmosphere, the air is cooler and so the water vapour condenses on dust particles, forming clouds. Clouds contain tiny*
droplets of water (liquid). When the droplets get large enough they may fall as rain (liquid), hail (solid) or snow (solid). Once on the ground the rain soaks into the soil or runs off the ground into rivers, lakes and the ocean. The warmth of sunlight causes the water to evaporate again. There is thus a cycling of water on earth. This is called the water cycle.


Students can be assisted in construction of a flow chart by helping them to distinguish between nouns and verbs describing processes.

If we consider the sentence ‘When water evaportates from lakes and oceans it rises in the atmosphere as invisible water vapour (gas)’:

- The word ‘evaporates’ is a verb – do they know what ‘evaporate’ means?
- The rest of the first part of the sentence gives details about this process and ‘from lakes and oceans’ states the place where the process is taking place.
- The second part of the sentence begins with ‘it’ which is a pronoun standing in for ‘water’.
- The verb ‘rises’ describes the second process in this sentence, while the rest of the sentence tells where and how the process occurs. This sentence explains how water changes into vapour. When a flow chart is made, an arrow that is labelled ‘evaporation’ would connect the states of water, ie water and vapour.
- It is worth noting that the noun ‘evaporation’ represents a process. This is worth pointing out, since normally processes are described by verbs, but in science such processes are very often represented as nouns – confusing the novice but powerful to the specialist.

**Listening, speaking, reading and writing in Science**

**Listening in science**

Students in the Science classroom obtain a large amount of information by listening.

- The teacher gives instructions, provides explanations and asks questions.
- Other students also provide information during group work, class discussion or in giving answers to questions.
- Students also obtain information from audiotapes, television, video and radio.

Listening is a most important skill and students will need guidelines on efficient and effective listening skills and practice in using these skills. The teacher must plan units of work that include listening activities with specific purposes and provide the student with models and opportunities to increase their skills in active listening.

**Listening for a specific purpose**

Most students when asked to listen for information and take notes will write down as much information as they can without processing it. It is important for students to understand that we often know some of the information we are listening to already or that some of the information being presented is irrelevant for our purposes. Exercises are needed that encourage students to listen actively for specific information and record notes only on this
relevant information. To start with, the requirements of the task should be minimal so that students do not have many issues to concentrate on.

**Sample task**
The teacher explains the topic to be listened to. The purpose is then explained and students are given instructions about what they are to do with the information. For example:

*We are going to listen to a taped interview with David Suzuki, one of many world experts on ecological problems.*
*I am going to ask you to listen for specific information.*
*Do not take notes on everything that is said.*
*Listen carefully until you hear the information that answers the questions I have given you and make a brief note.*

The teacher then asks some questions:

*What does David Suzuki believe is the biggest crisis facing the world today?*
*What does he believe is the most important change we can make to the way we live?*

**Structured listening**
Students often need to listen to obtain details such as names of objects or people, descriptions of processes or figures.

**Sample task**
The teacher should prepare the work sheet before the lesson and explain the purpose of the listening exercise. For example, a listening exercise can be used to get meanings for words if a ‘match meanings to words’ work sheet has been prepared. The listening exercise could be a prepared talk by the teacher.

It could be a work sheet for notes from listening to a prepared talk. The students listen to the talk and fill in the sheet after the teacher has finished. This can be done as a group exercise.

*An element is a pure substance which cannot be broken down into anything [simpler].*
*One example of an element is carbon. It is an element because it contains only [carbon atoms].*
*Examples of other elements are hydrogen, [gold] and [oxygen].*
*There are more than [100] elements.*
*Of these [90] occur naturally and the rest have been [created by scientists].*

**Following instructions**
This is a very common requirement in the science laboratory and one that is not always done well.

Teachers regularly give instructions to students on carrying out practical experiences, completing activities, completing work sheets and organising team activities. The language used for instructions includes lists, sequencing and identifying goals. It is a useful exercise to have students practise the skills of hearing and identifying the key points in sets of instructions before actually carrying out a practical experience based on oral instructions. Part of the practice can include the production of a written procedure from these oral instructions.
Suggested activity
The teacher needs to provide students with activities that will encourage them to describe procedures and processes, and to give instructions and follow them. Students could design experiments or procedures and give oral instructions to another team on how to complete the task. Students could also tape record their instructions and observe the other team carrying them out.

Sample task
Give students an unlabelled diagram of the digestive system. If the teacher has recorded a talk on the process of digestion, students whose skills are still developing will have opportunities to replay the recording to find instructions on which parts to label and what labels to put on the diagram. The instructions could include the correct spelling of the labels.

If the students are more efficient at following instructions, the teacher could give a live talk on the process of digestion and achieve this same task.

Another effective way of improving listening skills is to put the student in the role of instructor. Students could take turns, in teams or individually, to develop sets of oral instructions for the team/class to follow.

Speaking in science
The role of speaking and listening in order to learn is extremely important in the Science classroom as students are introduced to many new complex concepts.

If the teacher provides activities that encourage exploratory talk, students build their field knowledge. Exploratory talk is different from the kind of social talk that students engage in frequently and the teacher needs to plan activities that develop speaking skills in predicting, explaining and hypothesising if students are to be extended beyond the normal retelling and narrative of social talk.

The teacher should ask themselves the following questions before expecting students to start activities on a new topic:
- What is the topic about and what do my students already know about it?
- What language should be focused on to allow students to understand the topic?

Each student will bring their own unique understanding to the topic (based on their own experiences embedded in cultural and linguistic understanding). In introducing new concepts, the teacher must provide opportunity for the students to build up the field by exploratory talk before moving on to reading and written tasks. Exploratory talk can be used again any time in the teaching/learning cycle of the topic – for example after reading tasks – as this can assist students to incorporate new information into their existing understanding.

At all stages, the teacher will need to model language structures and ensure that new and technical words are properly understood. Given that the language experiences of students who are reluctant or poor readers may be limited, the introduction to new language through modelling and joint construction of oral as well as written texts will assist most learners to expand their vocabulary. This exploratory talk with the teacher modelling provides essential support for the second language learner, places the language structures firmly in context and gives the language learner an opportunity to practise in a supportive environment.
When students choose to communicate information, ideas or feelings about the topic, they must consider the **register**, which is the **how, what, who** of the communication.

- The **how (mode)** is the medium of communication: spoken or written. It is possible to speak like some people write, and many students write like they speak. Teachers want their students to come close to writing as scientists write.
- The **what (field)** of the text, is the topic or subject matter.
- The **who (tenor)** is the relationship between the speaker/writer and the audience/reader. An authority on a topic uses different language when addressing colleagues than when addressing learners.

Students must make language choices based on these different aspects. For example, should the language be personal or impersonal? This refers to the **who** aspect.

**Example**

*The cyclone warning system provides the inhabitants of the area with up-to-date information on the direction and intensity of the cyclone. This gives people time to prepare for the cyclone or to evacuate if the danger is too great. Some people ignore the warnings, which is pretty stupid if you ask me.*

The tenor is impersonal and authoritative, but at the end of the last sentence the speaker switches to the personal when stating an opinion in a rather colloquial manner.

**Suggested activity**

Group work provides students with the opportunity to speak and listen, exploring their own understandings and that of other students. However, the teacher must plan these discussions to ensure that students are actually increasing their understanding.

The knowledge students bring to the context could be identified by brainstorming and the construction of concept maps.

Students must be able to use the language of group work, if they are going to successfully explore their own understanding and that of other group members.

Teachers may need to model the language of:
- asking questions which stimulate discussion (open-ended, not closed, questions)
- interrupting
- agreeing and disagreeing
- giving instructions and explanations
- expressing feelings
- negotiating
- providing feedback.

The role of nonverbal cues or body language should be included, as these are culturally based and can often lead to mixed or confused messages, especially in the multicultural classroom.

**Presentations**

In order to respond to the requirement of syllabus content statement 4/5.18a) select, and use appropriately, types of texts for ... oral or written presentation, teachers will need to provide
opportunities for learning, practising and carrying out oral presentations because, like all aspects of communication, the skills of presentation can continually improve and develop.

**Suggested activity**  
The teacher can model this kind of speaking and ask students to identify the features of a satisfactory presentation. Discussion within groups of students, and between students and the teacher, can identify the characteristics of a good oral presentation fairly quickly. The discussion can begin with the students’ own impressions of presentations they have experienced.

**Sample task**  
The students can be given the task of preparing a presentation on some aspect of their course. The Prescribed Focus Areas content statements provide some excellent examples of potential presentations that students could prepare, for example 4/5.1b) describe (using examples including those developed by Aboriginal peoples) ideas developed by different cultures to explain the world around them.

Working together, teachers and students can develop a list of the attributes of a good presentation by tackling the questions below before working on a presentation:

- Who is my audience?
- What is their background in this topic?
- What will they be expecting?
- What is my focus or point of view on this topic?
- Based on my goal for the talk how will I organise the information?
- Can visual aids make my talk more effective?

Students also need time to practise their presentation. A group may present a talk, with each student presenting a different section.

During rehearsal, students may need to evaluate each other in terms of:

- speed
- volume
- speech mannerisms
- repetition, pauses
- reliance on script or cue cards
- use of technology and visual aids.

Students must be discouraged from reading any part of their talk.

Teacher and peer assessment of presentation can be achieved by considering the following points. To achieve maximum outcome from the task, students should be given the criteria on which they will be assessed during their preparation of the presentation.
Reading in science

Reading plays an increasingly important role in science during secondary education because learning becomes more and more student-centred with progression through Stages 4–5. This means that teachers cease to be the only source or even the main source of information for students.

Students will obtain information from a variety of sources during science lessons but many students will need guidance and advice on how to extract information efficiently from the reading sources. The benefit of providing guidance in reading skills for science is that students who experience success are more likely to retain an interest in acquiring further information throughout their lives. Reading has much to offer students in providing an important way of bridging the gap between knowledge acquired at school and the vast world knowledge bank that students can explore through books and the internet. Developing this lifelong curiosity is one aspect of producing scientifically literate citizens.

Strategies for increasing reading skills

Pre-reading strategies
The purpose of pre-reading is to become familiar with the text that is to be used as a source of information. This includes predicting what the text is about. If teachers can give students predicting exercises, success in these exercises will build student confidence. By using a range of pre-reading exercises, students recognise that reading has a purpose. They will bring prior knowledge to the text that they can use in interpreting new information. They also learn that predictions are constantly revised as new information is incorporated into existing schemata. In discussing their predictions they learn from other students and also learn to use context clues.

The survey step
Show the title, table of contents, chapter heading, or chapter headings, and subheadings and ask students to predict what would be contained in the text under each of these headings. Students may discuss their predictions in groups, and give reasons for their choice stating
what clues they used. They then confirm their predictions by reading the text. This is the survey step of pre-reading and gives the student a general idea of the type of information that may be found in the book.

**Sample task**
You need information on how plants make food. Which of the following books do you think would be useful?

*Plants of the Amazon*
*Food-making in plants*
*The gardeners guidebook*
*The life of plants*
*Green plants*

**Building topic vocabulary**
Have students in groups predict the key words and phrases that may be used. Teachers could use this strategy with the class to construct concept maps.

**Example**
Managing waste (chapter heading)
Pollution, air pollution
Composting
The greenhouse effect
People should recycle

**The skimming step**
Skimming is the next step in the pre-reading sequence and involves quickly reading through a text to get the general idea of what is in it. Skimming focuses readers on identifying what information is important and allows them better access to a text.

**Suggested activity (a group task)**
Hand out a science text containing information required on a topic. Prepare a work sheet that asks the following questions about the particular text.

**Sample task**
You have identified this book as a possible source of information about plants.
- What chapters have information on the topic? (This assists in unpacking the contents of the book.)
- Which chapter is the most useful? (This focuses the student on the purpose of the exercise.)
- What is the chapter called? (This gives a clue as to content.)
- Make an outline of the chapter subdivisions. (This unpacks the chapter for the student and finds the relevant section of the chapter for the student.)
- Why are some of the headings in different kinds of print (size, colour, etc)? (Font sizes and different colours help to give a visual overview of the structure of the chapter or are indicators of how the text is divided up.)

**The scanning step**
Scanning or selecting is the final step in pre-reading. After the students have identified that section of the book that is useful, they examine that section closely for the information required.
Suggested activity (individual or small group task)
Prepare a work sheet similar to the one below that focuses the students on identifying the precise information available. If the students were actually going to use the book for an assignment or note making, this section would be marked with a sticker or bookmark for further reference.

Sample task
Use the chapter you have identified to complete a table like the one below about that chapter of the book.

<table>
<thead>
<tr>
<th>Chapter heading</th>
<th>What I expect to learn from this chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>eg angiosperms</td>
<td>eg seems to have useful information about how angiosperms make food and why they need sunlight</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>List of potentially useful illustrations – photos, diagrams, tables, flow charts</th>
<th>What I learned from these illustrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>eg photograph of stomates</td>
<td>eg it looks like air goes in through the stomate holes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Look at the text</th>
<th>Relationship between text and illustrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>eg there is more information about stomates in the text</td>
<td>eg the text helps explain the diagram about stomates and gives some more information. (Reading the text may assist, complement or enhance the information in the diagram.)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Why some of the words are in italics, bold print, or different colours</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>eg every time a word is in bold, there is a definition of that word following</td>
<td>eg red is used to give the title of diagrams</td>
</tr>
</tbody>
</table>

Reading strategies

Once pre-reading has been accomplished, the students should be quite familiar with the text and can move on to the intensive reading stage. During this time, the students should be reading carefully all the sections that they have identified as useful. In spoken language that is face to face, we can refer to things in the physical context which are ‘outside the text’, for example, ‘put it down there’. In the spoken context pointing, holding or perhaps an inclination of the head would clarify ‘there’. In written language, however, all information must be within the text and it must be independent of the physical context. The text must be cohesive to make it predictable for the reader. There are a number of strategies used for making texts cohesive, one of which is ‘lexical chains’.

A text may have a number of lexical chains running through it. Each chain links a different content strand. The lexical chains may be incorporated into a text by:

- repeating words
- using synonyms
- using classes and subclasses
- using whole and parts
- using antonyms.
For example, in Watson (1992, p 128) we can identify the use of a lexical chain in its simplest form. The object of one sentence becomes the subject of the next sentence. In this example, the sentences work through to eventually swing back and give more information about the subject of the first sentence in the paragraph.

‘Mutations (in bold type to highlight the subject of the following paragraphs]

Variations are further increased when genes are altered. A change in a gene is called a mutation (notice use of italics where a definition is used). Mutations therefore change certain characteristics. For example, a variety of grapes called the Concord is a result of a mutation. This mutation caused a wild variety of grapes to produce grapes that were bigger and sweeter than previously. Such mutations can be transferred to future generations.’

Suggested activity
If students are assisted with the identification and grouping of different lexical chains through a text, they will learn to trace the connections and relationships between scientific ideas expressed in a text.

Sample task
Read the following paragraphs from Watson (1992, pp 88–89). Use different colours to highlight those words that correspond to a lexical chain. Remember that there may be several chains running through a text. This exercise is much more obvious in its outcome if colours rather than symbols are used.

Growing and feeding
All living things need food to stay alive and to grow. Food provides living things with energy for growing and repairing tissues. Different organisms require different types of food. The process of taking in food, digesting it and using it to provide energy is called nutrition.

Animals obtain their food by eating plants or other animals.

Some animals, like humans, eat both plant and animal material. Plants make their own food inside their leaves in a process called photosynthesis. Plant food is in the form of sugars. In order to make sugars, plants use carbon dioxide gas from the air, water from the soil and sunlight.
Most **living things** go through a marvellous process called **growing**. As humans **grow** from a baby to an adult they increase in size and change in appearance.

**Trees** and other **plants** also grow from a **seedling** (tiny plant) to an adult **plant**. Some **trees** seem to **grow** forever. However, they will eventually reach a particular height. Sometimes **growth** can take hundreds of years.

All **organisms** **grow** to a typical size and are called adults when fully **grown**. The adults then keep more or less a characteristic size for the rest of their lives. Most humans, for example, **grow** to between 150 cm and 180 cm in height.

Some lexical chains in this example are:
- Repeated words represented by the symbols ____ and ____
  eg living things, animals, plants
  grow, growth, grown, growing
- Synonyms represented by the symbol ______
  eg living things = organisms
- Group and its subgroups represented by ______
  eg living things, plants, trees, seedling

How do we use this information?

Students can create notes based on tree diagrams or concept maps from these lexical chains. For example, the lexical chains from the heading of the above passage can lead to:

```
Living things
  Animals
    Grow
  Plants
    Grow
    Make own food
      Photosynthesis
    Make own food
    Nutrition
    Feed
```

With guided practice in this process, students will develop better reading skills. The other benefit from exercises like this is the summarising and note-making skills that can be learned as a result. Students are learning to recognise the key issues in a text; once they have identified the issues they can develop their summary in the form of a concept map. Where key facts have to be memorised, this process produces a useful memory aid.
Writing in science

The Domains of language use in school Science identified by Veel (1997), and summarised in the diagram below, were ‘doing science’, ‘organising science’, ‘explaining science’, and ‘challenging science’. The diagram has been modified and also includes ‘chronicling science’ which will be important when addressing the Prescribed Focus Areas of the Science Years 7–10 Syllabus.

The experiments performed and the observations made allow scientists to group scientific information and to explain scientific phenomena. These understandings of science influence in turn new experiments and observations. The total understanding of science enables other scientists to challenge all kinds of processes and ideas.

All these scientific activities are written or written about. Science language has distinct features that can be taught using the idea of text types. The purpose of communication demands a certain way to organise information; the topic and the audience determine the words used. The idea of text types that organise words are an appropriate way to teach science language. By the end of Stage 3, students are expected to have a reasonable understanding of the main science text types used in school Science as set out below.

<table>
<thead>
<tr>
<th>Name of text type</th>
<th>Purpose of text type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recount</td>
<td>Retelling a series of events</td>
</tr>
<tr>
<td>Procedure</td>
<td>Instructing how to do something</td>
</tr>
<tr>
<td>Report</td>
<td>Describing what something is like</td>
</tr>
<tr>
<td>Explanation</td>
<td>Saying how and why something happens</td>
</tr>
<tr>
<td>Exposition</td>
<td>Convincing someone of a point of view</td>
</tr>
<tr>
<td>Discussion</td>
<td>Drawing a conclusion after discussing several points of view on an issue</td>
</tr>
</tbody>
</table>

As students learn more in the subject of science, it is possible to refine these text types by describing them in more detail and narrowing down their purposes. The following is an expansion of this.
<table>
<thead>
<tr>
<th>Doing science</th>
<th>Text type</th>
<th>Purpose of text type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Procedure</td>
<td>Instructing somebody how to do something</td>
</tr>
<tr>
<td></td>
<td>Procedural recount</td>
<td>Retelling the procedure and outcome of an activity</td>
</tr>
<tr>
<td></td>
<td>Experimental record</td>
<td>Recording the outcome of scientific activity</td>
</tr>
<tr>
<td>Explaining science</td>
<td>Sequential explanation</td>
<td>Explaining observable sequences of activities, where the focus is on the sequence rather than the cause (ie saying how a process happens)</td>
</tr>
<tr>
<td></td>
<td>Causal explanation</td>
<td>Explaining why an abstract and/or not readily explicable process occurs. The phases in the process are explicitly linked in a cause and effect relationship (ie saying how and why a process occurs)</td>
</tr>
<tr>
<td></td>
<td>Theoretical explanation</td>
<td>Developing a theoretical principle</td>
</tr>
<tr>
<td></td>
<td>Factorial explanation</td>
<td>Explaining the reasons or factors that contribute to a particular event</td>
</tr>
<tr>
<td></td>
<td>Consequential explanation</td>
<td>Explaining the effects or consequences resulting from a particular event</td>
</tr>
<tr>
<td></td>
<td>Exploration</td>
<td>Exploring competing explanations or theories for an event</td>
</tr>
<tr>
<td>Organising information</td>
<td>Descriptive report</td>
<td>Giving information about one type of thing (ie describing several aspects of a thing)</td>
</tr>
<tr>
<td></td>
<td>Taxonomic report</td>
<td>Describing parts or types of a group of things</td>
</tr>
<tr>
<td></td>
<td>Comparative report</td>
<td>Describing and comparing several things</td>
</tr>
<tr>
<td>Challenging science</td>
<td>Exposition</td>
<td>Arguing for a particular point of view on an issue</td>
</tr>
<tr>
<td></td>
<td>Discussion</td>
<td>Arguing the case from two or more points of view</td>
</tr>
<tr>
<td>Chronicling science</td>
<td>Biographical recount</td>
<td>Retelling the events of a person’s life</td>
</tr>
<tr>
<td></td>
<td>Historical recount</td>
<td>Retelling events from the past</td>
</tr>
</tbody>
</table>

It is recommended that teachers explain and model the appropriate structure for texts.

A way to further the understanding of literacy in science is by following a learning/teaching cycle. A model of a particular text type is provided to students. This model is then analysed with respect to structure and language features (the detail of this activity depends on the level of understanding of the students). Students who have successfully demonstrated the targeted language understanding can then be given an opportunity to write another text with their peers (with or without the teacher’s help). Students who have successfully written joint texts will be
well positioned to achieve success when they are given the opportunity to write independently. The amount of support that is provided in each of these writing phases will vary according to the outcomes the students have already achieved.

**Text types and the domains of language in science: apprenticing students into reading and writing scientific texts**

As described in the earlier section on *Reading in science*, providing students with pre-reading activities is a good starting point to assist them to read scientific texts. For example, teachers could brainstorm key words, talk about the content of the text that will follow, ask students to predict the content from pictures or other visual images, model for students how to read complex texts which integrate graphs, images and text or develop students’ language understandings about particular features of the text which is to be read. Providing activities that students complete while reading and after they have read will make the reading activity more meaningful.

Some of the more common text types which students will be required to read and write in Stages 4 and 5 are summarised below.

**Doing science**

The language most closely associated with doing science enables particular kinds of activities to take place and serves to record methods and observations accurately. The text types that achieve these functions are procedures, procedural recounts and experimental records. By writing procedures, students learn how to give instructions for carrying out experiments. By allowing students to prepare their own written procedures, teachers will be assured that the students understand what they have to do. These activity-based text types will often have diagrams, drawings and possibly flow charts, tables and graphs incorporated into them. Students will also need to practise the skills associated with interpreting and constructing the visual texts used in science.

**Procedures**

A procedure is a factual text that describes how something is accomplished through a sequence of actions or steps. It is structured with a goal or aim and a series of instructional steps or method. Often there is a list of equipment and a diagram. Verbs usually begin each instruction, since verbs describe the process to take place and action is what procedures are all about. Words or groups of words that indicate how, when, where and with whom are typically used at the end of the instructions. Often each instruction begins with a number or ordinal to ensure that the order of the instructions is followed. This text type often occurs as recipes, directions or instructions.

Examples of tasks in science requiring procedures include:

- Describe the steps taken to produce a natural indicator.
- List the steps involved in setting up a filtration experiment.
- Write up the method for your experiment on the effect of wind on plants.
- Prepare a set of instructions on how a wet slide mount is made.

The following text could be written or read during learning/teaching activities associated with Outcome 4.9: *A student describes the dynamic structure of Earth and its relationship to other parts of our solar system and the universe.*
<table>
<thead>
<tr>
<th>Structure</th>
<th>Language features</th>
<th>Procedure example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal or aim</td>
<td>• Starts with ‘To’</td>
<td>Convection currents in a beaker</td>
</tr>
<tr>
<td></td>
<td>• Has an action verb like ‘measure’ or a thinking verb like ‘find out’</td>
<td><strong>Aim</strong></td>
</tr>
<tr>
<td></td>
<td>• Action verbs frequently in first position in sentence (= command)</td>
<td>To produce a convection current in a beaker.</td>
</tr>
<tr>
<td></td>
<td>• Details like how, where, when at end</td>
<td><strong>Method</strong></td>
</tr>
<tr>
<td>Steps or method</td>
<td></td>
<td>• <strong>Fill</strong> a 250 mL beaker with 200 mL of water.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• <strong>Put</strong> the beaker on a gauze on a tripod.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• <strong>Place a lit Bunsen burner</strong> under one side of the beaker.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• <strong>Drop some dried peas into the water</strong> exactly above the flame.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• <strong>Observe for 5 minutes</strong> and record your results.</td>
</tr>
</tbody>
</table>

### Procedural recounts

In many subject areas this is the basic text type that retells a series of events. It is structured with a series of events sequenced in time. It is important to ensure that events are recorded with the correct chronology so that they are retold as they occurred. Recounts are a useful way to record method, observations and conclusion from a more personal perspective. They are also used to link up to an earlier activity.

The language is descriptive and in the past tense. Words that describe order are used to connect events. Details about where, when, with whom and how are also included. Action verbs predominate. Examples of tasks requiring procedural recounts include:

- Write down what happened after you had shaken the soil and you let the mixture settle.
- How did you light a Bunsen burner?
- What happened as you added hydrochloric acid to calcium carbonate?

<table>
<thead>
<tr>
<th>Structure</th>
<th>Language features</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal</td>
<td>• Thinking verbs often</td>
<td><strong>We had to find out how to boil water in a test tube properly.</strong></td>
</tr>
<tr>
<td></td>
<td>• Action verbs</td>
<td><strong>So Chris and I filled a test tube half full with water</strong> and then did all that other stuff that science teachers of Year 7 want good little students to do.</td>
</tr>
<tr>
<td>Record of events</td>
<td>• People as subject in informal texts</td>
<td><strong>We boiled the water without burning ourselves and the teacher was really pleased with us.</strong></td>
</tr>
<tr>
<td></td>
<td>• Action verbs in past tense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Details about when, where, how at end of sentence</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sequence words to order events</td>
<td></td>
</tr>
<tr>
<td>Evaluation (optional)</td>
<td>• As in record of events</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Words expressing judgement</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Structure</th>
<th>Language features</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal</td>
<td>• Thinking verbs often</td>
<td><strong>We had to find out how to boil water in a test tube properly.</strong></td>
</tr>
<tr>
<td></td>
<td>• Action verbs</td>
<td><strong>So Chris and I filled a test tube half full with water</strong> and then did all that other stuff that science teachers of Year 7 want good little students to do.</td>
</tr>
<tr>
<td>Record of events</td>
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<td><strong>We boiled the water without burning ourselves and the teacher was really pleased with us.</strong></td>
</tr>
<tr>
<td></td>
<td>• Action verbs in past tense</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Details about when, where, how at end of sentence</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sequence words to order events</td>
<td></td>
</tr>
<tr>
<td>Evaluation (optional)</td>
<td>• As in record of events</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Words expressing judgement</td>
<td></td>
</tr>
</tbody>
</table>
In general, science tries to concentrate on the science rather than on the people and so procedural recounts are not commonly valued as written text types. They can be used to link up to students’ previous experiences and knowledge.

**Experimental records**

These text types are used widely in school Science. They are made up of a procedure followed by a recount about the outcome of an experiment. After having recorded the procedure of the experiment, students perform it. Then they record their observations in the form of text, diagrams, tables or graphs and a conclusion that summarises the results or places them in a wider perspective. Tasks requiring experimental records include:

- Find out how high a tennis ball bounces off a concrete surface.
- What happens when metals are dropped into hydrochloric acid?

The following text could be written or read during learning/teaching activities associated with Essential Content 4.7.2a) relate properties of solids, liquids and gases to the particle model of matter.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Text</th>
<th>Common language features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Heating water</td>
<td></td>
</tr>
<tr>
<td>Aim</td>
<td>To heat water and record its temperature regularly</td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td>– thermometer&lt;br&gt;– water&lt;br&gt;– tripod&lt;br&gt;– gauze&lt;br&gt;– Bunsen burner&lt;br&gt;– beaker, 250 ml&lt;br&gt;– clock</td>
<td></td>
</tr>
<tr>
<td>Diagram</td>
<td>• Set up a tripod, Bunsen burner and gauze&lt;br&gt;• Pour 200 ml of water into a beaker&lt;br&gt;• Place the beaker of water on top of the gauze&lt;br&gt;• Light the Bunsen burner carefully&lt;br&gt;• Place the thermometer into the beaker&lt;br&gt;• Record the temperature of the water&lt;br&gt;• Place the burner under the beaker and start the clock&lt;br&gt;• Record temperature every half minute&lt;br&gt;• Remove the Bunsen burner when the teacher tells you</td>
<td><strong>DIAGRAM</strong> – What does it look like all set up?&lt;br&gt;• A scientific drawing with labels neatly to the side&lt;br&gt;• Drawing must be in pencil&lt;br&gt;• A ruler is used&lt;br&gt;• About as big as half a page&lt;br&gt;• No shading or colouring&lt;br&gt;• In two dimensions only</td>
</tr>
<tr>
<td>Method</td>
<td>Time (min): 0</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Temp (°C): 20</td>
<td>30</td>
</tr>
<tr>
<td>Results</td>
<td>• The temperature of the water increased at a steady rate when heated. When the water reached 100°C, the temperature stayed the same</td>
<td><strong>RESULTS</strong> – What did you observe (ie see, hear, smell, feel) during the experiment?&lt;br&gt;• Uses some abstract words, eg temperature&lt;br&gt;• Sentences often start with the thing measured or observed, eg the colour changed, the weight became ...</td>
</tr>
</tbody>
</table>
Organising scientific information

The huge amount of scientific knowledge that has accrued over centuries of science needs to be organised and stored in a useful form. The text type of reports does exactly that: information about things is sorted and grouped and then recorded in a concise manner. When students write reports, they themselves follow the information process of identifying, collecting, sorting, recording and evaluating information. Skills like skimming, scanning, note-taking, tabulating and drawing diagrams are extremely useful, therefore.

Reports

Reports function to give a picture of ‘the way the world is’ and so give static, summarising pictures of an area of scientific knowledge.

The structure of a report consists of an identification which names and often classifies the thing to be described and a description which provides the ordered descriptive detail. The language is technical, using simple present tense and generalised terms. Linking verbs such as ‘is’, ‘are’, ‘has’, ‘have’, or their synonyms like ‘is made up of’, ‘contains’ are often used when things are being described. When their activities are detailed, action verbs are more common.

Reports can be used to classify and describe. They can be constructed around observations that may be descriptive, comparative or hierarchical.

Tasks requiring reports include:
• Describe one mammal.
• Define the term ‘resistor’ and describe its role in electric circuits.
• What is a metal? What are the characteristics of metals? How are they used?
• Define the term ‘ore’ and describe the characteristics and uses of an ore of your choice.
• Do a project on a flowering plant of your choice.
There are three types of reports. They all have a similar structure but their purposes are different. A descriptive report describes several features of one thing (eg the planet Mars, echidnas); a taxonomic report makes the classification and features of a group of things obvious (eg vertebrates, rocks); and a comparative report compares and contrasts several aspects of two or more things (eg frogs and toads). The table outlines the features of reports.

<table>
<thead>
<tr>
<th>Differences in purpose of description</th>
<th>Descriptive report</th>
<th>Taxonomic report</th>
<th>Comparative report</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structure</strong></td>
<td>Provides detailed information about aspects of the topic being described. Each paragraph/section begins with a preview that indicates the information contained in the rest of the paragraph/section. The most important aspects are described first, then the less important aspects are described.</td>
<td>Provides brief information about several types/parts/classes of the topic being described. Each paragraph/section begins with a preview that identifies the type of information contained in the rest of the paragraph/section. The most important types/parts/classes are described first and finally the least important types/parts/classes are described.</td>
<td>Provides details about similarities and differences between two or more things. Each paragraph/section begins with a preview of the information contained in the rest of the paragraph/section.</td>
</tr>
<tr>
<td><strong>Identification</strong></td>
<td>Define the topic by using linking verbs, eg The Tetanus microbe is a bacterium called Clostridium tetani. Content of Description is signalled in text preview, eg It has particular structural characteristics, methods of obtaining nutrients and reproductive patterns.</td>
<td>Define the topics by using linking verbs, eg Animals can be divided into two main groups: Those which do not have a backbone (= invertebrates) and those that do (= vertebrates). Content of Description is signalled in text preview, eg The vertebrates can be divided into five main groups.</td>
<td>Definition of technical terms is achieved using linking verbs, eg Plant and animal cells are both eukaryotic, containing membrane-bound organelles. However, plant and animal cells also show significant differences. Content of Description is signalled in text preview.</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>Subtopics signalled through use of section previews, eg – Clostridium tetani is a single cell (ie this section is about its appearance) – Clostridium tetani obtains its food from other organisms (ie this section is about activities like</td>
<td>Subtopics signalled through the use of section previews, eg 1. Fish 2. Amphibians 3. Reptiles 4. Birds 5. Mammals. Topic is usually at beginning of sentences, eg Amphibians have a … Their young live …</td>
<td>Subtopics and comparative relationships signalled by section previews. Topic is usually at beginning of sentences, eg Cells are … Features described and classified through adjective/noun group, eg regular shape, definite outline.</td>
</tr>
</tbody>
</table>

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### Explaining events scientifically

This refers to the way science constructs explanations of phenomena based on experimentation, observation and understanding. The Science syllabus, particularly the Prescribed Focus Areas, expects students to form explanations that are based on relationships between events, principles and theories. The increasing ability to achieve this leads students to engage in the valued scientific ways of accounting for sequences of events.

**Explanations**

Explanations are ‘dynamic and unfolding’ and tell us how or why phenomena in the world operate. The language used in explanations is sequenced in a way so that a phenomenon can be understood. The construction of explanations requires explicit detail of the steps involved in processes. Students therefore need a thorough understanding of any process they are required to explain. (In common usage, the term ‘explain’ can be used quite differently from its scientific use, eg explain why you are late … will not lead to a scientific explanation. Students will need to learn to identify questions requiring scientific explanations, eg ‘describe how something occurs’ means ‘explain something’.)

Explanations use many technical terms. Words such as ‘because’ and ‘as a result of’ are used to establish cause–effect sequences. Explanations may use a temporal sequence to outline a series of events involved in the completion of a process. Words such as ‘when’ occur in such explanations.

Veel (1997) identifies six different explanation types ranging from the simplest, sequential explanations to the more complex explanations where factors, principles or theories are involved in explaining a phenomenon. In spite of their potential to be used at random, different types of explanation tend to occur as a fairly fixed sequence in school science. In other words, different ways of explaining phenomena are valued at different stages of school science.
Early on in science, sequential explanations – explaining how – are favoured. Sequential explanations often emerge directly from classroom activities and experiments, that is, from ‘doing science’. This is not surprising, since sequential explanations rely more on empirical techniques of observation and measurement than on theory. They are the closest to the world of investigation, observation and measurement.

As students progress from Stage 4 to Stage 6, the science of observation and measurement gives way to the science of abstract concepts. Causal explanations – explaining why – become a more valued way of explaining events. While causal explanations can also arise from classroom activity, they tend to require a scientifically more sophisticated understanding of the phenomenon, and so they occur later.

Theoretical explanations, as their name suggests, are associated with a more theory-based understanding of events. They are only indirectly associated with classroom activity and often rely on an understanding of a number of abstract concepts. Because of their link with more complex understandings, theoretical explanations tend to occur later rather than earlier in school science. While students may be required to read and understand theoretical explanations, they are required to write them less frequently.

Factorial and consequential explanations occur when the nature of the topic being studied demands a ‘non-linear’ style of explanation. Because they focus on a number of factors causing a phenomenon or effects resulting from an event, rather than a single cause–effect chain (linear), and because they are less easy to link to practical activities, they also tend to occur later rather than earlier in school science. Similarly, because explorations require students to follow two or more explanations, they also tend to be used later rather than earlier.

Explanations will often occur interspersed with descriptive passages in science texts and in tasks set both in the classroom and in assessment. For example, in a task on ores (define the term ‘ore’ and describe the characteristics and uses of an ore of your choice), the addition of the question, ‘How is this ore treated chemically before use?’ demands an explanation as part of the descriptive requirements of the task.

Tasks requiring explanations include:

- Describe how enzymes assist digestion. (sequential explanation)
- Describe how the structure of the ear allows us to hear sounds. (sequential explanation)
- Explain radioactivity in terms of release of particles and radiation when a nucleus alters. (causal explanation)
- Use the example of plate tectonics theory to explain how a model theory or law may gain acceptance in the scientific community. (theoretical explanation)
- Describe the main causes of the greenhouse effect. (factorial explanation)
- Why is the greenhouse effect so bad for people? (consequential explanation)
- Explain why the dinosaurs died out so suddenly. (exploration)
Causal explanation

<table>
<thead>
<tr>
<th>Structure</th>
<th>Language features</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification</td>
<td>Action verbs in present tense</td>
<td>Why does hair stand on end, when it is brushed with a plastic comb?</td>
</tr>
<tr>
<td>Explanation sequence</td>
<td>Action verbs in present tense</td>
<td>When two non-conducting materials like hair and plastic are rubbed against each other, electrons from the comb are transferred to the hair. As a result the brushed hair holds the same negative electric charge.</td>
</tr>
<tr>
<td></td>
<td>Action verbs in passive voice</td>
<td>Since objects of the same charge repel each other, the strands of hair move away from each other as far as possible causing them to stand up.</td>
</tr>
<tr>
<td></td>
<td>Time conjunctions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cause conjunctions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Long noun groups</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technical terms</td>
<td></td>
</tr>
</tbody>
</table>

Challenging science

This refers to arguing and persuading about issues involving science. These activities are essential for the innovation and upgrading of scientific ideas, concepts and practices. Challenging science allows students to develop a ‘critical scientific literacy’ and gives them opportunities to use science-based arguments in debates about the way we live and think. Society and scientists themselves will use these arguments to question existing theories and practices.

The main written text types used in challenging science are expositions and discussions. Both of these aim to persuade the reader to act or think in a particular way. These text types are particularly suitable for use in the Prescribed Focus Areas ‘The Nature and Practice of Science’ and ‘The Implications for Society and the Environment’.

Exposition

The language used has to persuade the audience or reader to accept a point of view. In science, this means, firstly, putting forward a number of scientific ideas in a clearly structured way; and, secondly, using language that pushes the reader in the desired direction towards the argued point of view.

In an argument, a position is taken and the points supporting this position are usually each considered in a separate paragraph. Each paragraph begins by stating the point of discussion. Then this view is elaborated, often involving an explanation. Finally the paragraph is brought to a close by presenting the point of view. An exposition starts with a statement of a particular point of view and closes with a repeat of that point of view. An exposition uses scientific understanding as well as judgemental or value-rich language. Terms like ‘the very great
majority of people’, ‘extremely rare’, ‘disastrous effects’, ‘should never be burnt’ attempt to sway the reader to the proposed point of view.

Tasks requiring arguments include:
- Give reasons why it is important to work safely in the school laboratory.
- Imagine you are Alfred Wegener. Support your theory of continental drift.
- Give reasons why society should support scientific research.
- Why should scientists assist in the control of greenhouse gases?

<table>
<thead>
<tr>
<th>Structure</th>
<th>Language features</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thesis (= point of view)</td>
<td>Action verbs in present tense</td>
<td>Protection against sunshine</td>
</tr>
<tr>
<td></td>
<td>General nouns</td>
<td>The sun produces many kinds of radiation including light and ultraviolet radiation.</td>
</tr>
<tr>
<td></td>
<td>Technical terms</td>
<td>Ultraviolet radiation is harmful to the skin and eyes, therefore people need to protect themselves against this type of dangerous sunshine.</td>
</tr>
<tr>
<td></td>
<td>Text preview</td>
<td></td>
</tr>
<tr>
<td>Arguments</td>
<td>Paragraph preview</td>
<td>The first argument deals with the skin. The surface layers of our skin contain living cells and under the surface are layers of cells that are constantly dividing to form new skin cells. These new cells are needed to replace those worn off on the surface of the skin. Ultraviolet radiation causes changes to living cells. Some of these changes cause painful skin blisters, but others are more serious. When the DNA in the nucleus of a skin cell is damaged, the cell produces unusual cells instead of the normal skin cells. This is the cause of skin cancer. Some forms of skin cancer lead to sickness and even death. So, it is vitally important to protect the skin against the dangerous ultraviolet radiation from the sun. Protection is given by covering the skin with clothes, by wearing a hat and by applying good sunscreens.</td>
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<td></td>
<td>Cause words (verbs, nouns, conjunctions)</td>
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<tr>
<td></td>
<td>Time conjunctions</td>
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<td></td>
<td>Judgemental words</td>
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<tr>
<td></td>
<td>Paragraph review</td>
<td>In summary, ultraviolet radiation is potentially very dangerous. People must protect themselves against it in order to avoid skin blemishes, blindness and even death. Wearing hats and sunglasses and applying a good sunscreen during long stays outdoors are excellent ways to reduce the terrible incidence of damage due to ultraviolet sun rays.</td>
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</table>

Reinforcement of thesis

Recommendation (optional)
Discussion

In a discussion, more than one side of an issue is explored and hence written or spoken about. The discussion is a text type through which we can delve into cultural, religious and ethical issues that may impact on scientific endeavour. Thus, the Prescribed Focus Area ‘The Implications for Society and the Environment’ includes some ideal topics in which to work with discussions in science writing.

Words that qualify, such as ‘usually’ or ‘probably’, are often used as well as words that indicate alternative arguments such as ‘on the other hand’ and ‘another point of view’ are used in writing discussions.

Examples of discussions include:

• Select a modern scientific development, such as gene technology, and explore the associated issues where public interests do not coincide with private enterprise.
• Outline the importance of energy as a resource and discuss the issues associated with the use of renewable and non-renewable sources of energy.
• Discuss issues associated with balancing human need with environmental protection and conservation.
<table>
<thead>
<tr>
<th>Structure</th>
<th>Language features</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issue</td>
<td>Technical terms</td>
<td>Should dangerous nuclear energy be used? Nuclear energy plays an important role in many aspects of medical and industrial technology. But despite its positive effects, nuclear energy also carries a number of dangers. This discussion attempts to find out whether the advantages outweigh the disadvantages. The advantages deal with medicine and industry and the disadvantages with residual isotopes.</td>
</tr>
<tr>
<td></td>
<td>Linking verbs in present tense</td>
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<tr>
<td></td>
<td>Thinking verbs</td>
<td></td>
</tr>
<tr>
<td>Arguments</td>
<td>Text preview</td>
<td>The first advantage of nuclear energy occurs in medicine. Doctors are able to find problems of the body not by complicated surgery but by a much simpler and less invasive method. This procedure involves a radioactive isotope being injected into the patient and then instruments are able to detect the position of the isotope as its nuclei decay and release radiation. For example, iodine collects in the thyroid gland and injection of radioactive iodine quickly allows an image of the gland to be photographed. In this way a doctor is able to determine fairly easily whether there is a problem with the thyroid gland.</td>
</tr>
<tr>
<td></td>
<td>Paragraph preview</td>
<td>The second argument in favour of nuclear energy usage occurs in industry. Radioactive isotopes are used extensively to check the integrity of metal structures, because tiny hairline fractures could result in a catastrophe. For example, pipelines carrying dangerous fluids can have a radioactive dye added to the liquid. This allows any seepage to be immediately detected, because the leaking liquid carries with it some radioactive material.</td>
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<td></td>
<td>Time conjunctions</td>
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<tr>
<td></td>
<td>Contrast conjunctions</td>
<td>On the other hand there are several problems associated with the production of nuclear energy and radiation. The main cause of these is that, although most isotopes have a short half-life and quickly disappear from the systems, residual quantities may linger and then create problems elsewhere in the environment. The first kind of problem is caused by the damage that radiation causes to living tissue. One long-term result of this damage is cancer. Cancer can result in a miserable sickness and even a painful death. Another potential problem of nuclear energy radiation is the chance of mutations occurring in the cells producing gametes. When this happens and the genes are changed, the changes are inherited by offspring. As a result the impact of nuclear energy emissions can be felt through several generations.</td>
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<td></td>
<td>Judgemental terms</td>
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<td></td>
<td>Paragraph review</td>
<td></td>
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<tr>
<td></td>
<td>Clearly structure indicators</td>
<td></td>
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<tr>
<td></td>
<td>Both sides of view</td>
<td>When looking at both sides of the issue it becomes clear that the far-reaching benefits of using nuclear energy outweigh the usually localised problems. Therefore, nuclear energy should be carefully and sparingly used in medicine and industry, while at the same time measures should be taken to safeguard against potential problems as much as possible.</td>
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<td></td>
<td>Cause conjunctions</td>
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</table>

Assessment

Thesis
Biographical and historical recounts

These text types tell a story and make sense of events and activities of people. They are used to talk or write about historical events and in the writing of biographies. In addressing the Prescribed Focus Area ‘The History of Science’ historical recounts and biographical recounts would be most useful.

Recounts can be both informative and entertaining. They begin with an introduction which identifies the setting, then follow with a retelling of a series of events about a person or a happening, and finally a concluding statement that outlines the effects of the events. The text is usually in the past tense and uses many time conjunctions like ‘when’ and ‘after’ and adverbial phrases of time like ‘in 1848’ and ‘before the development of the microscope’.

Tasks requiring recounts could include:
• How did Marie Curie discover radioactivity?
• Give an account of Charles Darwin’s voyage on the Beagle (or his visit to Australia) and his thoughts on evolution as he saw the organisms of South America and the Galapagos Islands.
• Trace the development of the discovery and acceptance of Helicobacter pylori as the cause of gastric ulcers.

<table>
<thead>
<tr>
<th>Biographical recount</th>
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<tbody>
<tr>
<td><strong>Structure</strong></td>
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<tr>
<td>Orientation</td>
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<tr>
<td><strong>Record of events</strong></td>
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<tr>
<td>Reorientation</td>
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</tbody>
</table>

Students should be encouraged to use the text type appropriate for the task and should be given opportunities to learn and practise each text type at appropriate opportunities. Once students can identify which text type is required, they can feel more confident in applying their understandings about it to the task and hence in writing the required piece of work.
Visual literacy

Visual literacy is the ability to decode, interpret, create, question, challenge and evaluate texts that communicate with visual images as well as, or rather than, words. Visually literate people can read the intended meaning in a visual text such as an advertisement or a film clip, interpret the purpose and intended meaning, and evaluate the form, structure and features of the text. They can also use images in a creative and appropriate way to express meaning.

Within any of the text types, a variety of visual images can be used to enhance the final piece of writing. These can include:

- photographs
- diagrams
- tables
- flow charts
- graphs.

As with text types, teachers need to help students analyse the implied meanings in visual images in order to create the intended impact. The interpretation, design, construction and use of these should be explicitly taught to students through the analysis of models and the practice of guided and independent writing.

The text types described in this support document do not account for all the written language that students will meet in textbooks or that students may use. There are many other types of texts written for students that include linking passages, captions, cartoons and even jokes. Students should be encouraged to exercise their creativity in the use of these alternative writing strategies wherever appropriate. Many pieces of writing are made up of several text types; for example, reports, expositions and discussions often contain an explanation. In order to fulfil a particular purpose, writers use many strategies including the joining of several text types (sometimes within the same paragraph). However, teaching students to write, speak and read is made a lot easier when the idea of text types is utilised.

Fictional writing can also be used as a tool for teaching science. For some students, this type of writing can be extremely enjoyable and meaningful, helping them to make sense of an experience or phenomenon. Narratives may have their place in the construction of science fiction which may be mythical or futuristic but which allow students to extrapolate from their science knowledge base into fantasy.

However, research indicates that the text types that recur in published science textbooks are what students are asked to produce in examinations and most often in classroom writing. These do not usually include narratives because narratives are not an efficient way of displaying scientific understanding. The overall purpose of narratives is to entertain. Factual text types play the biggest role in understanding and interpreting scientific knowledge in the school context. Mastery of these text types enables continued engagement in the world of science after Stage 5.
Using text types

It is important to have a clear idea of the purpose of each teaching unit while designing it. As Veel (1997) points out, depending on the aims and objectives of the unit of work, different types of meanings will be more important than others. This will be reflected in the type of writing required. This was summarised by Veel in the following way:

(i) *Focus on practical skills*

- Procedures and experimental records (highly valued)
- Explanations and reports (some emphasis)
- Expositions and discussions (little or no emphasis)

(ii) *Focus on social issues and impacts*

- Expositions and discussions (highly valued)
- Explanations and reports (some emphasis)
- Procedures and experimental records (little or no emphasis)

(iii) *Focus on explanations of phenomena*

- Explanations and reports (highly valued)
- Procedures and experimental records (little or no emphasis)
- Expositions and discussions (little or no emphasis)

Source: Adapted from Veel (1997, p 175).

The emphasis of the teaching unit needs to be determined during the planning stage. Then the teaching program and lesson sequence can be structured accordingly to include time for modelling, analysing and practising the targeted text type as well as achievement of the outcomes of the Prescribed Focus Areas and Domains of the syllabus.

The flow chart outlines some of the activities that should be considered for inclusion in the strategic design of a teaching unit. The emphasis on student-centred activities will ensure that students practise those skills and competencies important in the development of a scientifically literate person.
Sequencing activities in units

**Orientating activities**
Setting objectives and linking with previous learning through:
- discussing
- brainstorming
- negotiating
- listening
- viewing
- reading
- note-making.

---

**Enhancing activities for gaining control of subject matter**
Learning subject matter and thinking processes through modelling, deconstruction and joint construction by:
- experimenting
- reading
- discussing
- listening
- researching
cloze activities
- viewing
- note-making
- summarising
- diary writing.

---

**Enhancing activities for gaining control of writing processes**
Learning to use new text types, considering social and scientific contexts, applying thinking processes, choosing language features and communicative features through:
- shared and guided reading or viewing
- deconstruction and analysis of texts
- joint construction and group work
- transformations and reorganisations of data
- games
- practice drills
- discussion.

---

**Synthesising activities**
Writing or preparing presentations through:
- planning
- drafting
- conferring and consulting
- revising and redrafting
- editing
- proofreading
- rehearsing
- publishing, presenting or performing
- reflecting.
5.7 Numeracy in science

Numeracy is a fundamental component of learning across all areas of the curriculum. The development and enhancement of students’ numeracy skills and understanding is the responsibility of teachers across different learning areas that make specific demands on student numeracy.

The essential content of the *Science Years 7–10 Syllabus* provides opportunities for students to:

- make accurate measurements using a range of appropriate technologies and an appropriate number of trials
- record and organise data in tables or diagrams using appropriate units
- construct tables and graphs to clearly and succinctly present information and relationships
- apply mathematical procedures to calculations required in scientific investigations
- extract information from column graphs, histograms, divided bar and sector graphs, line graphs, composite graphs and flow diagrams
- express mathematical relationships by using symbols and the appropriate units for physical quantities.

The syllabus identifies numerous relationships for which students develop a qualitative understanding. Additional content provides further opportunities for students to broaden and deepen their quantitative understanding of these relationships.

The Data strand of the *Mathematics Years 7–10 Syllabus* extends from Early Stage 1 to Stage 5 and includes the collection, organisation, display and analysis of data.

Stage 4 students construct and interpret line, sector, travel, step and conversion graphs, dot plots, stem-and-leaf plots, divided bar graphs, frequency tables and histograms. In analysing data, they consider both discrete and continuous variables, sampling versus census, prediction and possible misrepresentation of data, and calculation of the mean, mode, median and range.

Stage 5 students communicate mathematical ideas using appropriate mathematical language and use algebraic, statistical and other notations and conventions in written, oral or graphical form. On the number plane they draw and interpret graphs of straight lines, simple parabolas, hyperbolas and graphs of physical phenomena. Formulae are used to find distance, gradient and midpoint.

References


National Science Foundation 2008, *Women, minorities and persons with disabilities in science and engineering*. Division of Science Resources Statistics (SRS), Virginia, NC.


Chapter 6

Assessment in Science

6.1 Developing an effective assessment program ..............................................................118
6.2 Determining School Certificate grades .................................................................120
6.1 Developing an effective assessment program

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

- assisting student learning
- providing information on student learning and progress in a course in relation to syllabus outcomes
- evaluating and improving teaching and learning programs
- providing evidence of satisfactory completion of the course
- reporting on the achievement by each student at the end of the course.

Establishing a science assessment program should occur during the planning and developing of units of work. By incorporating assessment activities into the units of work, the needs, interests and abilities of the students at the school can be met, while assessing their progress towards demonstration of achievement in relation to syllabus outcomes.

The outcomes of the Science Years 7–10 Syllabus specify the knowledge, understanding and skills expected to be learned by students as a result of studying the course. These outcomes are central to the decisions teachers make about planning and adjusting the learning program and assessing, monitoring and reporting student progress.

In a school assessment program the following need to be considered:

- a range of types of strategies appropriate to the outcomes being assessed
- an appropriate number of activities to achieve a balance between obtaining sufficient information and over-assessing
- a variety of activities so that students are given opportunities to demonstrate their level of achievement of outcomes
- valid and reliable activities provide accurate information on each student’s achievement
- informing students of the syllabus outcomes addressed and the criteria for assessing learning in each activity
- measuring student achievement in relation to syllabus outcomes
- recording observations in a manageable way using appropriate methods (eg visual representations, grades, marks or comments)
- providing meaningful feedback to students about what they are able to do and what they need to do to assist their learning and improve their level of performance.

An effective assessment program includes assessment for learning and assessment of learning activities. Both forms of assessment are essential and will overlap, but in order to enhance teaching and improve learning, greater attention needs to be paid to assessment for learning.

**Principles of assessment for learning**

The Science Years 7–10 Advice on Programming and Assessment provides guidance on incorporating the principles of assessment for learning into a school learning/teaching program. These principles can also be used to make judgements about the quality of assessment activities and practices.
Assessment for learning:
• emphasises the interactions between learning and manageable assessment strategies that promote learning
• clearly expresses for the student and teacher the goals of the learning activity
• reflects a view of learning in which assessment helps students learn better, rather than just achieve a better mark
• provides ways for students to use feedback to assist their learning
• helps students take responsibility for their own learning
• is inclusive of all learners.

Details of how these principles can be translated into practice are found in the *Science Years 7–10 Syllabus*, pages 70–71, with suggested examples of strategies that may be used in an assessment program. The table *Examples of Science Assessment Strategies and Activities* identifies for these strategies some examples of activities that could be used to gather information about student learning. Other strategies for assessing student learning could include informal teacher observation, questioning and interviews.

Assessment for learning should be an integral part of each unit of work. The activities used to gather evidence of learning should be designed to focus on outcomes and show a clear relationship to the syllabus content. A variety of types of strategies should be used to give students the opportunity to demonstrate outcomes in different ways and to improve the validity and reliability of the assessment. They should be used to support student learning and to provide feedback to students that enable them to actively monitor and evaluate their own learning.

The feedback that students receive from completing assessment activities will help teachers and students decide whether the student is ready for the next phase of learning or whether they need further learning experiences to consolidate their knowledge, understanding and skills. Feedback on assessment activities should be:
• provided in a timely manner
• linked to the specific outcomes and marking criteria addressed
• meaningful, constructive and provide students with an indication of their performance relative to the outcomes being assessed and their general progress.

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.

**Developing an assessment plan for each year**

The Board of Studies *K–10 Curriculum Framework* is a standards-referenced framework that describes through the syllabuses and other documents the expected learning outcomes for students. 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 a unit, course, year or stage schools may wish to report differentially on the levels of knowledge, understanding and skills demonstrated by students.
This information is also available for the teacher to use in making judgements about the student’s achievement relative to the outcomes being assessed and, where appropriate, the performance descriptors. 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.

An assessment plan reflecting the school’s organisation of the course is developed to show where assessment of learning tasks are scheduled throughout the year. Within the assessment plan it is necessary to establish an appropriate balance in the range of outcomes and content being assessed and in the selection of types of assessment strategies to be included. It is important that students not be over-assessed.

The Sample Year 10 Assessment Plan provides an example of a range of tasks that could address the requirements of the Year 10 Science course. The elements identified in this assessment plan include:

- the scheduled timing/date of each task
- an appropriate number (4) and range of types of tasks
- the outcomes assessed by each task
- a balance between the assessment of knowledge/understanding and skills outcomes (values and attitudes are not assessed)
- the areas for assessment (derived from the course objectives and developed to group outcomes into a manageable form).

In developing their assessment plans, schools may choose to use or adapt the proforma style and the types of tasks suggested. No one type of assessment strategy alone is adequate, as not all strategies will be applicable to a given outcome. It should be emphasised that:

- a single assessment task need not attempt to assess all the outcomes associated with an objective, nor all the content statements associated with an outcome
- the same outcomes may be assessed in different ways in different assessment tasks
- a variety of outcomes may be assessed by using one assessment task.

In a standards-referenced approach the sample model for evaluating assessment tasks could be used to check that the essential features in designing and marking the task, and feedback to students, have been addressed.

### 6.2 Determining School Certificate grades

During the course teachers collect information on the achievement of each student. The range of strategies selected should provide opportunities to integrate a broader range of knowledge, understanding and skill outcomes that may not be able to be covered by the external examination. The assessment tasks should reflect the relative emphasis that the school’s learning program places on the various aspects of the course. Greater weighting for grading purposes would generally be given to those tasks undertaken towards the end of the course.

Assessment in the course should relate to the stated objectives and outcomes as described in the syllabus. No specific allocation of marks is required for any syllabus objectives or outcomes. For the purpose of grading for the award of the School Certificate, assessment of values and attitudes must not be included.
The *Stage 5 Science Course Performance Descriptors* are used to determine School Certificate grades for Science. The descriptors have been developed from the Board’s general performance descriptors, and provide a more complete description of typical performance in the Science course at each grade level. The areas for assessment for Science are derived from the course objectives. They may be used as a framework for structuring the assessment plan and as organisers for assessment and reporting student achievement.

Teachers should interpret the Course Performance Descriptors in terms of standards that can be achieved by School Certificate students within the bounds of the course. The samples of student work that are provided on the *Assessment Resource Centre* website clarify the standards described in the Course Performance Descriptors. They illustrate the quality of work typically produced by students receiving each grade and will assist teachers in reporting student achievement.

Teachers should follow their school’s procedures for the allocation of School Certificate grades. To allocate a grade to a student at the end of the course, teachers make a judgement as to which grade descriptor best describes the achievement of that student. It is not intended that the Course Performance Descriptors represent a checklist, or provide a comprehensive description of student performance at each grade level.

Teachers should use their professional judgement in applying the Course Performance Descriptors. It is important that the determination of a grade is based on the student’s achievement relative to the Course Performance Descriptors and not any predetermined distribution of grades. There are many suitable models that schools may consider appropriate to supporting teacher judgement. Two possible approaches are available through the link *arc.boardofstudies.nsw.edu.au/go/sc/sc-grading*

The *Assessment Certification and Examination (ACE) Manual* contains further information relating to application of the Course Performance Descriptors, and assessment, grading and reporting on student achievement.
## Appendices

### Appendix 1.1
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Appendix 1.1  Further reading and research


Appendix 2.1 Sample content page

**Outcome 4.3:** A student identifies areas of everyday life that have been affected by scientific developments.

**Outcome 5.3:** A student evaluates the impact of applications of science on society and the environment.

### Essential content

<table>
<thead>
<tr>
<th>Students learn about:</th>
<th>Students learn to:</th>
</tr>
</thead>
</table>
| 4/5.3 the applications and uses of science | a) identify and describe examples of scientific concepts and principles that have been used in technological developments (including Australian examples)  
   b) discuss, using examples, the positive and negative impacts of applications of recent developments in science  
   c) identify and describe examples where technological advances have impacted on science  
   d) give reasons why society should support scientific research. |

### Stage 5

**Outcome 5.6:** A student applies models, theories and laws to situations involving energy, force and motion.

### Essential content

<table>
<thead>
<tr>
<th>Students learn about:</th>
<th>Students learn to:</th>
</tr>
</thead>
</table>
| 5.6.1 the wave model | a) identify waves as carriers of energy  
   b) qualitatively describe features of waves including frequency, wavelength and speed  
   c) give examples of different types of radiation that make up the electromagnetic spectrum and identify some of their uses. |

Additiona content is not prerequisite knowledge for following stages but may be used to broaden and deepen students’ knowledge, understanding and skills in Stage 4 and/or Stage 5.

### Wave model

- discuss similarities and differences between transverse and longitudinal wave models  
- relate the speed of light and the speed of sound to frequency and wavelength  
- compare different types of radiation making up the electromagnetic spectrum in terms of frequency, wavelength and energy  
- design and describe ways of enabling or impeding energy transfer by waves  
- describe quantitatively features of waves including frequency, wavelength and speed using $v = f\lambda$.

**Outcome 5.12:** A student relates the interactions involved in using some common technologies to their underlying scientific principles.

### Essential content

<table>
<thead>
<tr>
<th>Students learn about:</th>
<th>Students learn to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.12 technology</td>
<td>a) describe some everyday uses and effects of electromagnetic radiation, including applications in communications technology.</td>
</tr>
</tbody>
</table>
### Science Years 7–10 Support Document 2009 – Appendices

| Outcome 4.14: | A student follows a sequence of instructions to undertake a first-hand investigation. |
| Outcome 5.14: | A student undertakes first-hand investigations independently with safety and competence. |

#### Essential content

<table>
<thead>
<tr>
<th>Students learn about:</th>
<th>Students learn to:</th>
</tr>
</thead>
</table>
| 4/5.14 performing first-hand investigations | a) follow the planned procedure when performing an investigation  
                                           c) safely and efficiently construct, assemble and manipulate identified equipment  
                                           d) record data using the appropriate units.  |

| Outcome 4.18: | A student, with guidance, presents information to an audience to achieve a particular purpose. |
| Outcome 5.18: | A student selects and uses appropriate forms of communication to present information to an audience. |

#### Essential content

<table>
<thead>
<tr>
<th>Students learn about:</th>
<th>Students learn to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/5.18 presenting information</td>
<td>e) use drawings, diagrams, graphs, tables, databases, spreadsheets and flow charts to show relationships and present information clearly and/or succinctly.</td>
</tr>
</tbody>
</table>

Teachers will select the appropriate Essential content to achieve the relevant Stage 4 or 5 skills outcome.
Appendix 2.2 Background to contexts

The three major elements of content in the *Science 7–10 Syllabus* are Contexts, Prescribed Focus Areas and Domain. It is a syllabus requirement that each unit of work in the school learning program must contain content related to all three elements, including contexts.

Contexts are the framework that teachers devise to assist their students to make meaning of the syllabus knowledge, understanding, skills, values and attitudes. Teachers have the flexibility to select a range of contexts that will best meet the personal and societal interests and cultural backgrounds of their students. The syllabus does not specify contexts, because the choice of these will depend upon the societal context of the students.

Contexts are culturally bound and therefore communicate meanings that are culturally shaped or defined. Contexts draw on the framework of society in reflecting all aspects of everyday life. In the course of participating in these contexts, students learn various aspects of the everyday knowledge of the culture. How people react to new situations is determined by who they are – the sum of their past experiences, background influences and future aspirations. Aspects such as personality, gender, religious background and socioeconomic factors affect people’s interpretations of and opinions about unfamiliar material.

There is potential for conflict when students’ social values, world views, cultural background (including language) and everyday knowledge differ from those conveyed in school science. If shifts in science understanding are to be successful, it is important that students’ initial contacts with science do not challenge all aspects of their cultural background as well as their science preconceptions. For this reason, consideration of the culture of local and school community should be central to the decisions made on the broad or general contexts selected for the units of work in the teaching program.

It is important to recognise that what happens in the Science classroom will be influenced by the differing cultural values and attitudes that students bring with them. The student’s ‘comfort zone’ in terms of social order and intellectual development should be a major determinant in the choice of contexts. The general context for each unit of work should be congruent with the values, interests and social meanings of the students’ cultural background. It should allow interactions between student’s personal and societal interests and their understanding of science. Students then are more likely to achieve deeper understanding about their science learning which will strengthen their awareness of the context itself.
Current research has suggested that a powerful strategy for assisting students to make links between their learning in science and the society in which they live is by developing their understanding of science concepts and ideas within a network of contexts. Within the broad or general context selected by the teacher for the unit of work students would have the flexibility to identify relevant aspects of the context of interest to them. Different teams or groups in the class would be developing their understanding of the science knowledge, understanding and skills outcomes and content targeted in the unit in relation to different aspects of the general context.

It may well be that, within a school, cohort and/or a peer group, it is appropriate to choose different general contexts given the requirements of the students involved. Within the broad context of the unit of work the science concepts and ideas are developed within a network of related contexts. In consolidating the unit teachers would support the students in recognising that the science content they are trying to understand is relevant to a greater number of situations than just in the immediate aspect of the context they considered. Through the network of contexts students gain a greater awareness of the general context and how their increased science understanding relates to their life world.

Student interest, self-esteem, achievement and empowerment can be enhanced by a cultural approach to the selection of contexts in the school learning and assessment program. The selection of appropriate contexts in which to present the knowledge and understandings, skills and values and attitudes of the syllabus should empower students to make connections between the real-world of their everyday lives and the science ideas, concepts and principles explored in the classroom. In doing this, students will be encouraged to see relevance of their learning in science, move away from a concentration on their immediate environment and encouraged to begin to address those aspects of science which impact on the broader society.

Students’ experiential environments are not compartmentalised into the different branches of science. For this reason it is conducive to learning to choose general contexts that will draw on knowledge from across the branches of science and will enable students to relate their understanding to real-life situations in their life world. An understanding of the social and cultural contexts of science provides a basis for students to make informed future choices and ethical decisions about the local and global applications and implications of scientific research and technological developments.

In current major national and international science education reform documents there is advocacy for the development of students’ scientific capabilities as a key goal of all students’ experiences in school science (Connor 2007). This goal imposes a number of competing societal demands on science education (Fensham 1988, cited in Gough 1993), including:

- **Political:** A study of science can be expected to increase each student’s awareness of the issues which can impact on society and provide the student with skills to research and investigate science-related issues affecting society. A scientifically literate person would be more likely to engage in debate about decisions being made which can affect society as a whole. Contexts that increase scientific literacy will allow students to practise identifying and debating issues with a scientific basis that need to be addressed by society.

- **Economic:** A study of science can be expected to have an impact on the economic welfare of a society. Increases in conceptual knowledge and understanding and the subsequent spin-offs in technology can be at the heart of our nation’s intellectual and
economic wealth, as well as providing possible solutions to environmental issues. For this reason, contexts for increasing conceptual meanings should encourage all students capable of further and deeper engagement with science to achieve their potential.

- **Subject maintenance:** A study of science can be expected to increase each student’s bank of science knowledge and skills and their understanding about science. Conceptual development is integral to science education. Our society expects that the national bank of knowledge will continue to increase as a result of science education. Contexts that increase conceptual meaning will improve this subject maintenance by expanding students’ knowledge beyond basic concepts.

- **Cultural:** A study of science can be expected to provide a different view of the world and allow a broader interpretation of it. This may lead to a change in the ways that people view each other, society and the environment. Increases in science knowledge and technologies can and do impact on the cultural directions of society. Contexts that increase motivation would be expected to encourage a greater number of students to remain interested and involved in science.

- **Social:** A study of Science can be expected to highlight the ways in which our society has been and continues to be influenced by scientific advances. These advances affect the directions our society takes and the decisions made by society. Social transformations through science education can result in a questioning and re-evaluation of societal values, perspectives and beliefs. Contexts that increase societal and personal power will allow more members of the society to engage in debates and discussions about scientific issues that affect society.

- **Individual:** a study of science can be expected to lead individuals to grow intellectually and increase their ability to engage in society. Individuals’ own values, perspectives and beliefs can also be changed or modified as a result of science education. Contexts that increase communication skills or contexts that increase societal and personal power will assist more individuals to participate in society.

By choosing contexts relevant to the student’s life worlds and providing the opportunity for them to explore complex issues of cultural and social significance they gain a more sophisticated understanding of the nature of science and science knowledge. Conversely they also increase their understanding of the applications and impacts of science and technology in the real world and how decisions relating to these involve balancing the issue of constraints, consequences and risk.

The *Science Years 7–10 Syllabus* identifies that the contexts selected in the learning/teaching program could be used to enhance one or more of the following:

- motivation
- conceptual meaning
- communication skills
- scientific literacy
- personal and societal power.

**Increasing motivation**

Research indicates that many students favour issues and contexts with immediate relevance rather than those related to their possible future experiences. The real-life contexts that are
relevant to and interest secondary students vary with age, gender, socioeconomic groups and cultural background.

Contexts should include those that demonstrate science as a human endeavour which is influenced by and has impacts on society. Science knowledge and practice has a rich history. Scientific and technological ideas may develop over long periods of time, either in small increments or through a number of isolated advancements. Students should be made aware of the importance of curiosity, creativity, observation, perseverance and reflection on these periodic advancements. Teachers should consider contexts that highlight examples of, and allow students to practise, the combination of these attitudes at play in situations in their everyday lives.

As an ever-evolving field of human endeavour, science is dynamic. Science is rarely done in isolation, with scientists forming learning communities that may be highly specific or generalised. In many cases, ideas are built not only upon collaboration but also in competition between scientists. How ideas gain acceptance within the scientific community often reflects the personal and professional tensions between scientists and within scientific communities. Contexts which show science as dynamic demonstrate the human dimension of the scientific endeavour and have been shown to be effective in increasing student understanding and motivation for learning about science and their awareness of its connections to their own lives.

Choosing contexts that enable students to focus on science inquiry and provide them with opportunities to participate in the design of their own learning experiences can be effective in increasing and maintaining motivation. In these hands-on practical experiences students should be actively engaged in creative problem-solving processes in which they pose their own questions, plan and conduct the investigations, collect and analyse evidence and communicate their understanding. Where the students are involved in the design of all or part of the unit the teacher must have a clear overview of the intended targeted outcomes. Students may be given the freedom to identify the aspects of the context and steer the content in the direction of their choice. The teacher’s role is pivotal in facilitating the learning process to enhance students’ capabilities of learning how to learn science through inquiry and how the science knowledge and processes are applicable to situations in their everyday lives.

**Increasing conceptual meaning**

Students arrive at school with an enormous amount of knowledge gained from their observations of the natural and made environments, the media, internet, family members and peers – all of which helps to shape their thinking (Willison 1996). Often students will have strongly held ideas about phenomena that are quite different from the accepted scientific concepts and principles. Even when a variety of teaching strategies are employed within the learning program, changes do not necessarily occur in these alternative conceptions held by the student.

Contexts can be chosen that will assist students to develop conceptual meaning. Students develop a greater understanding of the many concepts used in science if they can easily make connections between the things they are already familiar with (the known) and the knowledge and understanding being presented (the unknown). The importance of making links in learning a highly conceptualised subject such as science cannot be overstated.
Successful science learning is characterised by the provision of learning/teaching environments that assist students to make these links; students are then able to recognise their interplay in the situations in their lives in which science is involved. It is important to construct conceptual understanding in science by resolving discrepancies between students’ experiences and observations and the explanations in appropriate contexts where the conceptual links are obvious.

Providing contexts to enhance conceptual meaning increases the opportunities they have of recognising that the concepts they are trying to understand are relevant to a greater number of situations than those immediately apparent to them. Using contexts as a means of making links either between other scientific concepts or real-life situations assists students to develop networks of concepts within networks of contexts, thus reinforcing and deepening their learning.

**Increasing communication skills**

For students to communicate scientific information appropriately and effectively, they need experience of the wide variety of texts used in science. Students should be provided with teacher modelling and scaffolds to assist them in developing their skills in speaking, listening, reading, writing, viewing and responding in science. Opportunities are needed for students to experiment with the construction and presentation of oral, written and visual materials to achieve a range of purposes, including communicating their understanding of science.

Being scientifically literate means that students can apply their knowledge of scientific concepts and processes to the evaluation of issues and problems that may arise and to the decisions that they make in their daily life, about the natural world and changes made to it through human activity. Scientific literacy will include a critical understanding of scientific language and the types of texts involved in learning and communicating science. It will also involve the ability to use these communication skills and the procedures of science in their life away from school and study.

Within the contexts of all units of work, opportunities should be provided for students to develop competence and confidence in the use of scientific language. Across the science learning/teaching program there should be a variety of experiences in different contexts for students to learn, practise and acquire a level of facility with the language of science. There is a need for the negotiation of meanings of ideas and words between students and their peers as well as with their teachers (Prawat 1989 quoted in Willison 1996). Students need to become familiar with the structure and rules, and the more formal definitions, symbolic expressions and conventions used in scientific communication.

The *Science Years 7–10 Syllabus* requires students to use drawings, diagrams, graphs, tables, databases, spreadsheets and flow charts to show relationships and present information clearly and succinctly. Through undertaking hands-on practical experiences based on the cross-curriculum content embedded in the syllabus, students develop skills in using a range of Information and Communication Technologies (ICT) to communicate data, information and their scientific understanding. Students should gain an awareness of the influence and impact on their everyday lives and, in modern society, of the increasing demand for confidence and competence in literacy, numeracy and ICT.
**Increasing scientific literacy**

Scientific literacy is identified as an overall aim or general purpose of science education (Bybee 1997). While the term ‘scientific literacy’ is well established in science education literature there are a range of conceptions that cause confusion in the wider community which create problems with its definition. Scientific literacy is best understood as a multi-dimensional continuum with ‘true’ scientific literacy only after long-term experiences throughout the compulsory years of schooling and beyond (Connor 2007). It is proposed that the long-term goal of science education should be in developing all students’ scientific capabilities.

These capabilities relate to the students’ use of scientific knowledge and processes to understand the world around them and to participate in making informed decisions that affect it (Thomson & De Bortoli 2008). The choice and range of contexts in the Stage 4 and 5 learning program should enhance the opportunities for students to engage in a variety of learning experiences that develop their science capabilities. A student-centred approach (Goodrum et al 2001) that is set in contexts relevant to students’ lifeworld in which they are actively and meaningfully engaged in learning to develop the scientific capabilities needed for them to willingly engage with science ideas and science-related issues as reflective citizens.

Contexts should be chosen to develop students’ scientific capabilities by providing opportunities for them to engage in the recognition and construction of scientific questions and to build confidence and competence in evaluating evidence, drawing conclusions and in communicating their scientific understanding to a variety of audiences. Students’ understanding of the nature and practice of science helps them to be questioning of claims made by others about scientific issues that impact on society. They should be able to evaluate information presented from a variety of sources including popular media and make informed decisions about the implications for society.

Scientific literacy is inclusive of both increased conceptual knowledge and attitudes towards learning and dealing with contrary views. It must help individuals to deal with the difficult challenge of relating scientific and technical knowledge to personal and societal values. It should allow people to make thoughtful decisions and have civil discussions with those who challenge commonly held viewpoints. Students need to learn how to make observations and pose questions that are the substance of science. They must also learn to do this ethically and with respect to the limitations of knowledge and the boundaries of science and a sense of the social, cultural and ethical implications of science and technology.

**Increasing personal and societal power**

Science education can be a process that increases personal and social development as well as developing the knowledge, skills and values of science. Without a socially critical orientation, schools do not educate; they only train students to participate in the given structures of society (Kemmis, Cole & Suggett 1983 cited in Gough 1993). A socially critical orientation would include:

- treating education as the process of reflection on the physical, intellectual and social world
- attempting to help students and communities to understand the structures and values of our society, and to evaluate them
- concerning itself with critical understanding, critical evaluation and informed commitment to the improvement of society.
In order to understand scientific concepts that are presented in a particular context, students’ knowledge and understanding about other aspects of the context may need to be further developed. This increases their confidence when they are discussing aspects of the situation compared to others who did not encounter that context in their science course. Practice in engaging in classroom debate about issues of science and technology that impact on society and individuals will assist students to develop skills that can be transferred to other instances of the same nature outside the classroom. For this reason, contexts should include those that impinge on societal issues, some of these are suggested by the Prescribed Focus Area – Implications for Society and the Environment.

Science education can be a process that increases personal and social development as well as developing the knowledge, skills and values of science. Given the explosion in scientific knowledge over the past twenty years, the ethics and social responsibilities of scientists and the appropriate use of scientific knowledge have begun to be questioned by society. Science teachers should have a key role to play in the intellectual and scientific education of students in the area of controversial issues and could play a significant role in assisting students in rational decision-making (White 1992; Van Rooy 1994). Practice in engaging in classroom debate about issues of science and technology that impact on society and individuals will assist students to develop the skills that can be transferred to other instances of the same nature outside the classroom. These skills include reflection on, critical understanding and evaluation of, and increased confidence in discussing aspects of the physical, intellectual and social world.

References

Bybee, R 1997, Achieving Scientific Literacy: From Purpose to Practices, Heinemann, Portsmouth NH.


**Further reading**


Appendix 2.3  Background to Prescribed Focus Areas

In the *Science Years 7–10 Syllabus* the Prescribed Focus Areas (PFAs) outcomes and content describe the emphases that are to be applied to learning/teaching in each of the units of work in the school program. It is a requirement of the *Science Years 7–10 Syllabus* that each year all of the following Prescribed Focus Areas must be addressed:

- history of science
- the nature and practice of science
- applications and uses of science
- implications for society and the environment
- current issues, research and development.

Each unit of work must include some essential content from at least one of the PFAs. While the syllabus provides PFA outcomes for each stage, the essential content is not stage-specific. For each unit of work teachers will select the appropriate PFA content to achieve the relevant Stage 4 and Stage 5 outcomes. The PFA content must not be taught in isolation; it must be clearly related to the concepts, ideas and understanding in the syllabus. Particular PFA essential content will be suitably addressed by the choice of appropriate contexts.

Students’ learning in science should be centred on their active participation in a range of types of hands-on practical experiences. Through their investigations of a range of issues relevant to their everyday lives in terms of historical connotations, impacts and applications of science and current research, students gain an understanding of science as a human endeavour that is responsive to and impacted on by social and cultural influences. By engaging in science inquiry students learn about and develop their understanding of scientific procedures, the nature and practice of science and its extension into relevant, real-life situations in their lives.

All PFAs contribute to the development of students’ understanding of science as a human endeavour. In the *Science Years 7–10 Syllabus* aspects of the nature and practice of science are threaded throughout the content of all of the PFAs. Through these different curriculum emphases, students’ understanding of science as an ever-developing body of knowledge, the provisional nature of scientific explanations and the complex relationship between evidence and ideas is increased.

Science understanding requires students to select and integrate relevant science knowledge and skills in ways that explain and predict other natural phenomena and to apply it to new situations and events (National Research Council 1996). The PFAs enable teachers to develop units of work that better balance the knowledge of science (concepts, explanations and theories) with more human-orientated science learning that has personal value and relevance to student’s interests, lifeworlds and future aspirations. As future citizens these students need to value and appreciate science and its achievements if they are to be able to make informed decisions about the environment and their health and wellbeing.

Each unit of work developed by teachers must, within an appropriate context(s) for their students, integrate selected skill, knowledge and understanding essential content including that from one or more PFAs. The PFAs provide the scope for teachers to make clear links in the learning experiences to the syllabus values and attitude outcomes. The *Science Years 7–10 Advice on Programming and Planning* suggests examples of some additional values and attitudes content that may be used to assist students to work towards achieving these outcomes.
The history of science

Knowledge of the historical background is important for an adequate understanding of science. In Years 7–10, students should develop an understanding of:

• the developmental nature of scientific knowledge and processes
• the part that science has played in shaping society
• how science has been influenced and constrained by societies.

In Years 7–10 students should gain an understanding of the development of some scientific ideas, the people that created them and how these ideas influenced and impacted on society. Many of the outstanding achievements in the history of science grew out of the struggles and successes of individual scientists who were seeking to make sense of the world. It inevitably takes place within a broad historical, social and cultural context, which gives substance, direction, and ultimately meaning to the work of individual scientists. Learning experiences should highlight for students that science has advanced through, and is open to, the contribution of many different people from different cultures at different times in history.

This PFA provides opportunities for students to develop their understanding that scientific ideas and theories are evidence-based but tentative in nature, as they are open to scrutiny by the science community. As a result of new evidence and improved understanding resulting from new technologies and/or changing perspectives these ideas, explanations and hypotheses may be accepted, modified or rejected. It may be the case that through this process the development of scientific ideas may continue over long periods of time. The complementary roles in society of science and technology and how developments in these have changed people’s understanding of the world are also considered in this PFA.

Central to this PFA is the recognition that, while science seeks knowledge and understanding of the world, it is always embedded in the culture of the times and its development is impacted on by societal, religious and ethical values. Scientists, scientific research and its applications are influenced and constrained by these values in societies. As the culture and values of societies change over time, so in turn scientific ideas and theories may gain or lose acceptance. Students should be given opportunities to consider social and ethical questions in relation to the scientific evidence relevant to social and environmental issues and discuss examples of how this may be used or weighed differently by different cultures and societal groups. This can also illustrate that knowledge (scientific or otherwise) is not value-free, and strengthen students’ capabilities and their commitment to exploring the ethical dimensions of science.

The history of science may be presented in a variety of ways. Storytelling and the use of narrative is one approach that has a strong research base in its impact on student engagement with and understanding of science. An effective narrative is more than a simple biography of a scientist or description of the development of an invention. In choosing a narrative teachers could begin with major historical events or periods in which science and scientists had a significant impact. The role of science may not be immediately evident to the students and the more effective narratives are those that allow the teacher to ‘reveal’ the science concepts at work. Investigating the historical and social contexts of scientists’ work introduces students to the complex interaction between human behaviour and scientific endeavour.
The nature and practice of science

In Years 7–10 the study of science should enable students to participate in science activities and develop an understanding of the nature and practice of science, including the importance of creativity, intuition, logic and objectivity. Students should gain an understanding of the nature of scientific explanations, their provisional character, the development of ideal cases from phenomena and the complex relationship between:

- the study of science for its own sake and the value of curiosity-driven research
- existing scientific views and evidence supporting these
- the processes and methods of exploring, generating, testing and relating ideas
- the stimulation provided by technological advances and the constraints imposed by the limitations of current technology, which necessitates the development of the required technology and technological advances.

In the Science Years 7–10 Syllabus this PFA identifies the ideas central to understanding the nature and practice of science; however, aspects of the nature of science relevant to the focus of each of the PFAs are included in their essential content. Further consideration of some of the research background is provided at the end of the section to assist teachers to review and extend their own understanding about this PFA.

Much research has focused on the nature and practice of science. Lucas (1997) stressed that anyone teaching science inevitably gives students a view about the nature of science even if they are not overtly including this as part of the curriculum. There is no universal agreement on what precisely constitutes the nature of science. Popper (1972) identified the scientific process as beginning when people are prepared to seriously test their beliefs against observational evidence; the scientific temper is one that seeks to falsify beliefs, hypotheses and theories. In contrast, Kuhn (1970) proposed that the nature of science is captured in the scientist’s decision to work within existing paradigms. Theories are not so much subjected to tests but are used to solve problems. The overthrow of engrained theories is ‘revolutionary’ science and is a rare event. Laudan (1977) sees science operating within a conceptual framework that focuses on solving problems. The difficulty in identifying a universal framework for the nature and practice of science is that different sciences work in different ways, some more experimental, others more observational, with the methods and methodologies of the sciences changing over time.

One thing common to much scientific practice is the use of the Hypothetico-Deductive Method. Scientists develop hypotheses about their field, they deduce observational consequences from the hypotheses, in conjunction with statements of initial conditions, and then experimentally, or otherwise, test to see if the consequences are true in nature. If the predicted observations occur, then the hypothesis is confirmed; if they do not occur then either the hypothesis has to be modified or assumptions about existing conditions that are coupled with the hypothesis in order to generate the predictions have to be modified.

The nature of science demands that scientists be sceptical and questioning. Science does not just accept that something works or happens in a particular way; rather the scientist attempts to answer the question ‘Why?’ with the objective of confirming or increasing their knowledge and/or developing new understanding. Science and scientists operate in a particular frame of meaning.

Students need to be introduced to the science frame of meaning, to the ways in which it differs from the everyday frame of meaning and to the processes and methods of science.
Some learning strategies that may assist students to achieve this could include experiences in which they:

- identify where scientific knowledge serves purposes that differ from those served by everyday knowledge
- explore how the scientific way of gaining knowledge can differ markedly from that adopted in everyday life
- analyse how a scientific interpretation of a problem may differ dramatically from an everyday interpretation
- practise monitoring their own thinking so that they are aware of the frame in which they are operating
- compare the different ways of knowing as conceptual development occurs.

To help them make sense of the scientific enterprise, learning experiences should be authentic and explore questions and/or problems raised by the students. Through their observation, investigations and conversation with others, students seek to not only find the answers and/or solutions but also develop their understanding of the procedures of scientific inquiry and the purpose and use of scientific explanations. The teacher’s major role would be to model and encourage the methods of interrogating one’s own understanding, as the students will not be sophisticated in this.

While it is possible to summarise the science frame of meaning it is not possible to describe a singular science method. The US Committee on Science, Engineering and Public Policy recognised that, throughout history, philosophers and scientists have sought to describe one systematic procedure that can be used to describe the generation of scientific knowledge (National Academy of Science 1995). The Committee indicated that the practice of science is so diverse and scientists so disparate that it was not possible to provide a single universal description of a science method. Scientists collect and analyse data, develop hypotheses, replicate and extend earlier work, communicate their results with others, review and critique the results of their peers, train and supervise associates and students, and otherwise engage in the life of the scientific community. Scientists are imaginative and yet sceptical; creative and yet critical; open to ideas yet single-minded.

The ongoing process of review and revision is critically important. It minimises the influence of individual subjectivity by requiring that research results be accepted by other scientists. It is also a powerful inducement for researchers to be critical of their own conclusions because they know that their objective must be to try to convince their ablest colleagues.

These mechanisms or methods of science do more than validate what comes to be known as scientific knowledge. They also help generate and sustain the body of experimental techniques, social conventions, and other ‘methods’ that scientists use in doing and reporting research. Some of these methods are permanent features of science; others evolve over time or vary from discipline to discipline. Because they reflect socially accepted standards in science, their application is a key element of responsible scientific practice. Sometimes it is important to distinguish the methods or techniques of science, from the methodology of science. The former are concerned with obtaining data, evidence or information; the latter is concerned with what is done with the data, with how the data bears upon theories or knowledge claims. Scientific method produces data about temperature changes over time in a certain area; scientific methodology gives the processes whereby such data can be related to different claims about global warming. Method, narrowly understood, is a practical skill; methodology embraces logical, mathematical and philosophical skills.
One goal of these processes is to facilitate the independent verification of scientific observations. Thus, many experimental techniques such as statistical tests of significance, double-blind trials, or proper phrasing of questions on surveys have been designed to minimise the influence of individual bias in research. By adhering to these techniques, researchers produce results that others can more easily reproduce, which promotes the acceptance of those results into the scientific consensus.

The fallibility of methods is a valuable reminder of the importance of scepticism in science. Scientific knowledge and scientific methods, whether old or new, must be continually scrutinised for possible errors. Such scepticism can conflict with other important features of science, such as the need for creativity and for conviction in arguing a given position. But organised and searching scepticism as well as an openness to new ideas are essential to guard against the intrusion of dogma or collective bias into scientific results.

In the *Science Years 7–10 Syllabus* active student participation in authentic scientific investigations should be at the centre of all learning units. Fensham suggests that understanding a discipline means being able to correctly use its forms of discourse. For students in Years 7–10 important discourses in relation to the nature and practice of science include: *Asking investigable questions, Describing a phenomenon, Arguing to establish a scientific claim, and Explaining macro-level behaviour by means of more micro-level ideas* (Fensham 2008, p 26). In units of work where this PFA is to be the emphasis applied to learning, students should have opportunities to practise and apply the relevant understanding and skills to develop these discourses.

**The applications and uses of science**

Setting science within a broader framework of society relevant to students’ everyday lives allows them to deal with real problems and applications. Their study of Science in Years 7–10 should increase their knowledge and understanding of:

- the relevance, usefulness and applicability of scientific concepts and principles
- the use of science in developing technological devices and systems
- the contributions of science to society, including Australian achievements.

There is a strong assumption in the community that science education must have something to do with technology and with preparing people to live in a technological society. Sometimes science and technology are related, sometimes they are not. At times science and technologies have developed independently of each other, in parallel, until someone puts them together. Sometimes the technologies have been designed because of advances in scientific knowledge. For example, before any applications were designed and made, the development of transistors was explored through investigation of p and n type semiconductors by William Shockley and others. In other instances certain technologies have been developed without the relevant scientific knowledge. If students gain an appreciation of examples of the spin-offs that may follow pure scientific research, they can engage in the continuing debate about the reasons, types and amounts of support that the community provides for scientific research.

Technology as application of science is an important aspect of this PFA. Some units of work in the school program in which this PFA emphasis is applied should provide opportunities for students to explore the relationship between science and technology and the potential interdependence of the two. In the last 25 years the most influential application of science has been the rapid development of digital technologies. Content relevant to using Information and
Communication Technologies (ICT) as a tool is embedded within the syllabus in the skills of working scientifically and should be included where appropriate across a range of units of work in the school program.

This PFA provides opportunities for students to consider future applications of scientific concepts and principles in developing technological systems and devices, including ICT. In the Domain: knowledge and understanding some of the Interactions essential content specifically requires students to learn about the uses of and interactions between the underlying scientific principles and some common technologies. In their exploration of examples of the contribution of science to society, including Australian achievements, students could consider the processes by which scientific knowledge gains acceptance and the role of creativity in how this is used or applied.

**Implications for society and the environment**

Science has an impact on our society and the environment and students need to develop an understanding of the importance of informed values and practices in relation to society and the environment. Their study of Science should enable students to develop:

- knowledge and understanding about the interrelatedness of people, their cultures and their biophysical surroundings
- skills in making decisions about issues, particularly those currently concerning society and the environment.

This PFA involves the development of ideas and opinions about the relationships between science, society and the environment. In units of work where this PFA is applied, students should be encouraged to discuss and debate scientific issues of relevance to their everyday lives. Opportunities should be provided for students to identify some social and environmental issues related to scientific developments. This would include giving examples to show that different cultures and groups in society, including Aboriginal and Indigenous people, may use scientific evidence differently in making decisions about these issues. In relation to the nature of science this PFA provides students with opportunities to distinguish between scientific, economic and legal arguments, using examples where the interrelationships between science and society are demonstrated. It requires students to gain awareness of the place of social and ethical consideration associated with the practice and applications of science.

The challenge is to highlight and celebrate the successes of science with students but at the same time expose them to the limitations of science. Students should be encouraged to seek out and examine examples of the implications of the impact of science on society and the environment and consider possible strategies for its future involvement. The role of evidence, scepticism and objectivity in decision-making, and creativity in developing new and different approaches to solving global issues, would be important considerations in relation to the nature of science in this PFA.

**Current issues, research and development in science**

In today’s society, more information is available to students than ever before about current issues, research and developments in science. Through their study of Science in Years 7–10, students should develop understanding of:

- links between classroom experiences and the world
- science as a human endeavour
• career opportunities in science and related fields
• media coverage of scientific events
• ongoing and recent developments in scientific ideas and applications, including recent Australian achievements.

The incorporation of current developments and latest research in science gives students an opportunity to investigate recent scientific contributions made by male and female scientists and the significance of their work to science and society. There is an emphasis on Australian science, to remind students that science in Australia is active and successful, and that Australian science and scientists are respected on the world stage.

Because of their potential impact, scientific discoveries and announcements are often featured in the media. The accuracy of many of the reports needs to be evaluated and this requires a sophisticated understanding of the nature of science and scientific knowledge. To develop the analytical and critical thinking skills, students need to be provided with learning experiences in which they have opportunities to practise and apply these skills in a variety of contexts.

In this PFA students should consider that decision-making in the real world in relation to current scientific research must balance issues related to risk, constraints and consequences, with the potential use and value of the research for society and the environment. Many of the current issues and areas of research today could conceivably become everyday events in the next few years. This future requires the support of scientifically and technologically informed citizens with the capabilities of actively participating in decision-making. All students need to be prepared through their study of science to have the scientific understanding and capabilities to engage as informed citizens in discussion of socio-scientific issues.

This PFA also allows students to find relationships between their developing science knowledge and understanding and their capabilities that will inform their choices for further education, training and employment. By identifying the areas where research still needs to be done and highlighting the potential benefits of these areas of research for society as a whole, students may be motivated after their school education has been completed to become informed, scientifically literate citizens with a continued lifelong interest in science and technology.

References


Further considerations about the history, nature and practice of science

The history of science

The history of science enables students to survey the development of some scientific ideas and their applications, together with evaluation of the outcomes of these applications. If students are taught only current understandings, it is hard to avoid the consequence that they will learn that there is one answer, now known and uncontroversial.

This PFA calls for not just a sanitised history of fully developed ideas, but a history of the creation of those ideas, the people who created them and their impacts on society. To achieve this it is not sufficient just to enliven factual content by bringing in some of the historical figures and their contributions. The portrayal of austere geniuses who latched with certainty onto truths hidden from lesser mortals differs markedly from the common reality and creates a mythology of scientists as different from other people. Einstein is a classic example. Many must see him as a wild-eyed, wilder-haired man of superhuman mental capacity who allegedly failed at school and did his best work as a lowly clerk. Many are unaware of his struggle with the philosophical implications of quantum mechanics or of his deep compassion and anguish at being instrumental in the setting-up of the Manhattan Project and the resultant human devastation of the atomic bomb (Jungk 1964).

Teachers need to recognise that the history of science can be presented to students in many different ways. They could consider how experimental results are of little value until they can be fitted into a framework of concepts. The history of science provides numerous examples of great scientific thinkers who had the evidence at their fingertips, but could not progress until they realised how to make sense of it. Students could consider Darwin with his observations from the voyage of the Beagle, Vine and Matthews with their seafloor magnetic data, or Franklin, Watson and Crick with copious X-ray data on DNA. No doubt the unwritten history of science contains even more examples of scientists who failed to make the connections.

This PFA emphasises to students that all the pieces of the jigsaw that go to make the answer are often present in the scientist’s mind but that these pieces may appear hopelessly jumbled, stored away in different pigeonholes, so that the need is to make connections between items of knowledge that were previously seen as unconnected. Or some of the key items may be in the form of tacit knowledge: understanding that they have in action, but which they are not able to articulate … yet. Or the conceptual block may lie elsewhere.

Very often the process for scientists is expedited by ‘thinking aloud’: discussing their thoughts with team members and others. They may or may not be experts, but their role is often to assist the scientist by pointing their thinking in the right direction. Asking the right question is critical here, as it is these questions that can clear the log jam. With few exceptions, scientific research cannot be done without drawing on the work of others or collaborating with others.

The nature and practice of science

The research reviewed (Matthews 1994, Brown 1998) identifies a number of reasons for the inclusion of the nature of science in school science curriculum:

- it promotes a robust understanding of science
- it makes school science more authentic
• it promotes a liberal education
• it engages students in the scientific tradition.

Brown (1998) identified the difficulties in not only characterising the nature of science for students but in developing teaching and learning strategies, since no conceptual framework exists that describes such strategies. This field, called Nature of Science (NOS) studies, has been extensively researched. See for instance Russell (1981), Wagner (1983), Duschl (1985, 1988, 1990), Bybee (1991), Abd-El-Khalick and Lederman (2000) and the contributions of Flick and Lederman (2004).

While Brown (1988) recognised the difficulties in characterising the nature of science, its inclusion in the *Years 7–10 Science Syllabus* means that some of the distinguishing features of this area need to be identified. Some commonalities can be identified in the research literature to assist in developing learning/teaching programs to address this PFA.

Science and scientists operate in a particular frame of meaning. Dawson (1992, pp 19–24) compares the characteristics of the everyday and scientific frames of meaning:

<table>
<thead>
<tr>
<th>Everyday Frame</th>
<th>Scientific Frame</th>
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</thead>
<tbody>
<tr>
<td>STATUS OF KNOWLEDGE</td>
<td>Knowledge is seen as:</td>
</tr>
<tr>
<td>• Knowledge relates to performing successful actions in familiar situations: not highly articulated or generalised.</td>
<td>• Knowledge is highly articulated, generalisable and abstract.</td>
</tr>
<tr>
<td>• Knowledge is seen as:</td>
<td>• Exists in a framework of mild to strong scepticism.</td>
</tr>
<tr>
<td>– self-evident</td>
<td>• Heavy concern with problematic knowledge and its theoretical explanations.</td>
</tr>
<tr>
<td>– unproblematic</td>
<td>• Knowledge structures attempt to integrate concrete experiences and theoretical explanatory frameworks.</td>
</tr>
<tr>
<td>and is often in</td>
<td>• Knowledge is validated by replication, internal consistency, and finally by the scientific community. Ultimately depends on an assessment of the strengths of evidence-theory coherence.</td>
</tr>
<tr>
<td>– recipe form.</td>
<td>• Novelties are not only met, they are more usually deliberately created to extend and test previous knowledge claims. Aim is to understand as deeply as possible.</td>
</tr>
<tr>
<td>EXTENSION OF KNOWLEDGE</td>
<td>Knowledge is validated and revalidated in response to the pragmatic motive (whether it works) and within social interactions (does it allow easy communication?).</td>
</tr>
<tr>
<td>• Novelties (ie new situations not interpretable within a current knowledge) are attended to if they are important for planned present or future action.</td>
<td>• Understanding is directed at creating an articulated (of both experimental and theoretical aspects) body of knowledge which enables both explanation and prediction.</td>
</tr>
<tr>
<td>• Understanding is aimed only at ensuring successful future actions (pragmatic motive).</td>
<td></td>
</tr>
<tr>
<td>COGNITIVE STYLE</td>
<td>• Relatively undemanding.</td>
</tr>
<tr>
<td>• Aim is to understand sufficiently to ensure successful actions.</td>
<td>• Demanding.</td>
</tr>
</tbody>
</table>

Dawson (1992) sees quite clear distinctions between the scientific frame of meaning and the everyday frame of meaning, which students share with their friends and family. Unlike the everyday frame, knowledge in the scientific frame undergoes a formal evaluation applied by the scientific community. In discovering underlying mechanisms for phenomena the scientist seeks empirical regularities, which may ultimately lead to generalisations, theories and laws. Through this process, science aims to produce knowledge of the world by discovering generalisations and the causal mechanisms that produce them.

Science may be an imaginative and exploratory activity with the scientist imagining what might be true. This may provide the incentive for finding out, as far as possible, what is true. On the other hand the scientist may see that truth resides in Nature and is to be got at only through the evidence of the senses, with the scientist’s task essentially one of discernment. Some major science advances were not necessarily the work of objective, cooperative people who rejected a theory if it failed to concur with all of the experimental facts. Westfall (1973) discussed Newton’s deliberate manipulation of his data to make it fit the equation.

Whether the object of science is the study of science for its own sake, curiosity-driven research or to extend human knowledge of the world beyond what is already known, eventually the individual’s knowledge enters the Domain of science when they present it to others for independent judgement of its validity. This process occurs in many different ways. Researchers talk to their colleagues and supervisors in hallways, laboratories and coffee shops, at social functions, and using Information and Communication Technologies (ICT). They trade data and speculations over computer networks. They give presentations at seminars and conferences. They write up their results and send them to scientific journals, which in turn send the papers to be scrutinised by reviewers. After a paper is published or a finding is presented, it is judged by other scientists in the context of what they already know from other sources. Throughout this continuum of discussion and deliberation the ideas of individuals are collectively judged, sorted, and selectively incorporated into the consensual but ever-evolving scientific worldview. In the process, individual knowledge is gradually converted into generally accepted knowledge.

If research in a given area does not use generally accepted methods, other scientists will be less likely to accept the results. This was one of several reasons for many scientists’ reacting negatively to the initial reports of cold fusion in the late 1980s. The claims were so physically implausible that they required extraordinary proof. But the experiments were not initially presented in such a way that other investigators could corroborate or disprove them. When the experimental techniques became widely known and were replicated, belief in cold fusion quickly faded.

In some cases the methods used to arrive at scientific knowledge are not very well defined. Consider the problem of distinguishing the ‘facts’ at the forefront of a given area of science. In such circumstances experimental techniques are often pushed to the limit, the signal is difficult to separate from the noise, unknown sources of error abound, and even the question to be answered is not well defined. In such an uncertain and fluid situation, picking out relevant and reliable data from a mass of confusing and sometimes contradictory observations can be extremely difficult.

In this stage of an investigation, researchers have to be extremely clear, both to themselves and to others, about the methods, including instruments being used to gather and analyse data. Other scientists will be judging not only the validity of the data but also the validity and
accuracy of the methods used to derive those data. The development of new methods can be a controversial process, as scientists seek to determine whether a given method can serve as a reliable source of new information. If someone is not forthcoming about the procedures used to derive a new result, the validation of that result by others will be hampered.

Methods are important in science, but like scientific knowledge itself, they are not infallible. As they evolve over time, better methods supersede less powerful or less acceptable ones. Methods and scientific knowledge thus progress in parallel, with each area contributing to the other.

A good example of the fallibility of methods occurred in astronomy in the early part of the twentieth century. One of the most ardent debates in astronomy at that time concerned the nature of what were then known as spiral nebulae – diffuse pinwheels of light that powerful telescopes revealed to be quite common in the night sky. Some astronomers thought that these nebulae were spiral galaxies like the Milky Way at such great distances from the earth that individual stars could not be distinguished. Others believed that they were clouds of gas within our own galaxy.

One astronomer, Adriaan van Maanen of the Mount Wilson Observatory in California, thought that spiral nebulae were within the Milky Way and sought to resolve the issue by comparing photographs of the nebulae taken several years apart. After making a series of painstaking measurements, van Maanen announced that he had found roughly consistent unwinding motions in the nebulae. The detection of such motions indicated that the spirals had to be within the Milky Way, since motions would be impossible to detect in distant objects. Van Maanen’s reputation caused many astronomers to accept a galactic location for the nebulae. A few years later, however, van Maanen’s colleague Edwin Hubble, using the new 100-inch telescope at Mount Wilson, conclusively demonstrated that the nebulae were in fact distant galaxies; van Maanen’s observations had to be wrong. Studies of van Maanen’s procedures have not revealed any intentional misrepresentation or sources of systematic error. Rather, he was working at the limits of observational accuracy, and his expectations influenced his measurements.

Though van Maanen turned out to be wrong, he was not ethically at fault. He was using methods that were accepted by the astronomical community as the best available at the time, and his results were accepted by most astronomers. But in hindsight he relied on a technique so susceptible to observer effects that even a careful investigator could be misled.
## Appendix 2.4  Student-centred approach to context

Changes in emphasis required to teach for scientific literacy.

<table>
<thead>
<tr>
<th>Teaching for scientific literacy requires:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Less emphasis on</strong></td>
<td><strong>More emphasis on</strong></td>
<td></td>
</tr>
<tr>
<td>memorising the name and definitions of scientific terms</td>
<td>learning broader concepts than can be applied in new situations</td>
<td></td>
</tr>
<tr>
<td>covering many science topics</td>
<td>studying a few fundamental concepts</td>
<td></td>
</tr>
<tr>
<td>theoretical, abstract topics</td>
<td>content that is meaningful to the student’s experience and interest</td>
<td></td>
</tr>
<tr>
<td>presenting science by talk, text and demonstration</td>
<td>guiding students in active and extended student inquiry</td>
<td></td>
</tr>
<tr>
<td>asking for recitation of acquired knowledge</td>
<td>providing opportunities for scientific discussion among students</td>
<td></td>
</tr>
<tr>
<td>individuals completing routine assignments</td>
<td>groups working cooperatively to investigate problems or issues</td>
<td></td>
</tr>
<tr>
<td>activities that demonstrate and verify science content</td>
<td>open-ended activities that investigate relevant science questions</td>
<td></td>
</tr>
<tr>
<td>providing answers to teacher’s questions about content</td>
<td>communicating the findings of student investigations</td>
<td></td>
</tr>
<tr>
<td>science being interesting for only some students</td>
<td>science being interesting for all students</td>
<td></td>
</tr>
<tr>
<td>assessing what is easily measured</td>
<td>assessing learning outcomes that are most valued</td>
<td></td>
</tr>
<tr>
<td>assessing recall of scientific terms and facts</td>
<td>assessing understanding and its application to new situations, and skills of investigation, data analysis and communication</td>
<td></td>
</tr>
<tr>
<td>end-of-topic multiple choice tests for grading and reporting</td>
<td>ongoing assessment of work and the provision of feedback that assists learning</td>
<td></td>
</tr>
<tr>
<td>learning science mainly from textbooks provided to students</td>
<td>learning science actively by seeking understanding from multiple sources of information, including books, Internet, media reports, discussion, and hands-on investigations</td>
<td></td>
</tr>
</tbody>
</table>

Source: Goodrum et al 2001, p 168. This format and some parts of the figure are derived from the *National Science Education Standards*, National Science Council, 1996, pp 52, 100, 113. Reproduced with the permission of the National Academies Press.
Appendix 2.5 Developing contexts in learning units

In planning the units of work for the school science program for Years 7–10 the choice of contexts for a variety of purposes allows teachers to take into account the intellectual, social and emotional development of their students. The syllabus does not specify the contexts as the choice of these will depend upon teacher judgement of what best meets the students’ interests, the school and the community culture. A suggested strategy for assisting students to make links between their learning in science and the society in which they live is through developing units of work in which the science concepts and ideas are embedded within a network of related contexts. This is described in the literature as a *network of concepts within a network of contexts*.

Teachers should be mindful that a unit of work within the scope and sequence may have a principal context without being exclusive of opportunities for the teaching and learning experiences to extend into or draw on further contexts. The principal context is more than simply the name of a unit of work; this context drives the teaching and learning process, influencing the range and type of learning-teaching experiences in the classroom.

Well-chosen contexts also assist in emphasising the Prescribed Focus Area (PFA) content through which students’ understanding about science as a human endeavour and its nature and practice are developed. The Prescribed Focus Area content is not stage-specific as some aspects may involve a more gradual development of understanding in students with a basic introduction in Stage 4 in one context followed by a more in-depth treatment in Stage 5 in a similar or different context.

Contexts can be drawn from a wide range of areas and the success of the chosen context will depend upon a number of factors, including the student’s social values, world views, language and cultural background. Within the broad or general context selected by the teacher for the unit of work, students would have the flexibility to identify relevant aspects of the context that motivates and is of interest to them. As well as considering relevancy and motivation, teachers need to be aware of the supporting resources available and how these may be manipulated and developed for inclusion in the learning-teaching experiences within the program.

A variety of well-chosen contexts across the school program increases the opportunity for students to be active participants in the learning process. Through the choice of relevant and appropriate broad contexts and the associated learning experiences students’ thinking and problem-solving skills can be enhanced. Similarly, through the network of contexts within each unit of work, students increase their understanding of science concepts and how these are applied in real-world situations relevant to their lives.

**Sourcing contexts**

Within the learning unit the context provides the framework that is used to make meaning of the selected values and attitude outcomes, knowledge, understanding (including Prescribed Focus Area) and skills content. While the following examples refer specifically in many cases to the Domain: knowledge and understanding content the *Science Years 7–10 Syllabus* requires that each unit of work must include the targeted essential content selected from a range of working scientifically skills and appropriate PFAs. In planning and programming a unit of work it is essential that there is a balance in the range of content selected and that it is integrated through the learning experiences.
The local environment

Contexts derived from the local environment could include aspects of the local geographic location and/or involve local community issues. A Stage 5 unit of work developed to cover the wave model (5.6.1) may look distinctly different for a school situated on the coast compared to a school situated in an inland rural area. A teacher at a coastal school may develop a context around science concepts involved in conducting a surfing competition, whereas a teacher at an inland school may develop a context involving investigations in communication over large distances (5.12).

Past and recent geological events may also provide local-specific contexts for teachers developing a Stage 4 unit of work covering the atmosphere (4.9.4), the hydrosphere (4.9.5) and/or the lithosphere (4.9.6). Contexts could be developed involving investigations into the type and origin of local soils, Indigenous and non-Indigenous land and water management practices, weathering and erosion.

Choosing contexts based on local community issues gives teachers the opportunity to draw on businesses and local industries, community group activities and significant local events, both recent and historical. A country or regional centre may have agricultural industries involved in the trialling of genetically modified crops, providing a possible context for a Stage 5 unit which includes genes and DNA (5.8.2). Another centre may be located in proximity to a major electrical power supplier, providing the basis for a Stage 4 unit on natural resources (4.11) and technology (4.12).

The global environment

A key feature of contexts involving global events and issues is their dynamic nature. Teachers developing and utilising these contexts can modify areas of investigation to reflect new discoveries, scientific theories and debates, environmental issues and current affairs. A Stage 5 unit using sustainability for the future as the context (5.11.1, 5.11.2) could contain learning/teaching activities utilising content from current research, social and political commentary (4/5.4, 4/5.5) on scientific evidence for climatic anomalies and changes to the biosphere.

Drawing contexts from global events and issues also assists teachers in developing teaching and learning strategies that combine prescribed focus area and skill outcomes. Units of work based on the global environment may be strongly focused on content from the working scientifically skills of research and reporting (4/5.16, 4/5.17, 4/5.18) not only on the underlying science concepts but also on personal and societal impacts (4/5.3).

Student experience

The student experience encompasses both everyday experiences and the school and community culture. When considering the school culture in choosing and developing contexts, teachers may incorporate aspects of a school’s curricular and extra-curricular activities. Schools often provide a diverse range of theses activities from which contexts may be chosen and developed. A school noted for sporting achievements may use a context surrounding fitness and health when developing a unit of work covering humans (4.8.5); a school that participates in rock eisteddfods and/or theatre may use a context investigating energy concepts (4.6.3, 4.6.4, 4.6.5) and use when conducting such productions.
Contexts can also be drawn from students’ everyday exposure to popular print and multimedia entertainment. A context that involves investigating the science in fantasy stories or science fiction and/or movies could be developed for either Stage 4 or Stage 5. A Stage 4 unit may incorporate learning activities where students design a ‘superhero’ based on energy changes and forces in action (4.6) where a Stage 5 unit may have activities where students investigate the science in scenarios involving DNA (5.8.2), natural selection (5.8.3) or technology (5.12).

**Teacher experience**

Teachers, like their students, bring prior experience to the classroom which can be drawn upon to assist in the choice of context. Knowledge gained from life experiences in work, travel and recreational interests can contribute to the development of a contextual-based learning unit.

A teacher with experience in orienteering, bushwalking or rock-climbing could develop a teaching program using a context of adventure travel within Australia that may include student research and/or investigation on fabrics (4.6.6) best suited to varying climatic conditions, food requirements (4.8.4, 4.8.5) terrain mapping (4.9.6) and safety (4.10). A teacher with travel experiences may develop a context on ecotourism within or outside Australia that allows students to research and plan their own eco-tour (5.9.4, 5.10, 5.11.2, 5.12).

Choosing a context based on personal experience allows a teacher to utilise their background knowledge of real-life applications and implications of scientific concepts. In this way, a teacher’s own scientific literacy is a major contributor to the teaching program and classroom experience of the students.

**Narratives and timelines**

Storytelling and the use of narrative has a strong research base in its impact on student engagement with and understanding of science. In choosing a narrative as a context for a unit of work, teachers could begin with major historical events or periods in which science and scientists had a significant impact. The role of science may not be immediately evident to the students and the more effective narratives are those that allow the teacher to ‘reveal’ the science concepts at work.

An effective narrative is more than a simple biography of a scientist or description of the development of an invention. A Stage 4 unit developed around the history of refrigeration and/or air-conditioning (4/5.1, 4.7.1, 4.7.2, 4.7.3) could include examples of their impact on people’s personal experiences with living in harsh climates and the problems of keeping food fresh (4/5.3). A Stage 5 unit on infectious and non-infectious disease (5.8.1, 5.8.4) could include narratives on examples where scientific ideas had struggled for acceptance. Investigating the historical and social contexts of scientists’ work (4/5.1, 4/5.2) introduces students to the complex interaction between human behaviour and scientific endeavour.

Constructing timelines of scientific and technological developments can introduce students to elements of the history of science. A context with some historical focus should expand on simply listing dates and names to providing students with opportunities to make links between key science ideas and discoveries and the resultant impact on society (4/5.3).
A context for a Stage 4 unit on the Newtonian model of the solar system (4.9.1) may also have students conducting research into pre-Newtonian ideas from a number of cultures including non-Western and Indigenous (4/5.4). Using a context concerning the application of nuclear energy (5.7.1, 5.12) could include student construction of a timeline for the development of the atomic model focusing on scientists’ use of evidence to construct atomic models (4/5.2).

Science inquiry

Choosing contexts that focus on science inquiry provides opportunities for students to participate in the design of their learning experiences. This can be effective in increasing and maintaining motivation provided the unit delivers its promise. Hands-on practical experiences in which students engage in creative problem-solving processes (4/5.20, 4/5.21) where they pose their own questions, plan and conduct the investigations, collect and analyse evidence and communicate their understanding develop their understanding about scientific inquiry. Where the students are involved in the design of all or part of the unit, the teacher must have a clear overview of the intended targeted outcomes. Different teams or groups in the class would develop their understanding of the scientific knowledge, understanding and skills outcomes and content targeted in the unit in relation to different aspects of the general context.

While the students may be given the freedom to steer the content and contextual material in the direction of their choice the teacher still maintains the pivotal role in facilitating the learning process to enhance students’ capabilities to learn how to learn science through inquiry. Self-directed learning through inquiry within an aspect of the general context of the unit of work that is of interest and significance to them provides students with the opportunity to gain a deeper understanding of the scientific concepts and how these relate to their world. In consolidating the unit teachers would support the students in recognising that the science content they are trying to understand is relevant to a greater number of situations than just in the immediate aspect of the context they considered. They would also gain greater awareness and understanding of the general context and its applications and implications for society and the environment in the real world.
Appendix 3.1 Learning principles

The learning principles that underpin the Science Years 7–10 Syllabus and the K–6 Science and Technology Syllabus are listed below with their implications for learning in the Science Key Learning Area.

Students learn when they are recognised and valued as:
- individuals who learn in different ways and at different rates according to their maturity, prior understanding and membership of particular groups. Teachers can cater for the favoured learning styles of all students by employing a wide range of learning and teaching strategies. In addition teachers may take into account students’ earlier experiences which may not have included using the language, tools and equipment associated with science
- social beings with membership of various social groups which may be based on gender, ethnicity and cultural background. Teachers can encourage students to be aware of the diverse range of contributions made to science by members of all sociocultural groups. This will not only increase individual students’ self-esteem but will also promote an appreciation of other cultures and their achievements.

Effective learning takes place when students are:
- interacting with the social and physical environment
- connecting current learning experiences to their existing understanding and prior experiences
- investigating ideas, relationships and issues
- communicating by using language and other forms of communication to construct and explore meanings
- doing by active participation and first-hand experiences
- reflecting on what they have been learning and how they have been learning.

Student learning is enhanced by learning activities which are:
- purposeful in that their purpose is understood
- appropriate to personal, social and cultural qualities
- challenging to current perceptions and involving meaningful problems
- cooperative and requiring collaboration as well as individual endeavour
- rewarding in that success can be achieved by investigating, designing and making activities and their choice and use.

Learning is enhanced by learning environments which are:
- secure thus facilitating students’ initiatives and learning attempts
- caring so that students feel valued by both their teachers and peers
- supportive in the nature of the learning activities
- structured to promote the processes of investigation and to facilitate students’ use of appropriate technology
- interesting and attractive, promoting students’ curiosity and desire to understand the world around them.
The nature of the learner

Students studying science may share common characteristics including:
- curiosity and the desire to understand and interact with the world around them
- some understanding of the world around them influenced by their socio-cultural backgrounds and their cognitive development
- some experience in investigating and designing, making and using technology
- some views about how living and non-living things behave or operate.

The diversity of the learner group

As well as their common characteristics students have a number of characteristics which make them different. Each student’s life experiences make him or her unique. Each student will also belong to particular social groups based on:
- ethnicity
- language
- gender
- socioeconomic background
- culture, including religious practices and beliefs
- geographic isolation
- learning difficulties
- special talents
- specific disabilities, eg intellectual, emotional, physical or behavioural.

Each student is an individual and will belong to more than one of these groups. All students will bring to the learning situation a set of understandings, skills, values and attitudes about science which arise from their level of development in several areas including:
- physical
- sensory
- emotional
- social
- aesthetic
- cognitive.

The learning environment

What the teacher brings to the learning environment

It is very difficult to describe the diversity and subtlety which constitutes good teaching. For the Science teacher it includes facilitating growth in knowledge and understanding, skill, self-expression and development of values and beliefs (Atkin 1994).

Some people feel that an effective teacher breaks things down into steps and is well organised, while others feel it is important for teachers to show that they care about students as individuals and inspire them to do their best. Speering and Rennie (1996) in their study of students’ perceptions about science described the disenchantment that many students experience with the student–teacher relationship in the secondary school. Many students referred to the nature of their relationship with their teachers when providing reasons as to why they did or did not like science. To be effective, the leadership provided by the teacher should hold positive assumptions about students and lead to a relationship which inspires, encourages and supports students in their endeavours.
The personal attributes of teachers that influence teaching performance (Baird 1988) can be categorised as:

- **Teacher intellectual competence**
  
  Baird defines intellectual competence as comprising four main components: attitudes (including values and concerns), perceptions (including expectations), conceptions (including theories and beliefs), and abilities.

  For example, consider a classroom teacher’s intellectual competence in relation to the school’s philosophy of differentiating the curriculum. In the classroom the teacher will bring with them particular attitudes, conceptions and abilities. In this example the school defines differentiating the curriculum as providing different work to suit individual needs. The classroom teacher will hold particular attitudes to, or may adopt a particular stance to, differentiating the curriculum. These attitudes will be closely related to their perceptions of how a differentiated program would operate in their classroom. Their attitudes and perceptions both impact on, and are impacted on by, their conception of the meaning of ‘differentiated’ and ‘curriculum’ and affect their ability to develop a differentiated curriculum.

  Teachers need to take account of how their attitudes, perceptions, conceptions and abilities influence their intellectual performance as they attempt to develop and implement a differentiated curriculum.

- **Teacher intellectual performance**
  
  Intellectual performance is influenced by a teacher’s behaviour, judgements, decisions and thoughts and can impact on students in many different ways. While recognising the limitations of research in these areas, Baird (1988) acknowledged that research into interaction in the classroom has highlighted ‘the complexity of science-learning environments’ (White & Tisher 1986). Atkin (1994) stressed that teacher behaviour which indicates that the teacher believes in a student with the expectation ‘you can do it’ has the potential to inspire and encourage a student.

**What the student brings to the learning environment**

In developing effective learning experiences for their students, teachers need to take account of the ideas that students have developed. This involves seeking out information about the learning experiences that have been provided for students in previous years and identifying what ideas the students currently have about the concepts addressed in the proposed learning and teaching program.

Osborne & Freyberg (1985) and Driver et al (1994), among others, have helped to focus attention on students’ prior understandings and the significant impact these have on their learning in the science classroom. The student’s view of the world and the meanings that they have for some of the words that are commonly used in the science classroom are always incorporated into future learning. This does not always result in congruence between the teacher’s understanding of what is being presented and the student’s interpretation of what has been presented. For example, Gunstone (1988) indicates that many students bring to their science classroom the view that heavier objects fall faster. When their science courses introduce the generalisation that acceleration due to gravity is independent of weight, some students conclude that heavy and light objects, therefore, must have the same weight (Gunstone et al 1981).
Gunstone (1988) described four consistent findings of research (Driver 1985, Osborne & Freyberg 1985) into students’ ideas and/or beliefs when they come to science in Stages 4 and 5.

1. They frequently already hold explanatory views of phenomena which are often personal, idiosyncratic interpretations of their experiences that differ from the explanatory views taught in the classroom.
2. Their views can be unaffected by traditional forms of instruction.
3. Particular views can be quite common – held by a large number of students – and are consistent across groups differing in age and nationality.
4. Students may simultaneously hold the scientific view and their own conflicting view. The scientific view is used to answer questions in an assessment situation and the conflicting view used to interpret the world.

**Taking account of students’ perceptions**

Teachers can increase the possibility of influencing a student’s understanding by taking greater account of the student’s present ideas and confronting and challenging those ideas in the learning experiences that they devise.

Driver et al (1994) identified that the demand made on the students in coming to understand a particular scientific idea involves:

- extending or refining an idea they already hold
- using, in a new range of situations, a concept which has been developed in a different situation
- radically changing their ideas.

Osborne and Freyberg (1985) recognised that students are only too willing to formulate theories about why the world is as it is. They describe the task of the science teacher as one of devising situations which increase students’ abilities to test those formulated theories in order to help students to assemble the facts systematically before jumping to conclusions. The situations that teachers devise should highlight both the consistencies and inconsistencies in the students’ theories.

The *Science Years 7–10 Syllabus* provides students with opportunities to increase their understanding of a wide range of concepts for which they have developed ideas from their own experiences outside the classroom as well as those presented in learning activities from Stages 1–3. The research of Driver et al (1994) identified a number of interrelated teaching strategies that teachers in Stages 4 and 5 could draw on to provide their students with opportunities for concept development. These strategies include:

- *Broadening the range of application of a conception*

  Students bring to the classroom many prior conceptions. By broadening the scope and number of situations to which they relate a concept, these prior conceptions can be used to extend their understandings. For example, students’ ideas about energy tended to follow a sequence in their evolution from primary to secondary school science.
By identifying students’ prior ideas about energy, teachers are better able to help students move along their evolutionary sequence. Students’ awareness of some non-living things possessing energy could be extended by exploring such things as coiled springs and generalising to energy stored in elastic materials.

- **Differentiation of a conception**
  In many areas students’ conceptions can be very general and not well defined. If this is the case teachers need to design experiences which will help students to separate the various aspects of a concept. For example, many students do not initially differentiate between the weight of an object and the energy transferred when it is lifted off the ground. Because of this confusion students may believe that weight is gained when an object is lifted off the ground. These concepts can be separated into their components by allowing students to measure the weight of an object at various heights off the ground using spring balances.

- **Building experimental bridges to a new conception**
  Many researchers have stressed the importance of constructing conceptual bridges from the known to the new (Brown & Clements 1987). The research of Driver et al (1994) stressed the importance of providing practical experiences to build such bridges.

A widely held prior conception of energy is that it can disappear. One of the strategies Driver used in the Children’s Learning in Science Project (CLISP) to confront this idea was to ask students to predict what happens to the heat in a hot cup of tea. To encourage the construction of energy going somewhere (throughout the room) and not ‘disappearing’, students undertook a number of investigations involving cooling the hot cup of water in a
series of containers with progressively larger outer volumes of cooler water. The temperatures of the inner (hot) water and outer (cool) water were recorded over a period of time and graphs drawn. After discussing the graphs students were then asked to think about what would happen if the outer container was the room itself. This hands-on investigation allowed students to construct their own notion of energy being spread out rather than disappearing.

- **Unpacking a conceptual problem**
  By unpacking the conceptual problem teachers are better able to identify the sequence they will use to further develop a concept. In teaching molecular theory of matter Driver (1985) found that while some students were willing to accept the existence of particles, they experienced difficulty with the concept of intrinsic motion of the particles. To further develop their understanding of molecular theory it was identified that students needed to have gained an understanding of the concept of motion requiring a force.

- **Importing a different model or analogy**
  Analogies are a thinking tool in science, particularly when generated by the student. If students are experiencing difficulty with a concept, teachers could draw on their experiences in another area to provide them with an alternative model or analogy. Harrison and Treagust (2005) emphasised that for analogies to be used as an effective tool the teacher needs to consider:
  - the suitability of the analogy to the learner
  - that an analogy does not provide learners with all facets of a concept and that multiple analogies can better achieve this goal
  - that not all learners are comfortable with multiple analogies.

  Aubusson and Fogwill (2005) found that analogical role-play provides a motivating, interesting and enjoyable way to sustain student engagement with ideas. Analogical role-play can be used to portray ideas and promote discussion.

  Many students experience difficulty in identifying how the events occurring in an electric circuit relate to current conservation. This is an example where multiple analogies can be used. Some of the analogies suggested by Harrison and Treagust (2005) include:
  - a continuous train that travels a loop and picks up people at one station (the battery) and drops them off at another station (the globe). It is important to identify the train carriages as the current and the people as the energy
  - a bicycle’s continuous chain transfers energy from the pedals on the gear wheel (the battery) to the sprocket on the rear wheel (the globe). It is important to identify the likeness between the continuous chain and a wire carrying a continuous current
  - a conveyer belt picks up coal at the mine (the battery) and drops it into nearby railway wagons (the globes)
  - a role-play where a student collects jelly beans from the teacher (the battery) and walks around a circle of students (the circuit) giving jelly beans to 3–4 students (the globes).

- **The progressive shaping of a conception**
  As teachers implement their teaching and learning programs and students increase their understandings of the concepts being presented, parts of the ideas that students develop will conform to scientific ideas while others will still need challenging. Students should be provided with opportunities to test out the aspects of their ideas that do not conform to
scientific ideas to see whether their understandings need to be modified. For example, although students can identify the melting point from a graph many will still suggest that melting occurs over a temperature range. Their everyday experiences add to the confusion and reinforce this idea because rarely are the substances which they observe melting maintained at a uniform temperature. Teachers can provide practical situations and learning experiences involving melting that will challenge the student to confront this confusion and so assist them to clarify their ideas.

- **The construction of an alternative conception**
  There will be times when students’ understandings do not conform at all to scientific ideas and attempting to shape these ideas to be scientific will only cause more problems. In this case Driver (1985) suggested that students’ ideas should be acknowledged and discussed. Teachers should then indicate that scientists have a different view and try to build an alternative model. This allows students to be exposed to the scientifically accepted view, to acknowledge that their ideas are different and to later evaluate their model in relation to the accepted view.

  For example, the CLISP research found that in discussing plant nutrition some students’ prior ideas tended to focus on ‘food’ as anything that is taken in from the outside, such as water, minerals, light and air. From a scientific perspective ‘food’ is related to the complex organic compounds that provide energy to maintain a living system. In this case students were presented with practical experiences that supported the alternative.

Driver (1985) summarised students’ prior ideas about a range of scientific concepts and has provided a bibliography of worldwide research studies that can assist teachers in developing teaching and learning experiences in their own programs which take into account what students bring to the learning environment.

**Identifying prior ideas**

In designing teaching programs it is critical that teachers attempt not only to identify the ideas related to the topic that students bring to learning experiences, but also to try to clarify those ideas. The teaching program should then create time for students to assess their ideas against those that the topic covers (Tasker 1992). There are a number of strategies that teachers can use. When using these strategies the student needs to be confident that there are no right or wrong answers and that they can freely express their own ideas or understandings. Examples of strategies that can assist teachers in identifying students’ prior ideas include providing opportunities for the student to:

- make sketches of their ideas by drawing the first pictures that come into their mind when particular concepts are mentioned. These can be used as the focus of discussion by encouraging students to explain their understandings
- construct concept maps either individually or in groups to assist teachers to identify the links that students are currently making and the ideas that they associate with a particular concept. They can be updated by students at regular intervals throughout a unit creating an opportunity for students to clarify their understandings and allowing teachers to see how students are interpreting the learning experiences
- use free written response by writing down what they know, or are confused about, in relation to an idea or concept. While this may be disconcerting for both teacher and students at first, it allows teachers to determine the understandings underlying students’ responses. Teachers may need to follow up with discussion to clarify students’ ideas and elicit further explanations
• use group discussions (either small group or whole class) to identify the prevalent ideas that students bring to their learning. Discussions can arise when teachers ask questions that stimulate thinking or probe student responses for clarification and elaboration. At this early stage teachers should refrain from providing the ‘correct’ explanations. It is most important that teachers allow the discussion to flow even though this may seem to take students down irrelevant paths.

Creating a positive learning environment

As well as recognising prior knowledge and understandings in designing effective learning experiences, the learning environment that the teacher develops should be taken into account. The challenge for science teachers in Stages 4 and 5 is to develop a positive environment that will enable their students to connect with the contexts in which the knowledge and understanding, skills and values and attitudes are developed and then to extend the students’ personal experience and knowledge of science.

Atkin (1994) identified motivation, ownership and self-direction as psychological conditions characteristic of effective learning. Although not all of these conditions are present in each effective learning experience they seem to encompass the psychological conditions characteristic of effective learning experiences in general. To create a positive learning environment science teachers need to maximise the conditions that enhance learning and minimise the conditions that hinder learning by:

• recognising that students bring with them their own interpretations of the world
• developing learning experiences that challenge alternative conceptions
• ensuring students have a clear understanding of what is expected of them
• involving students actively in their learning
• designing lessons which are student-centred, active, flexible and provide opportunities for student choice
• ensuring that the learning/teaching program explicitly builds on what students already know and understand, and makes clear links to students’ everyday lives and interests
• catering for a wide range of needs, abilities, interests and learning styles
• having a clear, integrated and ongoing focus on literacy
• allowing students to have some choice in how they demonstrate achievement of outcomes
• using technology in a planned way to make learning more effective, not as an end in itself
• employing a wide range of learning/teaching and assessment strategies
• ensuring students experience success often
• ensuring that links are made, wherever possible, between home, school, wider community and with other curriculum areas to increase understanding of what happens in the classroom.

Motivation helps to move the locus of control over the learning from domination by the teacher towards a partnership in which the student experiences a far greater sense of ownership of the learning. Tapping the students’ intrinsic motivation, however, does not mean that students are not exposed to the powerful models, theories, laws and skills which science has developed over the years.

Ownership develops when students feel they have some say in what is learned, when they experiment and discover for themselves and do not feel confined to replicating the one perfect way demonstrated by the expert. A climate in which mistakes are seen to be part of the learning process rather than failure appears to be essential for many students to take the risks involved in learning. Self-direction promotes effective learning as students negotiate or set
their own goals and work at their own pace in their own time. The differentiated curriculum that would then be provided may better cater to the needs of individual students. By asking students what they would like to investigate in relation to a topic, the teacher can include activities that students find relevant and thus maintain their interest and motivation.

**References**


Appendix 3.2  Planning and programming flow diagram

The following flow diagram provides an overview of the processes involved in planning and programming the learning units in the school Science program.

Establish a **Sequence** of possible learning units for the year/stage from current, revised and/or newly drafted units

Establish the **Scope** by identifying the targeted syllabus outcomes in the learning units for each year/stage

**Develop the learning units in the school program**

- Determine the targeted syllabus outcomes
- Identify the specific evidence of learning
- Plan the learning experiences

**Evaluate the school program**

- The context selected for each unit is relevant to students’ lives, cultural backgrounds and achieves the intended purpose
- All outcomes (including values and attitudes) are included
- All essential content: knowledge, understanding and skills are covered
- Each Prescribed Focus Area addressed at least once in each year
- Practical experiences occupy a minimum of 50% of course time
- One unit in each stage involves a Student Research Project (SRP)
- At least one SRP is ‘hands-on’
- The Stage 5 SRP is an individual task

**Meeting the Course Requirements**

- 400 indicative hours for Years 7 to 10
- Compliance with safety and use of animals legislation
- Providing for the learning needs of the full range of students
- All relevant school and/or system policies

**Use teacher and student evaluations to:**
- review target outcomes
- revisit contexts, essential content, learning experiences and assessment
- amend existing units and/or draft new units

**Check/adjust the targeted outcomes and content in the units using the Science Years 7–10 Syllabus Mapping Grids**
Appendix 3.3  Example of a Year 7 Science scope and sequence plan

<table>
<thead>
<tr>
<th></th>
<th>Term 1 (11 weeks)</th>
<th>Term 2 (10 weeks)</th>
<th>Term 3 (10 weeks)</th>
<th>Term 4 (10 weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1: Investigating science</td>
<td></td>
<td>Unit 2: Living things</td>
<td>SRP</td>
<td>Unit 3: Energy changes things</td>
</tr>
</tbody>
</table>
## Stage 4 Scope and sequence

<table>
<thead>
<tr>
<th>Stage 4 Outcome</th>
<th>A student:</th>
<th>Unit</th>
<th>Year 7</th>
<th>Year 8</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Prescribed Focus Area</td>
<td></td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.1</td>
<td>identifies historical examples of how scientific knowledge has changed people’s understanding of the world</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.2</td>
<td>uses examples to illustrate how models, theories and laws contribute to an understanding of phenomena</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.3</td>
<td>identifies areas of everyday life that have been affected by scientific developments</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.4</td>
<td>identifies choices made by people with regard to scientific developments</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.5</td>
<td>describes areas of current scientific research</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Domain: Knowledge and Understanding</td>
<td></td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.6</td>
<td>identifies and describes energy changes and the action of forces in common situations</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.7</td>
<td>describes observed properties of substances using scientific models and theories</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.8</td>
<td>describes features of living things</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.9</td>
<td>describes the dynamic structure of Earth and its relationship to other parts of our solar system and the universe</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.10</td>
<td>identifies factors affecting survival of organisms in an ecosystem</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.11</td>
<td>identifies where resources are found, and describes ways in which they are used by humans</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.12</td>
<td>identifies, using examples, common simple devices and explains why they are used</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Domain: Skills</td>
<td></td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.13</td>
<td>clarifies the purpose of an investigation and, with guidance, produces a plan to investigate a problem</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.14</td>
<td>follows a sequence of instructions to undertake a first-hand investigation</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.15</td>
<td>uses given criteria to gather first-hand data</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.16</td>
<td>accesses information from identified secondary sources</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.17</td>
<td>evaluates the relevance of data and information</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.18</td>
<td>with guidance, presents information to an audience to achieve a particular purpose</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.19</td>
<td>draws conclusions based on information available</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.20</td>
<td>uses an identified strategy to solve problems</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.21</td>
<td>uses creativity and imagination to suggest plausible solutions to familiar problems</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4.22</td>
<td>undertakes a variety of individual and team tasks with guidance</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Domain: Values and Attitudes</td>
<td></td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4/5.23</td>
<td>demonstrates confidence and a willingness to make decisions and to take responsible actions</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4/5.24</td>
<td>respects differing viewpoints on science issues and is honest, fair and ethical</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4/5.25</td>
<td>recognises the relevance and importance of lifelong learning and acknowledges the continued impact of science in many aspects of everyday life</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4/5.26</td>
<td>recognises the role of science in providing information about issues being considered and in increasing understanding of the world around them</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>4/5.27</td>
<td>acknowledges their responsibility to conserve, protect and maintain the environment for the future</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
## Appendix 3.4  Stage 4 content mapping grid – outcomes and essential content

<table>
<thead>
<tr>
<th>Unit</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Students learn about the history of science</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) identify some of the ideas from different cultures (including those of Aboriginal and other Indigenous people) that have contributed to science throughout history</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) describe some models and theories that have been considered in science and then been modified or rejected as a result of available evidence</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>c) discuss examples where societal, religious or ethical values have had an impact on scientific developments</td>
<td></td>
<td>✓</td>
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<tr>
<td>d) describe historical cases where developments in science have led to the development of new technologies</td>
<td></td>
<td>✓</td>
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<tr>
<td>e) describe historical cases where developments or improvements in technology have transformed science</td>
<td></td>
<td>✓</td>
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<tr>
<td>4.2</td>
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</tr>
<tr>
<td>Students learn about the nature and practice of science</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>a) evaluate the role of creativity, curiosity, objectivity and logical reasoning in describing phenomena, carrying out investigations and in the devising and testing of hypotheses</td>
<td>✓</td>
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<tr>
<td>b) distinguish between scientific argument and economic or legal argument</td>
<td>✓</td>
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<tr>
<td>c) apply scientific processes to test the validity of ideas and theories</td>
<td>✓</td>
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<tr>
<td>d) describe how an idea can gain acceptance in the scientific community as either theory or law</td>
<td>✓</td>
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<tr>
<td>e) use examples which show that scientists isolate a set of observations, identify trends and patterns and construct hypotheses or models to explain these</td>
<td>✓</td>
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<tr>
<td>f) give examples that demonstrate the benefits and limitations of using models</td>
<td>✓</td>
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<tr>
<td>g) identify that the nature of observations made depends upon the understanding that the observer brings to the situation</td>
<td>✓</td>
<td>✓</td>
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<td>4.3</td>
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<tr>
<td>Students learn about the applications and uses of science</td>
<td>✓</td>
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<tr>
<td>a) identify and describe examples of scientific concepts and principles that have been used in technological developments (including Australian examples)</td>
<td>✓</td>
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<tr>
<td>b) discuss, using examples, the positive and negative impacts of applications of recent developments in science</td>
<td>✓</td>
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<tr>
<td>c) identify and describe examples where technological advances have impacted on science</td>
<td>✓</td>
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<tr>
<td>d) give reasons why society should support scientific research</td>
<td>✓</td>
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<td>4.4</td>
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<tr>
<td>Students learn about the implications of science for society and the environment</td>
<td>✓</td>
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<tr>
<td>a) discuss viewpoints about some issues with a major scientific component</td>
<td>✓</td>
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<tr>
<td>b) give examples to show that different cultures or groups within a society (including Aboriginal and other Indigenous people) may use or weight criteria differently to make a decision about an issue involving a major scientific component</td>
<td>✓</td>
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<tr>
<td>c) identify choices that need to be or have been made when considering whether to use particular scientific advances</td>
<td>✓</td>
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<tr>
<td>d) discuss the place of social and ethical considerations in scientific practice and in applications of science</td>
<td>✓</td>
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<tr>
<td>4.5</td>
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<tr>
<td>Students learn about current issues, research and developments in science</td>
<td>✓</td>
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<tr>
<td>a) describe some recent scientific contributions made by male and female scientists, including Australians, and discuss the effect of their contributions</td>
<td>✓</td>
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<tr>
<td>b) evaluate the potential impact of some issues raised in the mass media that require some scientific understanding</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>c) identify scientific skills that can be useful in a broad range of careers</td>
<td>✓</td>
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<tr>
<td>d) identify possible career paths in science</td>
<td>✓</td>
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<tr>
<td>4.6</td>
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<tr>
<td>A student identifies and describes energy changes and the action of forces in common situations</td>
<td>✓</td>
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<tr>
<td>4.6.1 Students learn about the law of conservation of energy</td>
<td>✓</td>
<td></td>
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</tr>
<tr>
<td>a) identify situations or phenomena in which different forms of energy are evident</td>
<td>✓</td>
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<tr>
<td>b) use models to describe different forms of energy</td>
<td>✓</td>
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<tr>
<td>c) identify objects that possess energy because of their motion (kinetic) or because of other properties (potential)</td>
<td>✓</td>
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<tr>
<td>d) qualitatively account for the total energy involved in energy transfers and transformations</td>
<td>✓</td>
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<tr>
<td>4.6.2 Students learn about forces</td>
<td>✓</td>
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<td></td>
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</tr>
<tr>
<td>a) identify changes that take place when particular forces are acting</td>
<td>✓</td>
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<td>Unit</td>
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<tr>
<td>b) use the term ‘field’ in describing forces acting at a distance</td>
<td>✓</td>
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<tr>
<td>4.6.3 Students learn about electrical energy</td>
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<tr>
<td>a) associate electricity with energy transfer in a simple circuit</td>
<td>✓</td>
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<tr>
<td>b) construct and draw circuits to show transfer of energy</td>
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<tr>
<td>4.6.4 Students learn about sound energy</td>
<td>✓</td>
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<tr>
<td>a) describe sound as a form of energy requiring a medium for propagation</td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td>4.6.5 Students learn about light energy</td>
<td>✓</td>
<td></td>
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</tr>
<tr>
<td>a) describe light as a form of energy not requiring a medium for propagation</td>
<td>✓</td>
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<tr>
<td>4.6.6 Students learn about heat energy</td>
<td>✓</td>
<td></td>
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</tr>
<tr>
<td>a) identify processes of heat transfer by conduction, convection and radiation</td>
<td>✓</td>
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<tr>
<td>4.6.7 Students learn about frictional force</td>
<td>✓</td>
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<tr>
<td>a) describe friction as a contact force which opposes motion</td>
<td>✓</td>
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<tr>
<td>b) identify everyday situations where friction acts</td>
<td>✓</td>
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<tr>
<td>4.6.8 Students learn about electrostatic force</td>
<td>✓</td>
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<tr>
<td>a) describe ways in which objects acquire an electrostatic charge</td>
<td>✓</td>
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<tr>
<td>b) identify everyday situations where the effects of electrostatic forces can be observed</td>
<td>✓</td>
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<tr>
<td>c) describe the behaviour of charges when they are brought close to each other</td>
<td>✓</td>
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<tr>
<td>4.6.9 Students learn about magnetic force</td>
<td>✓</td>
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<tr>
<td>a) describe the behaviour of magnetic poles when they are brought close to each other</td>
<td>✓</td>
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<tr>
<td>b) identify everyday situations in which magnets and electromagnets are used</td>
<td>✓</td>
<td></td>
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<tr>
<td>4.6.10 Students learn about gravitational force</td>
<td>✓</td>
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<tr>
<td>a) identify that all objects exert a force of gravity on other objects in the universe</td>
<td>✓</td>
<td></td>
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<tr>
<td>4.7 A student describes observed properties of substances using scientific models and theories</td>
<td>✓</td>
<td></td>
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</tr>
<tr>
<td>4.7.1 Students learn about the particle model of matter</td>
<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td>a) describe the behaviour of matter in terms of particles that are continuously moving and interacting</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>b) describe expansion and contraction of materials in terms of a simple particle model</td>
<td>✓</td>
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<tr>
<td>c) relate an increase or decrease in the amount of energy possessed by particles to changes in particle movement</td>
<td>✓</td>
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<tr>
<td>4.7.2 Students learn about properties of solids, liquids and gases</td>
<td>✓</td>
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</tr>
<tr>
<td>a) relate to properties of solids, liquids and gases to the particle model of matter</td>
<td>✓</td>
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<tr>
<td>b) describe the physical changes that occur during observations of evaporation, condensation, boiling, melting and freezing</td>
<td>✓</td>
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<tr>
<td>c) explain density in terms of a simple particle model</td>
<td>✓</td>
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<tr>
<td>d) explain the changes in pressure of gases in terms of increases or decreases in frequency of particle collisions</td>
<td>✓</td>
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<tr>
<td>4.7.3 Students learn about change of state</td>
<td>✓</td>
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<tr>
<td>a) relate changes of state to the motion of particles as energy is removed or added</td>
<td>✓</td>
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<tr>
<td>b) relate energy transfers in melting and freezing, condensation, evaporation and boiling to the particle model</td>
<td>✓</td>
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</tr>
<tr>
<td>4.7.4 Students learn about elements</td>
<td>✓</td>
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</tr>
<tr>
<td>a) classify elements as metals or non-metals according to their common characteristics</td>
<td>✓</td>
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<tr>
<td>b) identify internationally recognised symbols for common elements</td>
<td>✓</td>
<td></td>
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<tr>
<td>4.7.5 Students learn about mixtures</td>
<td>✓</td>
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<tr>
<td>a) identify some common mixtures</td>
<td>✓</td>
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<tr>
<td>b) identify, using examples, the importance of water as a solvent</td>
<td>✓</td>
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<tr>
<td>c) describe aqueous mixtures in terms of solute, solvent and solution</td>
<td>✓</td>
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<tr>
<td>d) identify situations where the processes of filtration, sedimentation, sieving, distillation, chromatography, evaporation, condensation, crystallisation and magnetic attraction are appropriate to separate components of a mixture</td>
<td>✓</td>
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<tr>
<td>4.7.6 Students learn about compounds and reactions</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) distinguish between elements and compounds</td>
<td>✓</td>
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<tr>
<td>b) identify when a chemical reaction is taking place by observing changes in temperature, the appearance of a new substance or the disappearance of an original substance</td>
<td>✓</td>
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<tr>
<td>c) distinguish between compounds and mixtures</td>
<td>✓</td>
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</table>
## 4.8 A student describes features of living things

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<tbody>
<tr>
<td>4.8.1 Students learn about cell theory</td>
<td>✓</td>
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</tr>
<tr>
<td>a) identify that living things are made of cells</td>
<td>✓</td>
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<tr>
<td>b) identify and describe the functions of the nucleus, cytoplasm, cell membrane, cell wall, chloroplast</td>
<td>✓</td>
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<tr>
<td>c) identify that substances move into and out of cells</td>
<td>✓</td>
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<tr>
<td>d) distinguish between unicellular and multicellular organisms</td>
<td>✓</td>
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### 4.8.2 Students learn about classification

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<tbody>
<tr>
<td>a) classify living things according to structural features and identify that they have patterns of similarities and differences</td>
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<tr>
<td>b) identify a range of plants and animals using simple keys</td>
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### 4.8.3 Students learn about unicellular organisms

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<tbody>
<tr>
<td>a) identify that there is a wide range of unicellular organisms</td>
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<tr>
<td>b) explain that reproduction in unicellular organisms takes place by cell division</td>
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### 4.8.4 Students learn about multicellular organisms

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<tbody>
<tr>
<td>a) identify that tissues, organs and organ systems in multicellular organisms consist of different types of cells</td>
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<tr>
<td>b) explain why multicellular organisms require specialised organs and systems</td>
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<tr>
<td>c) identify the materials required by multicellular organisms for the processes of respiration and photosynthesis</td>
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<tr>
<td>d) describe the role of the root, stem and leaf in maintaining flowering plants as functioning organisms</td>
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### 4.8.5 Students learn about humans

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<tbody>
<tr>
<td>a) describe the role of the digestive, circulatory, excretory, skeletal and respiratory systems in maintaining humans as functioning organisms</td>
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## 4.9 A student describes the dynamic structure of Earth and its relationship to other parts of our solar system and the universe

### 4.9.1 Students learn about the Newtonian model of the solar system

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<tbody>
<tr>
<td>a) describe qualitatively relative sizes, distances and movements of components of our solar system</td>
<td>✓</td>
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<tr>
<td>b) describe relative movements of the planets, moons and sun</td>
<td>✓</td>
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<tr>
<td>c) explain night and day in terms of Earth’s rotation</td>
<td>✓</td>
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<tr>
<td>d) explain the seasons in terms of the tilt of Earth’s axis and its revolution around the sun</td>
<td>✓</td>
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### 4.9.2 Students learn about components of the universe

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<tbody>
<tr>
<td>a) describe some major features of the universe, including galaxies, stars, nebulae and solar systems</td>
<td>✓</td>
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<tr>
<td>b) use appropriate scales to describe differences in sizes of, and distances between, structures making up the universe</td>
<td>✓</td>
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### 4.9.3 Students learn about the structure of Earth

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<tbody>
<tr>
<td>a) describe the inner structure of the Earth in terms of core, mantle, crust and lithosphere</td>
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### 4.9.4 Students learn about the atmosphere

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<tbody>
<tr>
<td>a) identify gases that comprise the greater percentage of air and explain the difference between Earth’s atmosphere and space</td>
<td>✓</td>
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<tr>
<td>b) describe the importance of atmospheric gases, including ozone and greenhouse gases, to life on Earth</td>
<td>✓</td>
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### 4.9.5 Students learn about the hydrosphere

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</thead>
<tbody>
<tr>
<td>a) describe the water cycle in terms of the physical processes involved</td>
<td>✓</td>
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<tr>
<td>b) describe the effect of the forces of the sun and moon on the hydrosphere</td>
<td>✓</td>
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</tbody>
</table>

### 4.9.6 Students learn about the lithosphere

<table>
<thead>
<tr>
<th>Unit</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) identify that rocks are composed of minerals</td>
<td>✓</td>
<td></td>
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<tr>
<td>b) explain the breaking down of rocks in terms of physical and chemical changes</td>
<td>✓</td>
<td></td>
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<tr>
<td>c) relate the formation of landforms to weathering, erosion and deposition</td>
<td>✓</td>
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<tr>
<td>d) describe the origins of sedimentary, igneous and metamorphic rocks</td>
<td>✓</td>
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<tr>
<td>Unit</td>
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<tr>
<td>4.10 A student identifies factors affecting survival of organisms in an ecosystem</td>
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<tr>
<td>4.10 Students learn about ecosystems</td>
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<tr>
<td>a) describe some adaptations of living things to factors in their environment</td>
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<tr>
<td>b) describe, using examples of food chains and food webs from Australian ecosystems, how producers, consumers and decomposers are related</td>
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<tr>
<td>c) describe the roles of photosynthesis and respiration in ecosystems</td>
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<tr>
<td>d) discuss some effects of bushfires, drought and flood on Australian ecosystems</td>
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<tr>
<td>4.11 A student identifies where resources are found, and describes ways in which they are used by humans</td>
<td></td>
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</tr>
<tr>
<td>4.11 Students learn about natural resources</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>a) distinguish between natural and made resources</td>
<td>✓</td>
<td></td>
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<tr>
<td>b) give examples of resources from living things and resources extracted from the air, Earth and oceans</td>
<td></td>
<td>✓</td>
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<tr>
<td>c) identify fossil fuels and describe some of their uses</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>d) identify renewable and non-renewable sources of energy</td>
<td>✓</td>
<td></td>
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<tr>
<td>4.12 A student identifies, using examples, common simple devices and explains why they are used</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>4.12 A student learns about technology</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) identify technologies that make tasks easier or more convenient</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) identify a variety of energy transformations in everyday devices involving electrical, sound, light and/or heat energy</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>4.13 A student clarifies the purpose of an investigation and, with guidance, produces a plan to investigate a problem</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.13.1 Students learn about identifying data sources</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>a) describe a problem and develop an hypothesis or question that can be tested or researched</td>
<td>L</td>
<td>P</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>b) propose possible sources of data and/or information relevant to the investigation</td>
<td>L</td>
<td></td>
<td></td>
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<tr>
<td>c) identify what type of information or data need to be collected</td>
<td>L</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) justify why particular types of data or information are to be collected</td>
<td>L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e) identify the appropriate units to be used in collecting data</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>f) recommend the use of an appropriate technology or strategy for collecting data or gathering information</td>
<td>L</td>
<td>L</td>
<td></td>
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</tr>
<tr>
<td>g) formulate a means of recording the data to be gathered or the information to be collected</td>
<td>L</td>
<td>P</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>4.13.2 Students learn about planning first-hand investigations</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>a) identify variables that need to be held constant if reliable first-hand data is to be collected</td>
<td>L</td>
<td>L</td>
<td></td>
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</tr>
<tr>
<td>b) specify the dependent and independent variables when planning controlled experiments</td>
<td>L</td>
<td></td>
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<tr>
<td>c) describe a logical procedure for undertaking a simple or controlled experiment to collect valid first-hand data</td>
<td>L</td>
<td></td>
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<tr>
<td>d) establish an appropriate timeline for an investigation</td>
<td>L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.13.3 Students learn about choosing equipment or resources</td>
<td>L</td>
<td>L</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>a) identify advantages and limitations of using particular laboratory and field equipment for a specific task</td>
<td>L</td>
<td>L</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>b) select appropriate equipment (including safety equipment) and/or resources to perform the task</td>
<td>L</td>
<td>L</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>c) describe ways to reduce the risk to themselves and others when working in the laboratory or field</td>
<td>L</td>
<td>L</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>4.14 A student follows a sequence of instruction to undertake a first-hand investigation</td>
<td></td>
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</tr>
<tr>
<td>4.14 Students learn about performing first-hand investigations</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>a) follow the planned procedure when performing an investigation</td>
<td>L</td>
<td>P</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>Unit</td>
<td>1</td>
<td>2</td>
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<td>4</td>
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<tr>
<td>b) use time and resources effectively</td>
<td>L</td>
<td></td>
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<tr>
<td>c) safely and effectively construct, assemble and manipulate identified equipment</td>
<td>L P A</td>
<td></td>
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<tr>
<td>d) record data using the appropriate units</td>
<td>L P A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e) evaluate and modify experimental procedures</td>
<td>L</td>
<td>L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f) demonstrate the use of safe and hygienic work practices including the correct use of safety equipment</td>
<td>L</td>
<td>P</td>
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</tr>
</tbody>
</table>

4.15 A student uses given criteria to gather first-hand data
4.15 Students learn about gathering first-hand information ✓ ✓ ✓ ✓
- a) make and record observations and measurements accurately L L P | |
- b) use independently a range of data collection strategies and technologies such as data loggers L P P | |

4.16 A student accesses information from identified secondary sources
4.16 Students learn about accessing information from secondary sources ✓ ✓
- a) use a range of sources, including databases, CD-ROMs and the internet, to access information L | L | | |
- b) use a variety of techniques, such as keywords, skimming and scanning to identify appropriate information L P | | |
- c) extract information from column graphs, histograms, divided bar and sector graphs, line graphs, composite graphs, flow diagrams, other texts and audio/visual resources L | L | | |
- d) summarise information from identified oral and written secondary sources | L | P | | |

4.17 A student evaluates the relevance of data and information
4.17 Students learn about processing information ✓ ✓
- a) collate information from a number of sources | | | | |
- b) distinguish between relevant and irrelevant information | | | | |
- c) check the reliability of gathered data and information by comparing them with observations or information from other sources L | | | |
- d) organise data using a variety of methods including diagrams, tables, spreadsheets and databases L | | | |
- e) critically analyse the accuracy of scientific information presented in mass media | | | | |
- f) identify trends, patterns, relationships and contradictions in data and information L | | | |
- g) apply mathematical concepts and computer based technologies to assist analysis of data and information | | | | |

4.18 A student with guidance, presents information to an audience to achieve a particular purpose
4.18 Students learn about presenting information ✓ ✓
- a) select, and use appropriately, types of texts for different purposes and contexts including a discussion, explanation, procedure, exposition, recount, report, response or experimental record for oral or written presentation | | | | |
- b) select and use an appropriate medium to present data and information L | | | |
- c) select and use an appropriate method to acknowledge sources of information L P | | |
- d) use symbols to express relationships, including mathematical ones, and appropriate units for physical quantities L P | | |
- e) use drawings, diagrams, graphs, tables, databases, spreadsheets and flow charts to show relationships and present information clearly and/or succinctly L P | | |
- f) select and draw the appropriate type of graph (from column graph, histogram, divided bar, sector or line graph) or diagram to convey information and relationships clearly and accurately L | L | | |

4.19 A student draws conclusions based on information available
4.19 Students learn about thinking critically ✓ ✓ ✓
- a) justify inferences in light of gathered information L L P | |
- b) identify data which supports or discounts an hypothesis, a question being investigated or a proposed solution to a problem L P P | |
- c) predict outcomes and generate plausible explanations directly related to observations made L P | | |
- d) make generalisations in relation to a relevant set of observations or experimental results L P | | |
- e) anticipate and/or respond to problems as they arise in practical situations L | | | |
### Unit 1

<table>
<thead>
<tr>
<th></th>
<th>f) use models, including mathematical ones, to explain phenomena or make predictions</th>
<th>L</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g) use cause and effect relationships to explain ideas</td>
<td>L</td>
<td>P</td>
</tr>
<tr>
<td>4.20 A student uses an identified strategy to solve problems</td>
<td></td>
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<tr>
<td>4.20 Students learn about problem-solving</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td></td>
<td>a) identify the nature of a presented problem</td>
<td>L</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>b) describe different strategies that could be employed to solve an identified problem</td>
<td>L</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>c) use identified strategies to develop a range of possible solutions to a particular problem</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d) evaluate the appropriateness of different strategies for solving an identified problem</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>4.21 A student uses creativity and imagination to suggest plausible solutions to familiar problems</td>
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</tr>
<tr>
<td>4.21 Students learn about the use of creativity and imagination</td>
<td>✔️</td>
<td>✔️</td>
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</tr>
<tr>
<td></td>
<td>a) seek evidence to support claims</td>
<td>L</td>
<td>P</td>
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<tr>
<td></td>
<td>b) evaluate evidence for reliability and validity</td>
<td>L</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>c) produce creative solutions for problems</td>
<td>L</td>
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<tr>
<td></td>
<td>d) propose ideas that demonstrate coherence and logical progression</td>
<td>L</td>
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<td></td>
<td>e) apply critical thinking in the consideration of proposals</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td></td>
<td>f) formulate cause and effect relationships</td>
<td>L</td>
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</tr>
<tr>
<td>4.22 A student undertakes a variety of individual and team tasks with guidance</td>
<td></td>
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<tr>
<td>4.22.1 Students learn about working individually</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td></td>
<td>a) independently plan and conduct investigations, communicate information and understanding and solve problems</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>b) set and work to realistic timelines and goals</td>
<td>L</td>
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<tr>
<td></td>
<td>c) accept responsibility for maintenance of a safe working environment for themselves and others</td>
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<td>P</td>
</tr>
<tr>
<td></td>
<td>d) evaluate the effectiveness of their performance in completing tasks</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>4.22.2 Students learn about working in teams</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td></td>
<td>a) identify the specific roles needed when working in a team</td>
<td>L</td>
<td>P</td>
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<tr>
<td></td>
<td>b) match the tasks to the team members according to the requirements of the task and the skills of the individual</td>
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<tr>
<td></td>
<td>c) negotiate and allocate individual roles to members of the team</td>
<td>L</td>
<td>P</td>
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<tr>
<td></td>
<td>d) accept specific roles in a team while planning and conducting investigations, communicating information and understanding and solving problems</td>
<td>L</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>e) set and work to realistic timelines and goals as a team</td>
<td>L</td>
<td></td>
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<tr>
<td></td>
<td>f) accept personal responsibility for maintenance of a safe working environment for the team</td>
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<td>P</td>
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<tr>
<td></td>
<td>g) monitor progress of the team towards completion of the task</td>
<td>L</td>
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<tr>
<td></td>
<td>h) evaluate the process used by the team and effectiveness of the team in completing the task</td>
<td>L</td>
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</tr>
</tbody>
</table>
### Appendix 3.5 Sample unit proforma

Schools should design unit proformas that best meet their needs and circumstances. Schools may choose to use or adapt the proforma style provided below. The proforma below has been annotated to show the characteristics of each part.

<table>
<thead>
<tr>
<th>Unit title:</th>
<th>Stage 4 or 5 (Years 7–10)</th>
<th>Suggested unit length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Unit context:</th>
<th>Resources:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The chosen context should assist students to make meaning of their learning in relation to their past and current experiences. A context should be chosen after considering factors such as local resources and students’ interests, learning history and cultural backgrounds.</td>
<td></td>
</tr>
</tbody>
</table>

| Target outcomes: | |
|------------------| |
| Identifies the key outcomes addressed within the learning unit. Each unit of work must address at least one Prescribed Focus Area (PFA) outcome. The unit should also provide a balance between knowledge and understanding, and skills outcomes and content. Identified skills outcomes will be those that reflect the explicit teaching of skills within the unit. | |

| Unit overview: | |
|----------------| |
| Presents an outline of the structure of the unit. | |

<table>
<thead>
<tr>
<th>Students learn about:</th>
<th>Students learn to:</th>
<th>Integrated learning experiences, instruction and assessment:</th>
<th>Evidence of learning:</th>
<th>Feedback:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Knowledge and understanding</th>
<th>R*</th>
<th>Skills</th>
<th>Suggested learning strategies</th>
<th>Evidence of learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>A student:</td>
<td>Students learn about/learn to</td>
<td></td>
<td>Students learn about/learn to</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Suggested learning strategies**

- 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

<table>
<thead>
<tr>
<th>Knowledge and understanding</th>
<th>R*</th>
<th>Skills</th>
<th>R*</th>
<th>Context</th>
<th>Suggested integrated learning and assessment strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students learn about/learn to</td>
<td></td>
<td>Students learn about/learn to</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Suggested integrated learning and assessment strategies**

- Presents an overview of the framework and focus of teaching/learning in the lesson.

### Example 3

<table>
<thead>
<tr>
<th>Outcome</th>
<th>R*</th>
<th>Knowledge/understanding and skills</th>
<th>Suggested learning experiences and evidence of learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>A student:</td>
<td></td>
<td>Students learn about/learn to</td>
<td></td>
</tr>
</tbody>
</table>

*Registration

**Describes the details of the learning/teaching experiences 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.**
## Appendix 3.6 Examples of science assessment strategies and activities

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Examples of Activities</th>
</tr>
</thead>
</table>
| **Research assignments** | • finding simple definitions, factual information or biographies of scientists  
• researching examples of historical scientific and technological developments that impacted on science and/or society  
• comparing a range of contrasting views on a topic or current issues with a major scientific component  
• comparing information sources for accuracy and relevance  
• developing explanations or evaluations of the impacts or implications of scientific research |
| **Inquiry-based research and first-hand practical experiences (practical and field work)** | • identifying and carrying out a first-hand investigation of a question or problem (teacher observation of student performance – manipulative skills, safety)  
• using data collection technologies to gather and record first-hand data  
• gathering and processing data from peers, parents, the community relating to specific questions or issues  
• making accurate observations and collating relevant data/ information collected during a field trip to the local environment  
• planning and undertaking learning experiences beyond the classroom  
• extraction, reorganisation and use of data from secondary sources  
• constructing and/or interpreting of graphs, tables, diagrams, flowcharts, keys, spreadsheets and databases  
• compiling a diary, journal or practical report  
• identifying, selecting and using appropriate strategies to solve a problem  
• planning and conducting an open-ended investigation  
• planning and/or conducting a mandatory Student Research Project |
| **Teamwork (Appendix 6.5)** | • setting and working to realistic timelines to complete practical experiences  
• planning and monitoring progress to complete a hands-on practical activity, field work activity case study, web quest or open-ended investigation  
• gathering information from secondary sources for a research project  
• negotiating and accepting specific roles and responsibilities |
| **Presentations (Appendix 6.6)** | • presenting visually material gathered processed and analysed from a variety of types of sources  
• recounting an experimental procedure or answering questions about the results obtained  
• making an impromptu or prepared oral presentation  
• performing a role-play  
• presenting a poster, display, model or multimedia presentation  
• participating in a debate or an interview |
| **Peer Assessment** | • reflecting on a peer presentation, role-play or debate  
• evaluating the contribution and effectiveness of the team in maintaining a safe work environment  
• contributing constructive comments and/or suggesting improvements to the process used by the team members in completing a task |
| **Self-Assessment** | • completing self-paced, self-marking worksheets to assess knowledge, understanding and skills  
• evaluating the effectiveness of their own performance in completing a task  
• reflecting on their own learning in a unit of work or progress towards the achievement of syllabus outcomes |
Appendix 3.7 Learning science beyond the classroom

Interest and understanding in science can be enhanced through learning experiences outside the classroom. Investigating areas within the school grounds, walking to a local venue, visiting a museum, field centre, zoo, industrial site or other institution can be motivating and enlightening for students, providing opportunities for them to use and develop their curiosity, interests and skills. Such experiences relate classroom learning to the real world, facilitate catering for different styles of learning and enable access to resources not available in the classroom.

Adequate planning and organisation, including identifying the intended learning outcomes and evidence of learning, are crucial to the success of out-of-classroom science experiences to ensure that the interest of the students is maintained and that the desired outcomes are achieved.

Planning the experiences

1. **Articulate the purpose of the experience** to yourself, other teachers and helpers, and to the students. Ensure that it is part of a classroom-based learning unit and that it focuses on the unit outcomes.

2. **Check the school policies and procedures** for offsite activities, ensuring that risk assessment requirements have been followed. If using an external provider for the program, ensure that all school policy and procedure requirements have been addressed in their documentation, including risk assessment and supervision. Make sure that the required experiences fit comfortably into the time available.

3. **Familiarise yourself with the site.** If possible go to the site before you take the students – most sites give teachers free entry if they are planning to bring students. Become familiar with the logistics: determine the travel time and type and where the group will be dropped off and picked up; find out where to meet site staff; follow the route of the visit; find a lunch spot and the toilets. For outdoor venues find some landmarks which can be meeting places if someone is separated from the group. If it is not possible to pre-visit the venue, have a close look at the venue’s website and talk to site staff. Complete a thorough risk assessment.

4. **Give the students some ownership of the experience** by discussing with them:
   a. the purpose of the experience including the proposed learning outcomes, so they know why they are having the experience and how it fits into their classroom-based learning unit
   b. information about the venue itself: its location, layout and personnel
   c. use of maps and suggestions for meeting places (ensuring that the students’ physical needs are met)
   d. an appropriate schedule for the day, ideally with more detailed investigation occurring early and general viewing or activity happening later
   e. how to develop questions, based on their classroom learning, to which they could seek answers
   f. how they will record their findings
   g. clear, appropriate and fair behaviour guidelines, including those associated with listening to a speaker and possible profiles (eg sitting, kneeling, standing) that could be taken up if there are a number of people looking at the same thing
   h. contingency plans for variations or cancellation.

5. **Develop recording methods which are relevant, practical and appropriate.** It is important that students gain the big ideas about what an industry is doing, or an exhibit is presenting, or the state of the environment they are experiencing. Use a learner-centred approach including general questions that assist students to consider the whole experience, as well as questions the students have developed. Photos and recordings may be effective ways of gathering information.
Use the experience to stimulate interest in finding out more about a topic. If possible, when viewing displays, eg in museums and science centres, let students move around and focus on sections that interest them, rather than keeping them all together working through a structured worksheet.

6. **Show your own interest and learning on the day.** Rather than handing the class over to the site staff, be a model learner and participant, ensuring that students are able to learn effectively. If it is a venue where there is a guided tour, help the students to keep up with the guide, and ensure that all students are present before the guide begins speaking. If language is used that you believe the students do not understand, ask questions yourself which will lead to clarification for them.

7. **Enlist extra help.** It is generally preferable for students to be working in small groups rather than as a whole class. If appropriate and possible, invite parents or grandparents to accompany you. Helpers should have a clear understanding of their roles and responsibilities as supervisors. It is vital that they are familiar with the learning outcomes of the experience and your expectations of the students’ behaviour. Talk with them beforehand about maintaining a relaxed atmosphere, focusing on the students doing their own investigating. Ensure that each helper has a schedule, a map, a worksheet and your mobile phone number.

**Further reading**


Appendix 3.8 Year 7 Science

Unit 1: Investigating Science  Suggested time: 8 weeks  Teacher/Class:

Context
Students identify situations relevant to their interests and lives to gain an understanding of the nature and practice of science. Through first-hand practical experiences students draw on their prior knowledge of and skills in investigating and using technologies to develop their ideas about science as a way of answering questions about the natural world.

Description
This unit builds on the students’ Stage 3 understanding of science and technology to introduce them to the Stage 4 working scientifically skills. It revises cooperative teamwork skills and how they are used in investigating scientifically. Through actively participating in a variety of hands-on practical experiences students extend their understanding of how they and other people use scientific inquiry in problem-solving. Students clarify their understanding of procedural recount text and are guided in using this in writing a scientific report.

I am a scientist
Outcomes: 4.2, 4.13, 4.14, 4.15, 4.17, 4.19, 4.20, 4.21, 4.22, 4/5.23, 26
Team Assessment Task 1: Present a scientific report on a first-hand investigation planned and performed by the team.

How do I communicate science information?
Outcomes 4.13, 4.14, 4.18
Class Activity: Writing a procedural report for a first-hand investigation

Using investigations to solve problems
Outcomes: 4.2, 4.13, 4.14, 4.20, 4.22, 4/5.26
Team Activity: Plan and perform a first-hand investigation that uses working scientifically skills to solve a problem

Investigating science
Prior understanding Stage 3:
Inv 3.7, DM 3.8, UT 3.9, VA5
Syllabus outcomes:
PFA: 4.1, 4.2, 4.5
Skills: 4.13, 14, 15, 16, 18, 19, 20, 21, 22
V&A: 4/5.23, 26

About science
Outcomes: 4.1, 4.2, 4.5, 4.16, 4.22
Team Activity: Research how the work of an Australian scientist and a person who uses scientific skills in their workplace contribute to our everyday lives.

Making my science workplace safe
Outcomes: 4.13, 4.14, 4.19, 4/5.23
Individual Activity: What happens to the temperature of water as it changes state?
# Resources

<table>
<thead>
<tr>
<th>Syllabus outcomes</th>
<th>Syllabus content</th>
<th>Suggested learning experiences and evidence of learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>A student:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prior understanding Stage 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INV S3.7 Conducts their own investigation and makes judgements based on the results of observing, questioning, planning, predicting, testing, collecting, recording and analysing data, and drawing conclusions</td>
<td>Students learn to/about:</td>
<td>Using investigations to solve problems</td>
</tr>
<tr>
<td>VA 5 Works cooperatively with others in groups on scientific and technological tasks and challenges</td>
<td></td>
<td>Class activity: Students identify and review in a brainstorming activity their ideas/understanding from Stage 3 about the processes of investigating.</td>
</tr>
<tr>
<td>4.22 completes a variety of individual and team tasks with guidance</td>
<td></td>
<td>With teacher modelling the students use and annotate a webbing organiser to record the important processes in investigating scientifically.</td>
</tr>
<tr>
<td>4.20 uses an identified strategy to solve problems</td>
<td></td>
<td>Pair/Think Share activity: Students discuss the skills needed for teamwork. In pairs students:</td>
</tr>
<tr>
<td>4.13 clarifies the purpose of an investigation and, with guidance, produces a plan to investigate a problem</td>
<td></td>
<td>• describe and record on a webbing organiser their ideas about the types of skills needed to work cooperatively as a team</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• each pair compares their ideas with those of another pair</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• with teacher guidance, the class reviews their ideas and each student modifies and as appropriate annotates their webbing diagrams</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• with teacher guidance they identify, negotiate and allocate team roles for a first-hand investigation activity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Class activity: Teacher introduces the team activity in which the students are asked to solve a problem using their understanding of and skills in investigating and teamwork, eg Handout Sheets: Team Problem-solving Activity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Team activity: Students plan and perform a first-hand investigation to separate sand from a substance that dissolves in water (eg sugar).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Planning the investigation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In teams, with teacher guidance, students use a planning scaffold to:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• identify the nature of the problem to be solved</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• discuss a range of strategies and how these would provide possible solutions to solving the problem</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• select the most appropriate strategy for solving the problem and record the reasons for their choice</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• write the steps they will use to perform their investigation including how their findings will be recorded</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• identify risks that need to be reduced or eliminated in the plan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>select from provided equipment the resources needed to perform the task.</td>
</tr>
<tr>
<td>A student:</td>
<td>Students learn to/about:</td>
<td>Using investigations to solve problems (cont)</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>4.14 follows a sequence of instructions to undertake a first-hand investigation</td>
<td>4/5.14 perform first-hand investigations to: a) follow the planned procedure when performing an investigation c) safely and efficiently construct, assemble and manipulate identified equipment d) evaluate and modify experimental procedures</td>
<td>During this planning stage the teacher uses questioning and discussion with each team to stimulate their thinking about their plan, safe work practices to address risks and the problem-solving processes and thinking they are using. Each team checks their plan and risk assessment with the teacher before undertaking their investigation.</td>
</tr>
<tr>
<td>4.22 completes a variety of individual and team tasks with guidance</td>
<td>4/5.22.2 work in teams to: h) evaluate the process used by the team and the effectiveness of the team in completing the task</td>
<td></td>
</tr>
<tr>
<td>4.20 uses an identified strategy to solve problems</td>
<td>4/5.20 solve problems to: d) evaluate the appropriateness of different strategies for solving an identified problem</td>
<td></td>
</tr>
<tr>
<td>4.2 uses examples to illustrate how models, theories and laws contribute to an understanding of phenomena</td>
<td>4/5.2 the nature and practice of science to: a) evaluate the role of creativity, curiosity, objectivity and logical reasoning in describing phenomena, carrying out investigations and in devising and testing hypotheses g) identify that the nature of observations made depends on the understanding that the observer brings to the situation • value a scientific problem-solving approach • experience satisfaction in applying the processes of science</td>
<td></td>
</tr>
<tr>
<td>4/5.26 recognises the role of science in providing information about issues being considered and in increasing understanding of the world around them</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Appendix: Science Years 7–10 Advice on Programming and Assessment

Class activity: Students, with teacher guidance, review the ideas recorded at the start of the unit in ‘About Science’ and discuss their understanding of: • how creativity, curiosity, openness to new ideas and logical thinking were used in planning and performing their scientific investigation to solve a problem • why working in teams is important in scientific investigations • some ways the science and technology are interrelated.
Appendix 3.9  Sample feedback template for student research

(Assumes that each student is using a *diary or journal* in which he/she has interpreted the requirements of the task, set *goals* and produced a *workable plan* and *timeline*.)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Low</th>
<th>Satisfactory</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locates secondary sources of information or data, eg print, databases, CD-ROMs, visual, oral, internet</td>
<td>With teacher guidance finds TWO different types of sources of information identified in the plan</td>
<td>Finds at least TWO of the identified types of sources of information identified in the plan</td>
<td>Demonstrates well-developed skills in finding at least THREE of the types of sources of information identified in the plan</td>
</tr>
<tr>
<td>Uses a variety of techniques to access appropriate information and data from secondary sources, eg keywords, skimming, scanning, questioning, listening, viewing</td>
<td>With teacher guidance demonstrates the use of TWO different types of techniques to locate and identify information</td>
<td>Demonstrates the use of TWO different types of techniques to locate and identify information</td>
<td>Demonstrates well-developed skills in using a range of types of techniques to locate and identify information</td>
</tr>
<tr>
<td>Extracts appropriate information from a variety of types of first-hand and/or secondary sources, eg written, oral, visual</td>
<td>With teacher guidance chooses and records some relevant information from different types of sources</td>
<td>Chooses and records relevant information from a variety of the located sources</td>
<td>Demonstrates well-developed skills in choosing and recording relevant information from a variety of the located first-hand and/or secondary sources</td>
</tr>
<tr>
<td>Collates information from a number of acknowledged sources</td>
<td>With teacher guidance brings together some related information and records the sources</td>
<td>Brings together related information gathered from a number of acknowledged sources</td>
<td>Brings together related and relevant information gathered from a range of acknowledged sources</td>
</tr>
<tr>
<td>Checks the reliability of gathered data and information</td>
<td>With teacher guidance checks the reliability of gathered data and information by comparing these with teacher-selected sources</td>
<td>Checks the reliability of data and information gathered by comparing these with information from at least ONE other identified source</td>
<td>Checks the reliability of the gathered information and data by comparing these with a range of student-identified and selected sources</td>
</tr>
</tbody>
</table>
### Appendix 3.10 Sample evaluation proforma

| Learning unit/syllabus module: | Number(s) | ________________________________ |
| Name | | ________________________________ |
| Date commenced: | Date completed: | ________________________________ |

**Was the indicative time for the unit appropriate for the cohort?**

**What changes, deletions and/or additional resources would enhance learning and teaching in this unit?**

**How well does the targeted skills content selected for this unit address the skill development 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 learning/teaching strategies better integrate knowledge, understanding, skills, values and attitudes in the unit?**

**Which of the targeted Prescribed Focus Area and skill outcomes need additional emphasis in the unit of work?**

**In what ways could the assessment activities be further developed to:**
- 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: ________________________________**
Appendix 3.11 Sample focus questions for discussion and consideration in evaluation of a learning/teaching unit

<table>
<thead>
<tr>
<th>Indicative timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Is the indicative time for the unit appropriate? If not, which areas need more/less time?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Resources identified</th>
</tr>
</thead>
<tbody>
<tr>
<td>• What particular difficulties or problems were there with equipment or other resources used in first-hand investigations?</td>
</tr>
<tr>
<td>• What resources should definitely be deleted from the list?</td>
</tr>
<tr>
<td>• What new and/or better resources have been identified?</td>
</tr>
<tr>
<td>• In which areas of content would further/different resources be useful and/or are needed?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>First-hand experiences</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Which were the more appropriate practical experiences for the unit content?</td>
</tr>
<tr>
<td>• Which practical experiences were better for illustrating the skills content?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Skills development</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Which skills content needed more explicit learning/teaching experiences than others in this unit?</td>
</tr>
<tr>
<td>• 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?</td>
</tr>
<tr>
<td>• Was the selection of targeted skills content appropriate for the content addressed?</td>
</tr>
<tr>
<td>• In what ways does the skills content mapping need to be modified or changed to better address skill development across the course?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Learning and teaching strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Which of the learning and teaching strategies provided were appropriate in identifying and building on students’ prior learning and/or determining future directions?</td>
</tr>
<tr>
<td>• Were the suggested learning/teaching strategies effective in providing opportunities for conceptual development for all students?</td>
</tr>
<tr>
<td>• How effective were the context(s) selected in assisting students to make meaning of the content?</td>
</tr>
<tr>
<td>• Did this unit provide sufficient variation in learning opportunities for the range of different types of learners in the group?</td>
</tr>
<tr>
<td>• What was the student response to the unit?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessment tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Do the assessment activities:</td>
</tr>
<tr>
<td>– include a range of syllabus outcomes</td>
</tr>
<tr>
<td>– explicitly state the outcomes being assessed and clearly articulate the assessment criteria</td>
</tr>
<tr>
<td>– have well-constructed marking guidelines</td>
</tr>
<tr>
<td>– allow students to provide evidence of the breadth and depth of their learning in relation to the outcomes being addressed?</td>
</tr>
<tr>
<td>• How well do the feedback strategies communicate to students their strengths, weaknesses and areas for improvement?</td>
</tr>
</tbody>
</table>
Appendix 3.12  Example of a student feedback proforma for a unit of work

Name of unit ________________________________________________________________
Your name (optional) _______________________________________________________
Teacher’s name ____________________________________________________________

To help with the planning of future Science learning units, your feedback on the unit you have just completed is most important.

Respond to the statements below on a 1–4 scale where:

1 = Strongly Agree, 2 = Agree, 3 = Disagree, 4 = Strongly Disagree

Space is provided for additional comments at the end if you wish to make them.

<table>
<thead>
<tr>
<th>Statement</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>At the start, we discussed the unit and what we would like to learn about and do</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>During this unit, class members worked together cooperatively on the questions and problems we had identified</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>There was plenty of opportunity for me to discuss what we were learning about and doing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>We planned and carried out our own ‘hands-on’/practical experiences, as well as the ones our teacher suggested</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I was able to find and use a lot of useful materials (eg text references, online resources, etc) to help me understand the work</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I was provided with useful feedback on my progress during this unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I understand how my work in this unit will help me in future units</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall, I learned a great deal from this unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall, I really enjoyed this unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Additional comments (eg anything you would like to have learned more about, suggestions for improvement, etc)

_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________

Thank you for your feedback
Appendix 3.13  Maker model

With the child you name below in mind, look down the column headed ‘Characteristics’. Put a check mark in the column headed ‘True’ next to each of the characteristics that you feel is true of the child when he or she is challenged in the subject area you’ve specified below. When you’ve finished checking the characteristics, highlight the row of ‘Xs’ beside each characteristic that you have checked. Now, go back to the top. Look down each ‘Modification’ column and count the number of Xs that are highlighted. Record the total at the base of each column in the row marked ‘Actual Totals’. Estimate the proportion of the Total Possible Xs represented by the Actual Total. Circle the two or three largest proportions. These are the most recommended strategies for this child in this subject area. These are your starting points for modifying activities for this child in this subject area. Now, get your creative juices flowing and put them to work on a learning activity.

Name: _______________________________ Subject area: _____________________ Date: ____________

<table>
<thead>
<tr>
<th>True Characteristics</th>
<th>Content</th>
<th>Process</th>
<th>Product</th>
<th>Learning environment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Abstractness</td>
<td>Complexity</td>
<td>Variety</td>
<td>Study of people</td>
</tr>
<tr>
<td>1. Unusually advanced, fluent, rich vocabulary (oral or written)</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>2. Amazing store of information about a variety of topics</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>3. Quick mastery and recall of information</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>4. Rapid insight into cause–effect relationships; needs to know how and why of things</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>5. Quickly understands underlying principles, similarities, differences and is able to make valid generalisations across subject areas, events and/or people</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>6. Is a keen, intense and sensitive observer</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>7. Eager reader; reads &amp; understands sophisticated, difficult material</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>8. Enjoys reasoning things out; analysing knowledge; enjoys complex ideas</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>9. Becomes intensely involved in certain topics or problems; is absorbed and persists until task is completed</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>10. Easily bored with routine tasks</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>11. Not easily satisfied with his or her speed or products; perfectionist; self-critical</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Requires little direction from teacher or parent to complete tasks</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>13. Is interested in many ‘adult’ issues and problems</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>14. Often stubborn in beliefs</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>15. Loves to organise and bring structure to people, things and situations</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>True Characteristics</td>
<td>Content</td>
<td>Process</td>
<td>Product</td>
<td>Learning environment</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------</td>
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<td>---------</td>
<td>----------------------</td>
</tr>
<tr>
<td></td>
<td>Abstraction</td>
<td>Complexity</td>
<td>Variety</td>
<td>Study of people</td>
</tr>
<tr>
<td>16. Shows great concern for right and wrong; justice and fairness; can be extremely judgemental</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>17. Incredibly curious; constantly asking questions</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>18. Offers many ideas for solutions to problems; often unusual, clever, unique suggestions</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. Uninhibited in expressing opinion; spirited in disagreement</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. Adventurous risk-taker; loves speculating</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>21. Loves intellectual play, manipulating ideas, fantasy or imagining. Enjoys imagining improved versions of objects and systems</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. Keen sense of humour (sometimes appropriate, sometimes not)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum total possible for each modification</td>
<td>10</td>
<td>8</td>
<td>11</td>
<td>5</td>
</tr>
</tbody>
</table>

Source: Adapted from *Curriculum Development for the Gifted* (pp 8–17) by CJ Maker, 1992, Austin, TX: PRO-ED. Copyright 1992 by PRO-ED, Inc. Adapted with permission.
# Appendix 3.14 Lesson modification worksheet

Student’s name: ___________________________ Date: ________________

Subject area: ______________________________

## Unmodified lesson

<table>
<thead>
<tr>
<th>Objective:</th>
<th>Content:</th>
<th>Process:</th>
</tr>
</thead>
</table>

## Modifications recommended for this student (refer to chart)

<table>
<thead>
<tr>
<th>Content</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstractness</td>
<td>Higher-level thought</td>
</tr>
<tr>
<td>Complexity</td>
<td>Open-endedness</td>
</tr>
<tr>
<td>Variety</td>
<td>Debriefing/reasoning</td>
</tr>
<tr>
<td>Study of people</td>
<td>Freedom of choice</td>
</tr>
<tr>
<td>Methods of inquiry</td>
<td>Group interaction</td>
</tr>
<tr>
<td></td>
<td>Pace</td>
</tr>
<tr>
<td></td>
<td>Variety of learning processes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product</th>
<th>Learning environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real problems</td>
<td>Student-centred</td>
</tr>
<tr>
<td>Real audience</td>
<td>Independence</td>
</tr>
<tr>
<td>Transformation</td>
<td>Openness</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Accepting</td>
</tr>
<tr>
<td></td>
<td>Complex</td>
</tr>
<tr>
<td></td>
<td>High mobility</td>
</tr>
</tbody>
</table>

## Modified activity

<table>
<thead>
<tr>
<th>Content:</th>
<th>Process:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product:</th>
<th>Learning environment:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Self-check sentence:

If I modify the ____________________________________________
by _____________________________________________________________
then the bright/gifted student will learn ____________________________________________
as well as _____________________________________________________________

Appendix 4.1 Planning and recording proforma

Planning and recording proformas can be developed for students at different levels of experience and competence in designing and conducting investigations.

The language of the planning and recording proforma shown below is very simple. It is an example of one suitable for students in early Stage 4 to plan and conduct investigations, especially if they have limited former experience in undertaking open-ended investigations. After practice and familiarisation with this table in class, this type of planning and recording proforma could be further used to guide students in designing and conducting their student research project.

**Stage 4 planning and recording proforma**

<table>
<thead>
<tr>
<th>Question</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>What am I going to investigate?</td>
<td></td>
</tr>
<tr>
<td>What do I think will happen?</td>
<td></td>
</tr>
<tr>
<td>Why do I think it will happen?</td>
<td></td>
</tr>
<tr>
<td>What am I going to do?</td>
<td></td>
</tr>
<tr>
<td>What will I need?</td>
<td></td>
</tr>
<tr>
<td>How will I make it a fair test?</td>
<td></td>
</tr>
<tr>
<td>What happened?</td>
<td></td>
</tr>
<tr>
<td>How did what happened compare to my prediction?</td>
<td></td>
</tr>
<tr>
<td>Why did it happen?</td>
<td></td>
</tr>
<tr>
<td>What was difficult for me?</td>
<td></td>
</tr>
<tr>
<td>How I could improve this investigation?</td>
<td></td>
</tr>
</tbody>
</table>

The following planning and recording proforma is an example of one which can be used with students who have had some experience with open-ended investigations. It incorporates some additional and more demanding questions and may be more suitable for Stage 5.
## Stage 5 planning and recording proforma 1

<table>
<thead>
<tr>
<th>Question</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>What am I going to investigate?</td>
<td></td>
</tr>
<tr>
<td>What do I think will happen? Why?</td>
<td></td>
</tr>
<tr>
<td>Which variables am I going to: • change? • measure? • keep the same?</td>
<td></td>
</tr>
<tr>
<td>How will I make it a fair test?</td>
<td></td>
</tr>
<tr>
<td>What equipment will I need?</td>
<td></td>
</tr>
<tr>
<td>What happened?</td>
<td></td>
</tr>
<tr>
<td>Can my results be presented as a graph?</td>
<td></td>
</tr>
<tr>
<td>What do my results tell me? Are there any relationships, patterns or trends?</td>
<td></td>
</tr>
<tr>
<td>How can I explain the relationships, patterns or trends in my results?</td>
<td></td>
</tr>
<tr>
<td>What did I find out about the problem I investigated? How was the outcome different from my prediction?</td>
<td></td>
</tr>
<tr>
<td>What difficulties did I experience in doing this investigation?</td>
<td></td>
</tr>
<tr>
<td>How could I improve this investigation, eg fairness, accuracy?</td>
<td></td>
</tr>
</tbody>
</table>

The following planning and recording proforma is suitable for students towards the end of Stage 5 who have experience in independently planning and conducting open-ended investigations. It uses more formal language and incorporates more demanding questions.
## Stage 5 planning and recording proforma 2

<table>
<thead>
<tr>
<th>Question</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the problem I am investigating?</td>
<td></td>
</tr>
<tr>
<td>What do I know about this topic from personal experience and from science?</td>
<td></td>
</tr>
<tr>
<td>What variables may affect the phenomenon I am investigating?</td>
<td></td>
</tr>
<tr>
<td>Which of the variables am I going to investigate as the independent variable (the variable that will change to observe what effect it has on the dependent variable)?</td>
<td></td>
</tr>
<tr>
<td>How will the independent variable be changed in the experiment?</td>
<td></td>
</tr>
<tr>
<td>What is the dependent variable (the variable that responds to changes in the independent variable)?</td>
<td></td>
</tr>
<tr>
<td>How will I measure the dependent variable?</td>
<td></td>
</tr>
<tr>
<td>What question am I investigating? OR What hypothesis am I testing (the relationship between the independent and dependent variables)?</td>
<td></td>
</tr>
<tr>
<td>What do I predict will happen? Why?</td>
<td></td>
</tr>
<tr>
<td>What variables are to be controlled (kept constant) to make it a fair test?</td>
<td></td>
</tr>
<tr>
<td>How will I collect my data? (A description and explanation of the experimental set-up using a labelled diagram)</td>
<td></td>
</tr>
<tr>
<td>Are there any special safety requirements?</td>
<td></td>
</tr>
<tr>
<td>Were there any problems with the preliminary trials?</td>
<td></td>
</tr>
<tr>
<td>How did I modify my experiment to fix the problems?</td>
<td></td>
</tr>
<tr>
<td>What data did I collect to test my hypothesis?</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>How did I make sure that my data were accurate?</td>
<td></td>
</tr>
<tr>
<td>What is the best way to present my data? Is it appropriate to draw a graph? What type of graph is most suitable?</td>
<td></td>
</tr>
<tr>
<td>What are the patterns or trends in my data? What is the relationship between the variables I have investigated? Is the hypothesis supported by the data?</td>
<td></td>
</tr>
<tr>
<td>Using science concepts, how can I explain the patterns, trends or relationships I have identified in my data? What is my conclusion?</td>
<td></td>
</tr>
<tr>
<td>What were the main sources of experimental error? (sample size and selection, measurement error, poor control of variables)</td>
<td></td>
</tr>
<tr>
<td>How confident am I with my conclusion?</td>
<td></td>
</tr>
<tr>
<td>How could the design of the experiment have been improved to reduce error?</td>
<td></td>
</tr>
<tr>
<td>What have I learned about the topic of my investigation? How was the outcome different from my prediction?</td>
<td></td>
</tr>
<tr>
<td>What further investigations could be performed?</td>
<td></td>
</tr>
<tr>
<td>What have I learned about the methods of investigating in science?</td>
<td></td>
</tr>
</tbody>
</table>
## Appendix 4.2 Sample feedback template – Working in a team (Stage 5)

<table>
<thead>
<tr>
<th>Teamwork criteria</th>
<th>Low</th>
<th>Satisfactory</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defines team responsibilities</td>
<td>With teacher guidance outlines team responsibilities and goals</td>
<td>Defines team responsibilities and goals</td>
<td>Demonstrates confidence in describing team responsibilities and goals</td>
</tr>
<tr>
<td>Identifies and allocates specific roles</td>
<td>With teacher guidance identifies specific individual roles within the team</td>
<td>Identifies specific individual roles within the team and makes suggestions as to how they should be allocated</td>
<td>Matches team members to roles according to the specific requirements of the task based on the skills of the individual</td>
</tr>
<tr>
<td>Sets goals and timelines</td>
<td>With teacher guidance identifies goals and sets timelines for the task</td>
<td>Identifies goals and sets timelines</td>
<td>Demonstrates high-level skills in setting realistic goals and timelines</td>
</tr>
<tr>
<td>Communicates opinions/ideas</td>
<td>With teacher guidance expresses opinions and ideas</td>
<td>Clearly expresses opinions and ideas</td>
<td>Communicates opinions and ideas succinctly and logically</td>
</tr>
<tr>
<td>Uses listening and negotiation skills</td>
<td>With teacher guidance uses active listening and negotiation skills</td>
<td>Demonstrates some skills in active listening and negotiation</td>
<td>Demonstrates high-level active listening and negotiation skills</td>
</tr>
<tr>
<td>Engages in and monitors teamwork</td>
<td>With teacher guidance takes responsibility in a negotiated role to follow a plan to meet goals and timelines</td>
<td>Takes responsibility for roles within the team and works with others to meet goals, timelines and monitor progress of the task</td>
<td>Demonstrates responsibility in a number of roles and in decision-making so that goals and time lines are met and the progress of the task is monitored</td>
</tr>
<tr>
<td>Accepts responsibility for maintenance of a safe working environment</td>
<td>With teacher guidance takes responsibility for maintaining a safe working environment</td>
<td>Takes responsibility for maintaining a safe working environment</td>
<td>Demonstrates a high level of responsibility for maintaining a safe working environment</td>
</tr>
<tr>
<td>Team effectively completes the task</td>
<td>With teacher guidance identifies some processes which assisted the team to complete the task</td>
<td>Describes the effectiveness of some parts of the plan and some processes used by the team to complete the task</td>
<td>Evaluates the effectiveness of the plan and processes used by the team in completing the task</td>
</tr>
</tbody>
</table>
Appendix 4.3  Feedback template for student research project

This could be used for self-, peer- and/or teacher feedback.

<table>
<thead>
<tr>
<th>OUTCOMES AND CONTENT</th>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Needs to improve</td>
</tr>
<tr>
<td>(a) Identifying problem and data sources</td>
<td></td>
</tr>
<tr>
<td>• describes the problem under investigation</td>
<td></td>
</tr>
<tr>
<td>• develops a question or hypothesis for investigation</td>
<td></td>
</tr>
<tr>
<td>• describes different strategies and evaluates their appropriateness for solving the</td>
<td></td>
</tr>
<tr>
<td>problem/testing the question</td>
<td></td>
</tr>
<tr>
<td>• identifies the type and sources of data/information that need to be collected</td>
<td></td>
</tr>
<tr>
<td>• identifies information relevant to the problem, including background information</td>
<td></td>
</tr>
<tr>
<td>• identifies how the data and information will be collected and recorded</td>
<td></td>
</tr>
<tr>
<td>(b) Planning the investigation</td>
<td></td>
</tr>
<tr>
<td>• develops an appropriate timeline</td>
<td></td>
</tr>
<tr>
<td>• selects an appropriate strategy to solve the problem/test the question</td>
<td></td>
</tr>
<tr>
<td>• gathers information from a range of recorded sources</td>
<td></td>
</tr>
<tr>
<td>• identifies the variable(s) that will be kept the same</td>
<td></td>
</tr>
<tr>
<td>• identifies the variable(s) that will be changed</td>
<td></td>
</tr>
<tr>
<td>• describes and justifies the planned procedure</td>
<td></td>
</tr>
<tr>
<td>(c) Choosing equipment</td>
<td></td>
</tr>
<tr>
<td>• lists equipment and/or resources needed to perform the investigation</td>
<td></td>
</tr>
<tr>
<td>• carries out initial testing, making necessary modifications to equipment and/or</td>
<td></td>
</tr>
<tr>
<td>procedure</td>
<td></td>
</tr>
<tr>
<td>• justifies changes made to equipment and/or procedures</td>
<td></td>
</tr>
<tr>
<td>• lists possible risks and describes how they will be reduced</td>
<td></td>
</tr>
<tr>
<td>(d) Performing first-hand investigations</td>
<td></td>
</tr>
<tr>
<td>• follows planned procedure using time and resources effectively</td>
<td></td>
</tr>
<tr>
<td>• records data using appropriate units</td>
<td></td>
</tr>
<tr>
<td>• evaluates and modifies the experimental procedure</td>
<td></td>
</tr>
<tr>
<td>• makes observations and measurements over a number of trials</td>
<td></td>
</tr>
</tbody>
</table>
### OUTCOMES AND CONTENT

<table>
<thead>
<tr>
<th>Feedback</th>
<th>Needs to improve</th>
<th>Satisfactory</th>
<th>Well developed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(e) Processing information</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• organises data using a variety of methods</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• checks the reliability of gathered data by comparing with data from other sources</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• applies mathematical concepts to assist analysis of data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• identifies trends, patterns, relationships and contradictions in data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>(f) Critical thinking</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• identifies data which supports or discounts the hypothesis/question being investigated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• makes generalisations in relation to results</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• generates plausible explanations directly related to observations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• recognises errors and identifies areas for improvement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• evaluates the appropriateness of the strategy used to address the problem/question</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>(g) Presenting information</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• selects and uses appropriate text type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• selects and uses clear and appropriate ways of presenting information</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• selects and uses appropriate types of tables, graphs, spreadsheets, databases, flow charts or diagrams to convey information and relationships clearly and accurately</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• selects and uses an appropriate method to acknowledge sources of information</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Student comments:**

Student signature ______________________________

**Teacher comments:**
Appendix 4.4  Student reflection sheet

My student research project (SRP)
How am I going?

My SRP is due on ___________________________
I have now had my SRP for ___________ days/weeks.
I have spent ___________ hours on my SRP.

1. What is my SRP about? (Use point form)

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

2. Have I followed my plan? What changes have I had to make to my plan? Why were the changes needed?

___________________________________________________________________________
___________________________________________________________________________

3. What I have done so far in my SRP is

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

4. How do I feel about the work I’ve done so far?

___________________________________________________________________________
___________________________________________________________________________

5. What do I still have to do to complete my SRP? (Outline of my plan, which includes dates and what I will do each day/week.)

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

I have ____________ days/weeks until my SRP is due.

Parent’s comment: _________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
Appendix 4.5 Student research project timeline

This table could be subdivided into smaller progressions with a more explicit scaffold depending on the skills of the student involved.

<table>
<thead>
<tr>
<th>Date due</th>
<th>SRP</th>
<th>Student comment</th>
<th>Teacher comment</th>
</tr>
</thead>
</table>
| Week A   | Teacher:  
• introduces SRP  
• sets class timeline  
Students:  
• purchase journal  
• brainstorm and record ideas for the SRP  
• review the process  
• establish expectations, requirements and assessment criteria for SRP  
It is important that the student is able to honestly self-monitor throughout the project if there is to be genuine development of organisational and analytical skills  |  | Comments could relate to:  
• degree of success in following their plan and timeline  
• suggestions for improving their research, procedure, processes and quality of product  |
| Week B   | Student:  
• identifies problem and sources of information  
• records question/hypothesis  
• identifies strategies and solutions  
• outlines investigation plan  
• sets own goals and individual timeline  
• discusses question and plan outline with teacher  
• submits journal for checking  |  |  |
| Week C   | Student:  
• discusses proposed question, planned investigation and risk assessment with teacher  
• carries out initial testing using proposed equipment  
• evaluates procedure, makes and records modifications  
• performs investigation  |  |  |
| Week D   | Student:  
• prepares outline of report including procedure, results, preliminary discussion and conclusions  
• submits and discusses report outline with teacher  |  |  |
| Week E   | Student:  
• presents final report in an appropriate format  
• presents journal  
• provides SRP timeline, self and peer evaluations  |  |  |
| Week F   | Teacher:  
• provides individuals and teams with feedback  |  |  |

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Appendix 4.6 Student research project journal

Instructions to students

Part of the assessment of your SRP is for the final report and part for your planning and the work you complete along the way. To help your planning and work throughout the research project you will need to keep a journal. This is a book in which you record a brief summary of what you do each time you work on your SRP.

Note: Your journal is a diary of your research project – not everything that happens in your life! Include ideas, research, plans, difficulties and changes but make sure you stick to the topic of your research project.

Here are some suggestions for your journal:

• **Buy a good quality, lined book** – don’t use loose-leaf or scraps of paper or you may lose important information. A4 is the best size.

• **Begin your journal with an outline of what your SRP is about** – information provided by the teacher, what you want to investigate, what activities you think you will carry out and why you are doing this topic. Discuss this outline with your teacher and make any changes suggested.

• **Set out a week-by-week plan** (a timeline) of what you plan to do. This plan may change as you go along, but it will help to set the work out at the beginning – it will surprise you how much there is to do.

• **Treat your journal as a diary** – record every piece of work you do (eg library visits, interviews, telephone calls) – it is your way of showing your teacher that you have taken the SRP seriously and worked consistently.

• **Record the details** of all books, magazines, etc, while using them so that it is easy to complete a bibliography for your final report – include author, title, publisher, date of publication and the pages that you referred to. This will save time later.

• **Record details of all** letters sent and phone calls made as well as surveys handed out and interviews you conducted. Glue in rough drafts of surveys and letters as well as a copy of the final product.

• **Record your failures as well as your successes** – keep a record of strategies you considered to solve the problem and why you rejected some and kept others. Note phone call details, even if the person you called was no help; record details of library visits even if you couldn’t find the information you needed; and record all letters sent, even if you didn’t receive replies; etc.

• **Record all the details of the hands-on investigations you carried out** including the planned procedure, equipment used, modifications to the procedure and why these were made, risk assessment and how hazards were minimised and the results obtained. *Photographs over the period of the SRP is a good way to record your investigation procedure, observations and results.*

• **Include** the outline of your report and subsequent drafts of your final report.

• Don’t rewrite your journal – it is meant to be your original work. So don’t copy it out neatly again or put it on computer. It is meant to be a rough workbook.
Appendix 5.1 Employability skills

This information is provided as teacher background only to demonstrate the close links that exist between the Working Scientifically skills in the Science Years 7–10 Syllabus and the range of skills that employers identify as important in the workplace.

The Employability Skills build on the Mayer Key Competencies Framework (developed in 1992) which attempted to describe generic competencies for effective participation in work. The Business Council of Australia (BCA) and the Australian Chamber of Commerce and Industry (ACCI), in consultation with other peak employer bodies, produced the Employability Skills for the Future report which was officially released in May 2002. The report indicated that business and industry required a broader range of skills than the Mayer Key Competencies Framework. It featured an Employability Skills Framework identifying eight Employability Skills:

- communication
- teamwork
- problem-solving
- initiative and enterprise
- planning and organising
- self-management
- learning
- technology.

The report demonstrated how Employability Skills can be further described for particular occupational and industry contexts by sets of facets or important work skills.

The following table contains the Employability Skills facets identified in the report:

<table>
<thead>
<tr>
<th>Skill</th>
<th>Facets</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Communication</strong></td>
<td>Aspects of the skill that employers identify as important. The nature and application of these facets will vary depending on industry and job type.</td>
</tr>
</tbody>
</table>
| that contributes to productive and harmonious relations across employees and customers | • listening and understanding  
• speaking clearly and directly  
• writing to the needs of the audience  
• negotiating responsively  
• reading independently  
• empathising  
• using numeracy effectively  
• understanding the needs of internal and external customers  
• persuading effectively  
• establishing and using networks  
• being assertive  
• sharing information  
• speaking and writing in languages other than English |
| **Teamwork**         | • working across different ages irrespective of gender, race, religion or political persuasion  
• working as an individual and as a member of a team  
• knowing how to define a role as part of the team  
• applying teamwork to a range of situations eg futures planning and crisis problem-solving  
• identifying the strengths of team members’ coaching and mentoring skills, including giving feedback |
<table>
<thead>
<tr>
<th>Skill</th>
<th>Facets</th>
</tr>
</thead>
</table>
| **Problem-solving** that contributes to productive outcomes | • developing creative, innovative and practical solutions  
• showing independence and initiative in identifying and solving problems  
• solving problems in teams  
• applying a range of strategies to problem-solving  
• using mathematics, including budgeting and financial management, to solve problems  
• applying problem-solving strategies across a range of areas  
• testing assumptions, taking into account the context of data and circumstances  
• resolving customer concerns in relation to complex project issues |
| **Initiative and enterprise** that contribute to innovative outcomes | • adapting to new situations  
• developing a strategic, creative and long-term vision  
• being creative  
• identifying opportunities not obvious to others  
• translating ideas into action  
• generating a range of options  
• initiating innovative solutions |
| **Planning and organising** that contribute to long-term and short-term strategic planning | • managing time and priorities – setting timelines, coordinating tasks for self and with others  
• being resourceful  
• taking initiative and making decisions  
• adapting resource allocations to cope with contingencies  
• establishing clear project goals and deliverables  
• allocating people and other resources to tasks  
• planning the use of resources, including time management  
• participating in continuous improvement and planning processes  
• developing a vision and a proactive plan to accompany it  
• predicting – weighing up risk, evaluating alternatives and applying evaluation criteria  
• collecting, analysing and organising information  
• understanding basic business systems and their relationships |
| **Self-management** that contributes to employee satisfaction and growth | • having a personal vision and goals  
• evaluating and monitoring own performance  
• having knowledge and confidence in own ideas and visions  
• articulating own ideas and visions  
• taking responsibility |
| **Learning** that contributes to ongoing improvement and expansion in employee and company operations and outcomes | • managing own learning  
• contributing to the learning community at the workplace  
• using a range of mediums to learn – mentoring, peer support and networking, IT and courses  
• applying learning to technical issues (eg learning about products) and people issues (eg interpersonal and cultural aspects of work)  
• having enthusiasm for ongoing learning  
• being willing to learn in any setting – on and off the job  
• being open to new ideas and techniques  
• being prepared to invest time and effort in learning new skills  
• acknowledging the need to learn in order to accommodate change |
| **Technology** that contributes to the effective carrying out of tasks | • having a range of basic IT skills  
• applying IT as a management tool  
• using IT to organise data  
• being willing to learn new IT skills  
• having the OH&S knowledge to apply technology  
• having the appropriate physical capacity |
## Appendix 6.1 Year 10 Science assessment plan

<table>
<thead>
<tr>
<th>Task description</th>
<th>Task 1 Term 1, Week 5</th>
<th>Task 2 Term 2, Week 6</th>
<th>Task 3 Term 3, Week 5</th>
<th>Task 4 Term 4, Week 3</th>
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<tbody>
<tr>
<td>Task description</td>
<td>Performing a first-hand investigation</td>
<td>Half-yearly examination</td>
<td>Planning a first-hand investigation</td>
<td>Secondary sources research task</td>
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<td>Weighting</td>
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<td>20%</td>
<td>30%</td>
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<td>Knowledge and understanding</td>
<td>5.4, 5.7</td>
<td>5.1, 5.7, 5.8, 5.10, 5.12</td>
<td>5.2, 5.6, 5.11</td>
<td>5.3, 5.5, 5.6, 5.9, 5.12</td>
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<tr>
<td>Planning and conducting investigations</td>
<td>5.14, 5.15, 5.16, 5.17, 5.22</td>
<td>—</td>
<td>5.13, 5.22</td>
<td>5.13, 5.16</td>
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<tr>
<td>Problem-solving</td>
<td>—</td>
<td>5.19, 5.21</td>
<td>5.17, 5.19, 5.20, 5.21</td>
<td>5.17, 5.19, 5.20, 5.21</td>
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<tr>
<td>Communicating</td>
<td>5.18</td>
<td>5.18</td>
<td>5.18</td>
<td>5.18</td>
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</tbody>
</table>
Appendix 6.2  Model for evaluating an assessment task

Does the task focus on outcomes?

What is the purpose of the assessment task?
Which syllabus outcomes are to be assessed by the task?

What type of task is appropriate for the outcomes being assessed?

Is the type of task appropriate for the outcomes being assessed?
How is the task integrated into the learning/teaching program?
Have the students had opportunities to develop the knowledge and skills being assessed?

How has the task been designed?

Does the task have an explicitly stated purpose that addresses the outcomes?
Have the requirements of the task, including marking criteria, been communicated clearly?
Does the task give students the opportunity to demonstrate what they know and can do?
Are sources and stimulus material clear and appropriate?
Does the task include assessment of some higher-order thinking skills?
Have marking guidelines providing for the full range of student responses been devised?

Is the task valid?

Does the task assess a balanced selection of knowledge and skills outcomes?
Does the task assess only performance relevant to the task?
Do the marks or grades which have been allocated reflect the relative importance of each part of the task? For Year 10, have the areas of assessment according to the course performance descriptors been identified?
Will appropriate discrimination of student performance be achievable?

Will the task produce reliable results?

Are the instructions unambiguous?
Is the language level appropriate?
Is the task an appropriate length?
Is the level of difficulty of each item suitable?
Do any of the items contain gender or cultural bias?
Is there a shared understanding of the demands of the task among the teachers responsible for the marking?
Are the marking guidelines able to be applied consistently?

How will feedback be provided to the students?

Is there opportunity for students to obtain individual feedback in a timely manner?
Is feedback linked to the the specific outcomes and marking criteria addressed by the task?
Does each student get meaningful, constructive feedback about what they are able to do and what they need to do in order to improve their level of performance?
Is there opportunity for self and/or peer evaluation?
Appendix 6.3 Purpose of the assessment task

Assessment can be grouped into three broad categories:

**Diagnostic** – this type of assessment can be used to determine students’ needs. It is a useful planning instrument to include at the beginning of a unit provided that the unit is sufficiently flexible to accommodate changes indicated by the assessment. During a unit, diagnostic assessments provide the teacher with information about special remedial help or special instruction that a student may need.

**Formative** – this type of assessment is most useful, involving the use of classroom observations and activities embedded within the learning unit to improve knowledge, understanding, conceptual development and skills. Students know and recognise the standards for which they should aim and there is feedback that leads them to identify what they should do next in order to improve. Students review and reflect on their performance and progress, and develop skills in peer- and self-assessment.

**Summative** – this type of assessment provides information about the degree of achievement of students at the end of a learning unit, year or stage. These assessment tasks are conducted primarily so teachers can make judgements about student achievement at or up to a certain time. Formal assessment tasks such as tests, examinations, projects or major assignments are generally used to make summative judgements. Summative assessments may also be used to compare students by providing a relative assessment of a student’s performance.
Appendix 6.4 Research assignments

Research assignments are usually extended activities that involve investigation of a problem by gathering and processing information from a range of first-hand and/or secondary sources. The presentation of the research assignment will generally include a written, oral, visual or multimedia report.

If as well as the product, the skills and processes involved in undertaking research are to be assessed, this record could be maintained in a log, journal or diary for the activity. Students need to develop an understanding that it is scientifically acceptable to be able to make only a tentative interpretation or explanation, or to reach a conclusion, based on some sets of data.

Students should be given clear guidelines for types of tasks, and a timeline that should include identified progress check points with the teacher. A useful strategy is to require students to submit a plan of their research assignment for discussion with their teacher or peers before launching into the main body of the research assignment.

Teachers and students need to have a clear understanding of the purpose of the task, why it is being undertaken and how it relates to their learning. If the activity is to be used to assess students’ learning, the criteria that will be used should be provided with the activity. If a research assignment is to be undertaken by a team, the suggested teamwork criteria in Appendix 6.5 could be used; these could be adjusted appropriately for an activity to be completed by an individual student. The activities could be assessed by the teacher, the students themselves, other students and teachers or combinations of these.

Some criteria that could be used in assessment of research assignments include:
- planning
- gathering information from a range of resources
- checking reliability of gathered data
- collating and summarising information
- interpretation of findings
- presentation
- discussion of process and findings
- creativity and imagination.

Feedback should be constructive and meaningful. It should use strategies that focus on what was expected in the activity. This feedback should also provide opportunities for the student to reflect on their learning.
Appendix 6.5 Teamwork

Working individually and in teams is one of the working scientifically skill outcomes to be addressed in each stage. The Science Years 7–10 Syllabus identifies essential content for these outcomes that is not stage-specific and should be demonstrated by students by the end of Stage 5. Teamwork is one of a range of Employability Skills identified by employers as important in the workplace. The Employability Skills build on the Mayer Key Competencies (1992) which attempt to describe generic competencies for effective participation in work.

Working in a team requires the use of effective communication and interpersonal skills. When introduced to and while undertaking the team activities, teachers may need to introduce opportunities for students to review their prior understanding and develop their communication and interpersonal skills – such as active listening, conflict resolution, negotiation skills and team building – that are needed to work effectively with others.

When students are conducting team activities, teachers are well placed to assess their level of skill development in both working individually and in teams. Such skills can enhance learning within and beyond the classroom for most students. Clear guidelines in relation to the knowledge, understanding and skills requirements need to be in place before the team activity begins, including, if appropriate, the criteria to be used in assessing students’ teamwork skills and participation.

Some examples of the types of criteria that could be used to assess students’ skills in working individually and in teams during the planning and performing of teamwork activities are suggested below:

1. During the planning stage of an activity, the team members should:
   • identify the requirements of the activity
   • identify the specific team roles that are need for the activity
   • describe the roles and responsibilities and match these to the skills of individuals in the team
   • negotiate to allocate roles to individual team members
   • record the agreed and accepted roles and responsibilities of each team member
   • collaborate to set realistic timelines and goals
   • keep a journal and record all aspects of the planning and processes, including individual work and teamwork that occur during the activity.

2. During the implementing stage of the activity, team members should:
   • accept personal responsibility for meeting individual goals and timelines
   • participate in team discussion, communicating their opinions and ideas
   • listen to and negotiate with other team members
   • participate in discussions designed to monitor team roles and progress
   • work effectively in individual roles and as a team to meet timelines and goals
   • record any variations to the planned individual and/or team responsibilities as they evolve and the reasons for these variations.

3. During the review stage of the activity, team members should:
   • assess their own and others contribution within the team to complete the activity
   • reflect on and record the effectiveness of the plan and processes used by the team
   • assist in the preparation and/or presentation of the product.
Peer assessment could also be included as a strategy for assessing teamwork skills. It would be important that students gain skills and experience of peer assessment in a variety of situations and are provided with specific, clear criteria for the activities they are assessing. It is important that they have developed sound interpersonal skills and are sensitive and respectful in their dealings with each other. Assessment of each student’s capabilities in working effectively in a team, and how they engage with and manage their roles and responsibilities, may also be used to identify potential leadership qualities.

If the team activity is to be used to gather evidence of student learning, the students need to be informed of the criteria that will be used to assess their learning. The sample feedback template provides an example of one model that could be used to inform students what they need to do to demonstrate evidence of learning in relation to working in a team. It would also provide effective student feedback that enables students to recognise their strengths and areas for development.
Appendix 6.6 Observation and oral presentations

As students are planning and conducting hands-on practical experiences teachers often have the opportunity to observe aspects of learning. The recording of these observations provides evidence of learning for teachers when making judgements about students’ achievements of particular syllabus outcomes. A systematic approach to the recording of such information increases the effectiveness of observation as an assessment strategy.

By listening to what students say, including their responses to questions or other input, teachers are able to gather evidence both formally and informally about students’ existing science knowledge, understanding and attitudes. Through interviews (which may only be a few minutes in duration) and effective questioning teachers can collect specific information about the ways in which students think and their science attitudes in certain situations. The students’ responses to questions and their comments will often reveal strengths, misunderstandings, alternative conceptions, levels of understanding about science and scientific inquiry, interests, attitudes and capabilities.

Through interviews, student oral explanations and demonstrations, rather than from written work, the teacher can often better:
- diagnose difficulties in student knowledge and/or understanding and assess their progress
- check the student’s comprehension of scientific information and understanding of concepts/ideas
- identify the level of a student’s skills development in critical and creative thinking
- judge a student’s ability to apply their scientific knowledge to an unfamiliar context
- assess a student’s ability to communicate their understanding about science
- improve a student’s confidence by making them aware of what they know and can do
- judge the level of a student’s participation and contribution as a team member.

Records of teacher observations form a valuable addition to information gained using other assessment strategies and facilitate a teacher’s judgement of their students’ level of achievement of the syllabus outcomes at key points. Recording of information from observation can be through:
- anecdotal records
- checklists
- journals
- annotated class notes.

Recording student performance needs to be based on readily observable criteria, and needs to be manageable. Teachers should make decisions about which aspects of student performance in an activity should be recorded, and in what format. The sample recording sheet provides one example.

A scale such as the one following may be a useful way of summarising the extent of students’ learning. This method can be adapted to capture evidence of an individual student’s strengths and the areas for improvement in various elements of one activity. The example shows how individual students performed in the same assessment activity.
Sample recording sheet

<table>
<thead>
<tr>
<th>Student</th>
<th>Activity – Oral presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>x</td>
</tr>
<tr>
<td>B</td>
<td>x</td>
</tr>
<tr>
<td>C</td>
<td>x</td>
</tr>
<tr>
<td>D</td>
<td>x</td>
</tr>
<tr>
<td>E</td>
<td>x</td>
</tr>
<tr>
<td>F</td>
<td>x</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Progressing</th>
<th>Satisfactory</th>
<th>High</th>
</tr>
</thead>
</table>
Appendix 6.7 Written tests

Written tests are a valuable means of obtaining evidence of learning at various points in the learning/teaching cycle. They can be appropriate ways of assessing some syllabus outcomes and content, but they may not be appropriate for assessing all outcomes and should be used in conjunction with a variety of other assessment strategies.

In determining whether it is appropriate to use a **written test**, it is important to consider the:
- purpose of the assessment (e.g. diagnostic, formative or summative)
- objectives and outcomes to be assessed
- preferred learning styles of different students and their levels of confidence in Science.

**Constructing written tests**

As for all types of assessment tasks, written tests should be based on the knowledge, understanding and skills outcomes that have been explicitly taught in the units to be assessed by the test. Objective items and short response items are the only types of questions used in external Science tests or examinations. Questions requiring extended responses are not included in external Science tests and examinations and therefore would not be included in class tests or examinations.

Specific marking guidelines and/or schemes should be developed at the same time as the test to ensure the questions are written in such a way as to draw the correct response from a well-prepared student. The responses that the students give will provide evidence of learning directly related to the outcomes being assessed.

**Objective items** are those based on small amounts of stimulus material where students need to relate to the content of a statement, diagram or set of data and make a choice in response to it. These types of items include multiple-choice, true/false or constrained response questions.

**Short response items** require students to recall or process information, and respond by providing anything from a word or number to writing a sentence or paragraph of information, or drawing a diagram or graph. An example of these types of items also includes the 6–8 mark responses required in School Certificate tests in Science, in which students need to draw on and synthesise knowledge, understanding (including PFAs) and skills content to demonstrate their level of achievement of syllabus outcomes. Such items are referred to as holistic questions; they invite creative and integrated responses that may be worth more marks than the sum of their individual parts. These items require flexible marking guidelines that acknowledge and reward a range of student responses and can include the use of tables, diagrams, equations and calculations.

Both of these types of items may be used to allow students to demonstrate achievement across all levels in the performance scale.

As part of their learning experiences, students can be involved in setting questions for tests or quizzes. They could write questions and solutions and submit these to the teacher for possible inclusion in the test, especially where assessment for learning is involved. Where judged to be appropriate by the teacher, students can also mark their own tests or those of their peers. Carefully monitored, this gives students some ownership of the test, allows them to identify their own learning needs and can help improve their performance and attitudes towards tests.
In designing and constructing written tests, some important considerations include:

- Arrange items in increasing order of difficulty so that less able students have some early success.
- Avoid testing minute details of content unless they are vital in meeting course objectives and outcomes.
- Difficult questions are those requiring sophisticated reasoning or understanding of a high-level concept, not because the question tests knowledge of obscure or esoteric content.
- **Key words** can assist in defining the scope and depth of treatment of a content point. For a definition of each word, refer to the *Glossary of Key Words*.

Further information is available on:

Appendix 6.8  Sample recording sheet – oral presentation

<table>
<thead>
<tr>
<th>Criteria</th>
<th>1</th>
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<th>3</th>
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<tbody>
<tr>
<td>A</td>
<td>Content</td>
<td>relevant</td>
<td>interesting</td>
</tr>
<tr>
<td>B</td>
<td>Organisation</td>
<td>engaging introduction</td>
<td>ideas logically developed</td>
</tr>
<tr>
<td>C</td>
<td>Use of Voice</td>
<td>clear</td>
<td>variation of tone</td>
</tr>
<tr>
<td>D</td>
<td>Use of nonverbal aspects of communication</td>
<td>eye contact with audience</td>
<td>appropriate use of facial expression</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student name</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<tbody>
<tr>
<td>Jerod Anderson</td>
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<td>Vanessa Brown</td>
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<td>1</td>
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</table>
Appendix 6.9  Pathways of keywords in assessment

Third Storey: Why?
Evaluative

Critically evaluate
Justify
Assess
Synthesise

Second Storey: How?
Interpretive/Inferential

Why/How
Conditions
Discuss
Pros and cons

MAIN IDEAS

Compare
Analyse

First Storey: What?
Literal

Explain
Distinguish
Describe
Contrast
Outline
Identify

(See Board of Studies Glossary of Key Words; see also Bloom’s Taxonomy)