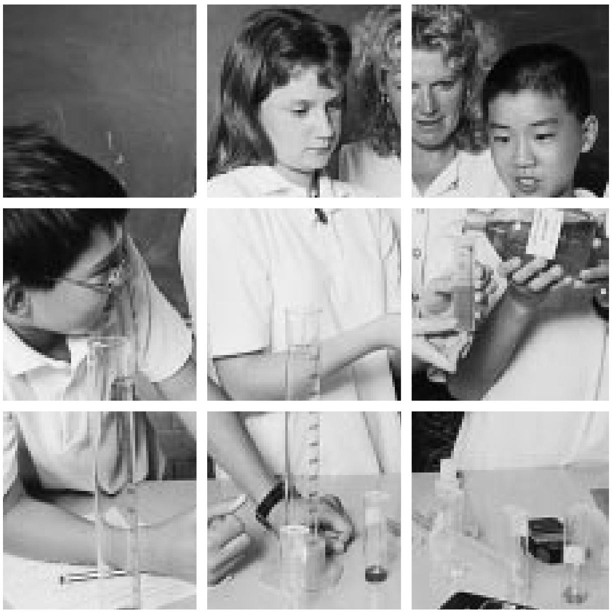
SCIENCE

Learning Area Statement



In the Science learning area students learn to investigate, understand and communicate about the physical, biological and technological world and value the processes that support life on our planet. Science helps students to become critical thinkers by encouraging them to use evidence to evaluate the use of science in society and the application of science in daily life.

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Definition & Rationale

Science is a dynamic, collaborative human activity that uses distinctive ways of valuing, thinking and working to understand natural phenomena. Science is based on people's aspirations and motivations to follow their curiosity and wonder about the physical, biological and technological world. Scientific knowledge represents the constructions made by people endeavouring to explain their observations of the world around them. Scientific explanations are built in different ways as people pursue intuitive and imaginative ideas, respond in a rational way to hunches, guesses and chance events, challenge attitudes of the time, and generate solutions to problems. As a result of these endeavours, people can use their scientific understandings with confidence in their daily lives.

Science has many methods of investigation, but all are based on the notion that some form of evidence is the basis for defensible conclusions. Because scientific explanations are open to scrutiny, much scientific knowledge is tentative and is continually refined in the light of new evidence. The quest to construct coherent, tested, public and useful scientific knowledge requires people in their scientific undertakings to be creative and open to new ideas, to be intellectually honest, to evaluate arguments with scepticism, and to conduct their work in ways which are ethical, fair and respectful of others.

Science is part of human experience and has relevance for everyone. All people can experience the joy and excitement of knowing about and understanding the world in which they live. A knowledge of science enables them to value the systems and processes that support life on our planet, and to take a responsible role in using science and its applications in their daily lives. Through science people are able to develop a sense of place. They recognise that people from different backgrounds and cultures have different ways of experiencing and interpreting their environment, so there is a diversity of world views associated with science and scientific knowledge which should be welcomed, valued and respected in science education.

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Learning about science enables students to explore the organisation and structure of the social, economic, political and technological world. They learn how science and technology are inter-related, and how their applications shape the way humans live. They analyse the pressures and processes which determine the priorities for research and the direction and development of science and technology. They become aware that the promised benefits of research should improve the quality of life and be shared as widely as possible.

Science education empowers students to be questioning, reflective and critical thinkers. It does this by giving them particular ways of looking at the world and by emphasising the importance of evidence in forming conclusions. Science education develops students' confidence to initiate and manage change to meet personal, vocational and societal needs. Science education assists students to be active citizens by providing the understandings they need to be informed contributors to debates about sensitive, moral, ethical and environmental issues. An appreciation of scientific knowledge, processes and values has the potential to help students build a more productive and ecologically-sustainable environment. It is important that students in Western Australian schools appreciate and understand how the study of science presents them with opportunities for responsible decision making in their local, national and global communities.

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Science Learning Outcomes

WORKING SCIENTIFICALLY

INVESTIGATING

1. Students investigate to answer questions about the natural and technological world using reflection and analysis to prepare a plan; to collect, process and interpret data; to communicate conclusions; and to evaluate their plan, procedures and findings.

COMMUNICATING SCIENTIFICALLY

2. Students communicate scientific understanding to different audiences for a range of purposes.

SCIENCE IN DAILY LIFE

3. Students select and apply scientific knowledge, skills and understandings across a range of contexts in daily life.

ACTING RESPONSIBLY

4. Students make decisions that include ethical consideration of the impact of the processes and likely products of science on people and the environment.

SCIENCE IN SOCIETY

5. Students understand the nature of science as a human activity.

UNDERSTANDING CONCEPTS

EARTH AND BEYOND

6. Students understand how the physical environment on Earth and its position in the universe impact on the way we live.

ENERGY AND CHANGE

7. Students understand the scientific concept of energy and explain that energy is vital to our existence and to our quality of life.

LIFE AND LIVING

8. Students understand their own biology and that of other living things, and recognise the interdependence of life.

NATURAL AND PROCESSED MATERIALS

9. Students understand that the structure of materials determines their properties and that the processing of raw materials results in new materials with different properties and uses.

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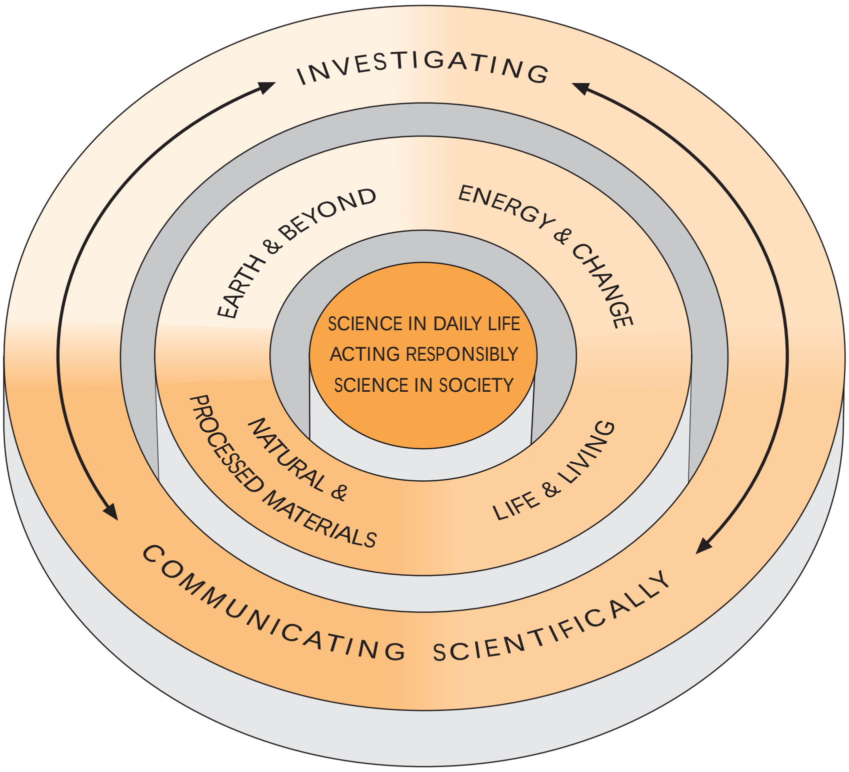
INTRODUCTION

The outcomes of the Science Learning Area Statement are organised into two parts. The Working Scientifically outcomes address the skills of scientific inquiry and the ways people use scientific information. The Understanding Concepts outcomes encompass distinctive scientific understandings, theories, ideas and knowledge, and draw from the traditional scientific disciplines. The paragraphs beneath each outcome exemplify, further explain and illustrate achievement of the outcome from a kindergarten to year 12 perspective. In some situations, teachers may choose to develop a science program based on the traditional disciplines of science. In others, an integrated approach, perhaps developed in the context of other learning areas, may be appropriate.



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WORKING SCIENTIFICALLY

Working Scientifically comprises five outcomes: Investigating, Communicating Scientifically, Science in Daily Life, Acting Responsibly and Science in Society. In planning curricula, learning experiences should link the Working Scientifically outcomes with the development of scientific conceptual understandings and the process outcomes in other learning areas.

INVESTIGATING

1 Students investigate to answer questions about the natural and technological world using reflection and analysis to prepare a plan; to collect, process and interpret data; to communicate conclusions; and to evaluate their plan, procedures and findings.

Students plan investigations using a variety of processes that may involve exploring ideas and materials; reflecting on their knowledge and experience; reviewing background information; thinking laterally; discussing ideas; clarifying purposes; identifying variables; making predictions and educated guesses that lead to research questions or hypotheses; and inventing feasible, valid and accurate strategies for investigation.

Students collect data by obtaining suitable materials and equipment; designing and building equipment and tools where necessary; choosing suitable measurement methods; and sequencing procedures effectively. Students may use scientific instruments, audio-visual equipment and computers for collecting, organising, interpreting and representing data. They take care to ensure that measurements and observations are accurate, sufficient and relevant, and that the process of data collection does not harm other people, animals or the environment. Students ensure that investigations are conducted safely and ethically, while working individually and in cooperative teams in group investigations.

Students process data by recording and classifying information in organised and logical ways, using quantification and calculation where necessary; searching for patterns in results; and constructing graphical and symbolic representations. They draw conclusions by linking new and old understandings; adjusting personal and established theories and models; constructing explanations and solutions; and proposing further investigations.

Students review and evaluate their investigations and the implications of their data as an integral part of the science inquiry process. They challenge their own beliefs and ways of doing things by reflecting on their investigations; questioning personal or received ideas and solutions; revising and adding to their questions in the light of new evidence; and identifying issues and converting them into questions that the practice of science can seek to answer.

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COMMUNICATING SCIENTIFICALLY

2 Students communicate scientific understanding to different audiences for a range of purposes.

Students realise that the purpose of communication in science is to present essential scientific information in a form suitable for their audience. They communicate findings and understandings using technical language and genres suitable for the occasion. They use information technology to find and access background information from various sources and to organise information.

Students use spoken, written, diagrammatic, representational and symbolic forms to communicate effectively in science to peers, teachers and communities: for example, they communicate their science knowledge about a snail or lizard by drawing a picture of the animal and correctly labelling its parts, or writing a story about a snail or lizard, conveying what a snail or lizard is like from a science point of view, rather than what it feels like to be a snail or lizard. Students may debate the arguments for and against establishing an abalone or crocodile farm. Other students may compile their research findings into a database that visitors to a nature centre could use to find out about the natural history of gastropods or reptiles in the locality.

SCIENCE IN DAILY LIFE

3 Students select and apply scientific knowledge, skills and understandings across a range of contexts in daily life.

Students explore and explain natural and technological phenomena in their everyday world in terms of scientific concepts. They identify relevant scientific concepts to explain the operation of tools and appliances, farms and gardens, industrial processes, and health and hygiene. They give appropriate scientific explanations for safe procedures, such as those used in storing household chemicals, lighting camp fires, refuelling an engine, or handling animals. Students routinely read labels and practise safe procedures in handling all substances in the home, garden and workplace, including cleaners, solvents, medicines and fuels, as well as known toxins, such as herbicides and pesticides.

Students recognise when scientific knowledge can be used to explain and predict events in their daily lives: for example, as the school sports carnival approaches, they might use knowledge of their own biology to plan a high energy diet and a schedule of exercise to maximise performance on the day. Students synthesise scientific understanding with a range of other information to solve practical problems: for example, they might use soap to reduce friction and help make a drawer slide more smoothly or use a mirror to search for a pen that has fallen behind a cupboard.

ACTING RESPONSIBLY

4 Students make decisions that include ethical consideration of the impact of the processes and likely products of science on people and the environment.

Students think and act carefully and with concern about the ways science is used in their home, school and the broader community. They consider the positive and negative personal, social, economic, technological, cultural, political and environmental implications of scientific knowledge and how it is used. They recognise that risks and uncertainties arise from processes and products of science that impact on people, their human rights, their cultures and the environment. Students discuss the scientific aspects of and form reasoned judgements about issues ranging from, for instance, the recycling of drink containers to the aggressive advertising of infant formulas in developing countries. They consider what, if any, action they might take.

Students critically analyse the impact on their local environment of human activities such as the use of fire, urban development, farming, mining and tourism. They acknowledge human responsibility for the effects of science and make responsible decisions about their own use of science and its products: for example, after noticing that weeds are invading a natural bushland area in the school grounds, students make a list of possible solutions to the problem of killing the weeds. They evaluate the solutions from a scientific point of view and decide to remove the weeds by hand and compost them rather than use a herbicide.

SCIENCE IN SOCIETY

5 Students understand the nature of science as a human activity.

Students appreciate the evolutionary nature of scientific knowledge and understand that science is a human endeavour. They have a sense of the history of science, its relationship with other human endeavours and how it contributes to society. They understand that new discoveries in science and how they are used may be controversial because they challenge people's established beliefs. In order to reconcile the conflict between their views and those of others, they uphold attitudes and values, such as openness to new ideas, intellectual honesty, respect for evidence and commitment to scientific reasoning. Students understand how theory, observation and experiment are interrelated. They appreciate that when they make observations, they do so from their own point of view and way of thinking. They recognise that aspects of scientific knowledge are constructed from a particular gender or cultural perspective. They know about the lives and contributions of some women and men scientists at local, national and international levels. They give examples of how science is used in different workplaces and consider the prospect of careers in science.

UNDERSTANDING CONCEPTS

Four outcomes are identified: Earth and Beyond, Energy and Change, Life and Living and Natural and Processed Materials.

Through achieving these outcomes, students' conceptual understandings of the physical and biological world will be enhanced. These outcomes should be developed in conjunction with the Working Scientifically outcomes. The emphasis placed on particular concepts may vary according to students' needs and location, including the physical, biological and technological nature of the environments in which they live.

EARTH AND BEYOND

6 Students understand how the physical environment on Earth and its position in the universe impact on the way we live.

Students know that the sustainability of life depends on the quality of the air and the availability of water and materials from the ground, and they use these resources wisely. They recognise and interpret weather patterns and describe how the weather affects them and their environment. They might demonstrate this by devising methods to measure and record wind, cloud cover, rain and temperature over a week and relate weather conditions to the clothes they wear and the activities they undertake. They explain how and why weather patterns are monitored and used to make forecasts and predict events such as droughts and cyclones.

Students recognise that humans have made use of the earth's materials according to properties of these materials: for example, they might describe how wet sand makes better sandcastles than does dry sand; explain why adding humus to a sandy soil makes plants grow better; suggest why chert is preferred to sandstone for the manufacture of stone tools; or discuss how the nature and variety of archaeological artefacts can be used to deduce how past civilisations lived and worked in their environment.

Students understand that the earth's resources are finite and argue the importance of conserving and replacing them: for example, they identify and take steps to remedy water wastage in their home or school by detecting leaky taps, monitoring the placement of sprinklers, describing water consumption in their community (taking into account seasonal variation and the nature of the water supply) or creating an effective plan to monitor community water use.

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Students understand that the earth is composed of materials that are altered by forces within it and on its surface. They describe the processes of weathering, erosion and tides and how such physical processes affect the landscape. They give examples of erosion in their local area, such as in river beds, sand dunes or salt lakes, and evaluate the success of steps taken to remedy its effects.

Students identify some common minerals, describe the origin of rocks and give examples of common rock types and how they are used. They use a map showing the location of earthquakes and volcanoes to identify the position of tectonic plate margins and describe the processes happening. Students understand how the geological occurrence and properties of an ore are related to how it is mined. They recognise the impact of mining on the physical environment and suggest ways in which the area can be rehabilitated: for example, students explain why topsoil is removed and stored during bauxite mining and replaced to begin rehabilitation.

Students recognise the relationship between the earth, our solar system and the universe. They know that the moon, sun and other stars appear to move relative to the earth and that these movements correspond to the pattern of day and night, the seasons and the behaviour of living things: for example, students name the stars, moon and sun and realise that the sun is linked with daylight and the moon and stars with night time. Alternatively, they measure the length of the shadow of a stick at intervals during the day and relate the results to the relative position of the sun. Students might construct a 'lunar log' of the moon's position and appearance over a month and use the relative positions of the sun, moon and earth to interpret their results.

Students describe how changing ideas and theories about the nature and origin of the universe are interwoven with the changing cultures of different civilisations and societies. They contrast the ideas and beliefs held by people of different cultures, and in earlier times, about the importance of the sun and examine how these beliefs affected people's daily lives. Students use their knowledge of theories about conditions on other worlds and the origin of life on the earth to speculate about the possibilities of life in other parts of the universe.

ENERGY AND CHANGE

7 Students understand the scientific concept of energy and explain that energy is vital to our existence and to our quality of life.

Students define the scientific concept of energy, give examples of energy sources and describe patterns of energy use around the home and in the community. They recognise change as something that involves the transfer of energy, such as being warmed by heat from the sun or hearing the sound of wind in the leaves. From their investigations they learn that some human activities require more energy than others.

Students understand and apply their knowledge about a range of concepts associated with energy, such as current and static electricity; the principles of machines; the nature of light, sound and magnetism; the nature of collisions; and the processes of heating and cooling. They relate different forms of energy (such as kinetic, potential, thermal, electrical, chemical and nuclear) to physical, chemical and biological change and interaction: for example, they suggest ways to cool down on a hot day or describe how energy in the form of X-rays is used in medicine and industry and explain the care and safety aspects involved.

Students know that energy has renewable and non-renewable sources, and that there are social issues involved in its production and use. They estimate the economic and ecological cost of using different energy sources and plan energy-saving practices in the home, school or community: for example, they might prepare a timeline showing how various energy sources have been used for activities such as transport in a particular society and examine the shortcomings and benefits of those sources to that society.

Students understand that energy can be transferred from one form into another, and that change involves the transfer of energy. They realise that the same source of energy can be used for different purposes: for example, electricity from a battery can be used to make a toy move, a radio produce sound or a torch give out light. They describe how objects such as electric toasters, mouse-traps and apples act as both receivers and sources of energy. Students use a scientific model to explain the transfer of heat in solids, liquids and gases or the process of magnetising a piece of iron.

They consider the concepts of force, work and power in terms of energy transfer. They apply the principles of energy transfer, conservation and efficiency to sequences of interaction, such as the generation of heat from fuel or the output of light from an incandescent bulb: for example, they use the principle of conservation of energy to calculate the efficiency of a kettle or describe the energy changes in a roller-coaster or a pendulum clock and explain the apparent loss of energy in these systems.

LIFE AND LIVING

8 Students understand their own biology and that of other living things, and recognise the interdependence of life.

Students understand the interdependence of all living things in an environment and can explain how changing one aspect of the environment will affect other organisms. They understand the concept of an ecosystem. Using an ecosystem they have studied, such as a terrarium in the classroom, an aquarium in the home, a park or a paddock, students describe the variety of relationships that exist between the organisms. They also consider the influence of physical conditions such as light, moisture and temperature on the ecosystem. They use diagrams and other means to model the flow of energy and the cycling of matter within an ecosystem. They predict the consequences of change in an unfamiliar ecosystem on the population and distribution of the organisms within it.

Students understand the relationship between structure and function in living things and use that as a basis for understanding life-maintaining processes. They identify the characteristics of living and non-living things. They recognise themselves as living things and give examples of their needs and the characteristics that identify them as living. They classify plants and animals into major groups by describing similarities and differences.

Students describe how living things function as whole organisms and explain the relationship between structure and function in systems, organs, tissues and cells: for example, they describe how different animals move in different ways and relate movement to the shape and function of body parts. They recognise different types of plant cells in microscope slides and suggest what their function might be. Students understand physiological processes such as digestion, respiration, circulation, homeostasis, excretion and movement. They know about the effects of disease and how to maintain a healthy lifestyle.

Students can describe how organisms grow and reproduce, and understand how they change over generations. They understand the concept of life cycle and describe some examples for plants and animals. They link reproduction with the inheritance of characteristics, by, for example, recognising that living things grow to resemble their parents. They differentiate between learned and inherited characteristics and use scientific models and theories to give reasons for these things.

Students recognise that a sustainable environment supports a variety of living things and understand the importance of biodiversity in maintaining adaptability, continuity and change in living things. They realise the significance of particular characteristics in relation to survival, adaptation and extinction. They give examples of special relationships between living things, such as the structure of lichen, mistletoe and the mistletoe bird, and how galls form on trees. Students critically examine the place of humans in ecosystems and discuss how to act with compassion and care to sustain these systems. They recognise the ways that humans have changed their local environments and identify some changes as beneficial and others as detrimental for themselves and other organisms.

Students consider theories of evolution and the evidence for them: for example, they examine fossils found on a field trip or a visit to a museum, and find out ways in which they are similar to and different from today's organisms and suggest reasons for the differences. Students consider the ethical implications of humans controlling reproduction, altering genes and changing the lifestyles of other organisms, and can take an informed position in debate about these issues.

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NATURAL AND PROCESSED MATERIALS

9 Students understand that the structure of materials determines their properties and that the processing of raw materials results in new materials with different properties and uses.

Students understand that different materials have different properties and can relate these properties to their uses. They identify similarities and differences between materials by sorting or classifying materials in their homes or classrooms according to their properties, including colour, shape, composition, hardness or reaction with substances such as water. Students explain the relationship between the uses and properties of materials and consider the suitability of alternative materials for particular purposes. They make and modify materials and examine and evaluate the new properties: for example, students might make soup or biscuits, and compare the advantages and disadvantages of the home-made and pre-processed goods in terms of ingredients, taste and shelf-life.

Students understand how the structure of materials can explain their behaviour and properties. They use a range of ways to explain the structure and behaviour of materials, including phases of matter such as solids, liquids, gases, plasma and gels; atoms, molecules, macromolecules and polymers; and elements, compounds and mixtures. Students use diagrams to show how different materials might look under a hand lens and speculate about their structures affect their properties. They distinguish between compounds and mixtures in terms of their composition and make use of scientific models for the structure of matter to explain things such as diffusion, solution and condensation.

Students describe the interactions between, and changes to, materials. They describe and measure aspects of change such as evaporation, solubility and corrosion. They distinguish between changes that can be reversed, like freezing water, and those which cannot, like mixing paints or cooking an egg. They use scientific ideas and models to describe and explain physical and chemical changes. They identify factors that influence the nature and rate of change and know that matter is conserved during these change processes: for example, they demonstrate that sugar dissolves more quickly in hot water than in cold, and explain where the sugar goes when it dissolves. They might use examples of corrosion around their home to describe the chemical changes involved and explain how the process can be slowed or reversed.

Students examine industrial processes and analyse the features designed to make such processes ecologically sensitive and more efficient in their use of materials. They use flow diagrams to represent the sequence of reactions in chemical processes, such as the manufacture of fertiliser or the extraction of ore. After a visit to a factory, bakery, smelter, cannery, a service station or roadhouse, they consider whether materials and energy are used efficiently, identify waste products and decide whether these are disposed of safely.

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SCOPE

The Scope of the Curriculum

PHASES OF DEVELOPMENT

During schooling, students' learning progress depends on their level of maturity, and the learning and teaching programs offered. Because learning is cumulative, schools should offer science curricula that are forward-looking, so that students' earlier learning experiences provide a foundation for later experiences and learning.

In this section, the scope of the curriculum is described at four overlapping phases of development. The descriptions of student behaviours, appropriate learning experiences and expected outcomes are presented in an integrated and holistic way. The purpose of this approach is twofold. Firstly, the approach emphasises that a quality science program enables students to work scientifically to expand and modify their scientific understandings. The selection of learning experiences is neither prescriptive nor exhaustive, but provides examples of possible learning opportunities for students to work scientifically with ideas and concepts. Secondly, the approach highlights the developmental nature of students' learning. It must be remembered that students will progress at different rates. On the basis of a school's particular location and its resources, teachers will make collaborative decisions about the teaching and learning program, and particular approaches to pedagogy and assessment that will provide their students with the best opportunity to achieve the intended outcomes. Often teachers will find that students' learning is best served by using a thematic approach which links the science outcomes and encourages achievement of the outcomes of the Overarching Statement as well as outcomes from other learning areas.

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EARLY CHILDHOOD
(typically kindergarten to year 3)

Features of their personal world fascinate young children. They have a natural curiosity and are keen explorers of their environment. They like to build, invent, make and solve practical problems of their own choosing. They learn through direct experiences with objects using all of their senses. They can represent situations and events through stories and play using concrete objects. Young children actively construct their knowledge and understanding of the world. Provision should be made for children to work on self-initiated activities as well as in co-operation with others.

Young children should be allowed to explore their interests freely. They need opportunities to ask their own questions and search for the answers, often in a game-playing situation. Typically, young children ask questions to seek information and gain immediate satisfaction. Usually the questions involve only one or two categorical variables ('Do insects drink water?' 'Are all rocks hard?'), but the questions are not always simple ('Why is the sky blue?'). While they may have lots of ideas at once, young children tend to manipulate a single idea or concept at a time. They often interpret phenomena separately rather than holistically: for example, they may focus on the parts of a plant rather than the plant as a whole.

Working in science

During the early childhood years, a rich, experiential curriculum will enable young children to develop a repertoire of encounters with, and knowledge about, their world that can be built on in the future. The Working Scientifically outcomes are important. Young children should be provided with opportunities to practise and develop their investigative skills using everyday materials and organisms: for example, they might explore the behaviour of substances such as sand, clay and gravel, and try different ways of separating them. They might devise ways of testing the reaction of a plant or animal to a change in its environment, by varying the temperature or the amount of light or moisture. They might carry out a range of activities in which they investigate forms of energy, such as light (using mirrors and magnifying glasses) or sound (using musical instruments).

Young children must be encouraged to use all of their senses to develop the skills of observing, labelling, comparing, describing and sorting, and to wonder about the differences and changes they observe in their everyday world: for example, they might observe and describe changes in bread as it becomes mouldy, an ice block as it melts, tadpoles as they change into frogs, or clouds as they become big and dark and bring rain. They might watch animals grow and see that caterpillars make a cocoon or chrysalis and change into a moth or butterfly, but that grasshoppers, fish and puppies stay much the same shape as they become bigger. They might observe that sometimes the moon can be seen in the daytime, but at other times not. Young children may be helped to suggest simple explanations for some of their observations.

They might speculate about why plasticine can be reshaped many times but paper cannot, why fruit cans rust when left outside but drink cans do not, or why the stars disappear on cloudy nights.

By manipulating things like balls, blocks and stones, and describing their motion and position, young children begin to understand that the effects of change can be observed, described, measured in some way and controlled. At first, they need to be helped to make measurements using rulers and balances. They should be encouraged to communicate their findings in a variety of ways, including labelled drawings, pictorial graphs, oral and written forms, and acting out of stories. As their investigative skills develop, young children learn to say in advance what they will do in their investigation and tell whether the result is expected or not.

Typically, young children should learn to label, describe, sort and order objects, create a plan and follow a short sequence of steps. They should begin to use symbols to represent objects and events and their rapidly-expanding language skills will provide opportunities to begin to develop a science vocabulary.

Developing conceptual understanding

While young children develop concepts and vocabulary from their experiences, many science concepts (such as energy, ecosystem, air pressure and molecule) remain abstract. During the early years, curriculum experiences should be designed to give young children frequent opportunities to begin exploring concepts like these, which provide the foundation for later understandings. They might investigate energy through the changes it produces in themselves (sunburn), other objects (wind in the trees) and their homes and communities (turning on the lights when it is dark). Although they may not yet understand energy as a concept, young children typically develop intuitive notions about it: for example, energy is needed to make things move or to heat water and humans need food for energy. In helping young children to develop science concepts, the teacher needs to consider how simple explanations used in science have the potential to develop misunderstandings later: for example, we say ‘the sun has gone down’, when we mean that our side of the earth has turned away from the sun.

Young children should be involved in a range of activities from each of the conceptual outcomes. Often the same activity will cover content from several different outcomes: for example, in making biscuits, young children experience the properties of the uncooked dough, which allow kneading and shaping, and find they are different from those of the cooked dough, which has been changed by heat energy. While the biscuits are a food source that provides humans with energy, they are not necessarily an appropriate food for pets or other animals. Often science activities link readily to other learning areas: for example, making and baking biscuits also provide opportunities to contribute to outcomes in Technology and Enterprise relating to the technology process, materials, systems and enterprise, or to Health and Physical Education relating to a healthy lifestyle.

MIDDLE CHILDHOOD (typically years 3 to 7)

As children develop during these years, fascination with their personal world quickly extends to exploration of the wider environment, the close and tiny to the far and gigantic, from germs to galaxies, for example. They can see themselves as members of groups: their family, their class, their school, their club, their community. They begin to see things from others' points of view and like to work collaboratively, planning and discussing what they are doing with their peers. They are usually interested in adventure stories, science fiction and the work of scientists, both past and present. They enjoy field trips and excursions and readily make links between what they know and experience in their lives and what they experience vicariously through the media, including books, TV, videotapes and computer programs.

Children's analytical and intuitive thinking becomes more refined and they are able to deal with more than one concept at a time. During this period, most children begin to classify in a hierarchical way, and to consider systems in terms of their interrelated parts. However, most still find it difficult to comprehend abstract concepts such as density and the difference between heat and temperature. They can apply possibly conflicting explanations of observed events side by side: for example, they might describe a rainbow in terms of light and water droplets in one situation, but in another use an explanation involving a mythical being.

Working in science

During the mid-childhood years, Working Scientifically continues to be a central part of a curriculum that works towards the achievement of science outcomes. Children should be involved in partial investigations, structured by the teacher on particular topics, but they also need the freedom to pose questions that are relevant and meaningful to them. With experience, the questions they ask tend to become more focused and they should be encouraged to plan investigations in increasing detail, using two or more variables. With practice, they become less likely to guess, and more likely to predict the outcomes of their investigations: for example, children might investigate the effect of rotor diameter on descent time for a paper helicopter or the effect of light and soil type on the growth of sunflower seeds.

By collecting data for their investigations, children are given practice in using simple equipment carefully and consistently, and opportunities to interpret their observations and present them in diagrams, written reports, tables and simple graphs: for example, they might plan an investigation using chromatography to separate the food colourings used in lollies. They may need to try different methods of extracting colours from the lollies in order to develop the most effective method for producing and comparing chromatographs. Initially, most children will need to be shown how to find patterns in their data, make summaries and suggest explanations for their observations. Children should be encouraged to reflect on their investigations, identify difficulties and suggest improvements. They will need considerable practice and encouragement to examine all of the evidence they collect – not only that which confirms their expectations – and to challenge their own views. They also may need help to develop the notion of a 'fair test' and the usefulness of repeating measurements.

Developing conceptual understanding

In mid-childhood, the development of children's understanding of abstract concepts such as energy requires curricula that are designed to build on and extend their earlier experiences. Activities involving different forms of energy, like electricity, light, heat and solar energy, can be used to help children begin to develop the notion of energy transfer, ideas about energy sources and receivers, and how energy transfer occurs. They might build a solar cooker, for example, and describe how the sun's energy is collected and focused to provide heat to cook the food.

Teachers need to structure learning activities that promote interaction, so that children learn to reflect on and evaluate their own ideas by talking with others. Many opportunities for children to learn about science concepts should be offered in technological and problem-solving contexts, allowing links to be made across learning areas: for example, dismantling devices such as old toasters or clocks enables children to investigate how these things work and to examine the techniques used to enable or impede energy transfer, such as the use of switches, levers, reflectors and insulators. Teachers should use such activities to help children develop safe working practices in science. Problems requiring considerable imagination should be posed. Children might be asked to use their understanding of animal adaptation and habitat to predict and draw what a creature capable of living on another planet could look like.

Learning experiences must allow children to continue exploration of their own world, and begin to expand their activities beyond the limits of the school grounds. Learning and teaching programs should be designed to provide children with opportunities to think often about science events and processes so that they can begin to make links between science at school, at home and in the community and learn to act in a responsible way. A field trip to the local rubbish disposal site provides opportunities for teachers to integrate concepts and processes in science and with other learning areas at a level appropriate to the children's development. At the site, children might investigate the physical environment, such as the suitability of the soil or rock type and the proximity to water supplies; the nature and biodegradability of the waste materials; and the biological habitat that has developed. They might compare and contrast the kinds of rubbish generated by their school and homes in the community and critically analyse community attitudes to waste management and disposal.

EARLY ADOLESCENCE
(typically years 7 to 10)

Students' interests during these years extend well beyond their own communities and they begin to develop concerns about wider issues. Adolescents align strongly with their peers and are concerned with establishing their own identities. They want to understand their world, especially in terms of how it affects them, and often question accepted practices and other people's priorities: for example, they want to have reasons why they should do assignments, and teachers find it a challenge to create tasks which students consider to have a purpose relevant to them.

Whereas in the earlier years exploration of the natural world was important in helping students to understand science, typically students now begin to use science to help them to understand the world. Most can think logically and analytically and use scientific concepts and generalisations to suggest explanations for phenomena rather than looking for specific facts. Thus they should be provided with opportunities to make predictions and hypotheses in their investigations and to use scientific models to cope with abstract concepts and processes such as the kinetic theory, atomic structure, genes and light years. In addition, these investigations should be structured to encourage students to examine these concepts and processes from different cultural perspectives.

Working in science

The outcomes-focused approach proposed in this curriculum statement is best served by a curriculum in which Working Scientifically remains central. The investigative approach typically used in the primary school needs to be continued into the secondary school to achieve a balance between content and process. The conceptual outcomes are anchored in the importance of science to society and the way we live. To achieve them, students must continue to have ample opportunities to investigate issues and apply concepts in the world around them.

During the adolescent years, learning and teaching programs should be designed to help students understand that science is a discipline in which intuitive and analytical thinking are linked during scientific investigations. Typically, students learn to plan investigations using scientific knowledge to select or adapt equipment where necessary. They should learn to appreciate the value of doing exploratory work to refine the investigation process and use appropriate ways to record and display their data, draw their conclusions and interpret them in the light of current scientific knowledge. Students need time at the end of investigations to allow for the recognition of confirming and refuting evidence and sources of possible errors, as well as to attempting to correct them.

Not all investigations will be designed to test hypotheses. Some will demonstrate concepts such as leaf transpiration, reactions between acids and bases, the need to repeat measurements to develop a ratio to define density, or the hardness and cleavage of common minerals. Some investigations should be open-ended and these will often encourage integration across the Understanding Concepts outcomes, or with other learning areas. Teachers should devise investigations that students find interesting around topics based on current events or problems demonstrating the interrelationship of science, technology and society. There should be occasions when students' investigations impinge on the world outside the classroom in order to further strengthen their skills in relating science to everyday life. This may be enhanced by communicating their findings to a wider audience or taking a stand on an issue they consider to be important, such as destruction of a wetland or the impact of mining on an ecosystem.

Developing conceptual understanding

At this phase of development, students should be provided with opportunities to re-examine many ideas from the conceptual outcomes in science introduced in their earlier work. Not only does this assist in the building of knowledge and understandings, it also helps students to challenge their early ideas and choose between alternative constructions they may have about particular concepts. Abstract concepts such as kinetic energy, electromagnetic radiation, natural selection and plate tectonics may be introduced during this phase, and, with considerable assistance, many students will begin to develop and use scientific models to explain associated phenomena. In order to advance learning about concepts such as forces, energy transfer and chemical reactions, students' investigations need to become more quantitative: for example, they might investigate the efficiency of simple machines, such as pulleys and levers, by comparing input and output energy; calculate the yield of a compound in a chemical reaction; or measure the amount of oxygen used by a respiring plant. As their measurement skills become more accurate, students may use simple mathematical expressions to explain their observations.

During this phase, students typically develop an appreciation of how ideas about scientific processes and concepts are constructed. They should be aware of the contributions made by different people from different backgrounds to our understanding of the scientific world. Opportunities should continue to be provided for them to study cross-curriculum topics that link the process and conceptual outcomes in science and connect clearly to the outcomes of other learning areas in the Curriculum Framework: for example, science-related topics such as crime detection, marine studies, photography, flight or ecotourism provide many possibilities for integrated learning, which increases students' understanding of the connected nature of knowledge and processes.

LATE ADOLESCENCE/ YOUNG ADULTHOOD (typically years 10 to 12)

The science outcomes are relevant to all students in their final years of schooling. Whatever their future directions it is essential that young adults realise the importance of science in helping them to build understandings about themselves and the natural world. There need to be different emphases in curricula to cater for the wide range of students' interests, past achievements and post-school destinations.

Scientific understandings and skills are essential for many careers and vocations, and students should be encouraged to study science for as long as possible at school to keep their career options open. Young adults will be deciding about the particular science courses that they will study. Some select one or more science courses and study these in depth for university entrance; some choose more vocationally-based science courses; and others choose a mixture of courses.

At this stage, many young adults develop sophisticated explanations for concepts. They become increasingly adept at using scientific language in their explanations and are confident in dealing with abstract concepts. They are more capable of linking theoretical ideas with scientific applications and these links need to be encouraged and made explicit in science curricula. Many students are concerned about improving their achievement and, as a consequence, are more committed to study outside school hours. They think more about the science they are learning and how they learn. As well, they realise that improving organisational and study skills will lead to achieving outcomes at a higher level.

Working in science

The outcomes for Working Scientifically are important for all young adult students and learning and teaching programs should be structured to provide them with opportunities to demonstrate the outcomes of the Investigating process at increasingly higher levels. Opportunities must also be available for young adults to develop a greater understanding of the influence and impact of science on peoples' lives. As their depth of understanding of scientific concepts develops, students are better able to apply and evaluate scientific knowledge in different contexts and to act responsibly by making decisions based on the consideration of many factors.

Developing conceptual understanding

The conceptual outcomes for Earth and Beyond, Energy and Change, Life and Living, and Natural and Processed Materials, align to some extent with subjects such as Geology, Physics, Biology and Chemistry, but there is also overlap. Students who choose to study specialist science courses, such as Physics or Biology, will develop and refine their science knowledge and skills in the context of the specialist area. Others may take an integrated science subject or one which has a vocational orientation and they will experience quite different science content.

Science curricula in the post-compulsory years should offer young adults the kinds of experiences that enable them to develop the science knowledge and skills that they see as relevant to their personal aspirations. Although the concepts might be similar, or extend those covered at earlier stages, the teaching strategies and assessment procedures for students at this level should recognise the increasing maturity of young adults. Curricula need to provide opportunities for them to use science in ways that are meaningful and enable them to investigate and make informed judgements about issues they perceive to be relevant.

Learning, Teaching & Assessment

A great deal is known about how students learn science and about classroom conditions that support learning. In this section, the principles of learning, teaching and assessment reflect best practice in the teaching of science and the assessment of students' learning. The principles are connected to those in the Overarching Statement and thus provide another link for teachers to integrate their science programs into other learning areas. The outcomes in the Science Learning Area Statement are best achieved when science programs reflect the developmental nature of scientific understandings and encourage students to generate conceptual frameworks rather than require them to learn many separate scientific facts.

Learning in science is likely to benefit from programs which emphasise the development of concepts rather than the learning of facts. It is the responsibility of teachers to plan and implement a science program that gives all students appropriate opportunities to learn, and sufficient time for them to develop their conceptual understandings.

LEARNING AND TEACHING

■ *Opportunity to learn*

Learning experiences should enable students to engage with and apply the actual processes, products, skills and values which are expected of them.

There is no single best approach for the teaching of scientific concepts and processes. Opportunities to learn are increased when students engage in a variety of learning experiences. Depending on the nature of the scientific learning task, at times students might work with concrete materials or abstract ideas, or they might use mental models and language tools, such as metaphor and analogy, to help them understand phenomena at different levels of abstraction. For example, different ways of thinking and working are required for students to develop science ideas at the macroscopic level, such as measuring the growth of seedlings, and the microscopic level, such as how plant cells divide.

Teachers need to consider carefully the physical environment in which students learn and provide equipment and materials that encourage students to work scientifically with concepts. Engaging in practical investigations helps students to build on their knowledge and experiences to construct concepts that have meaning for them. Students will require assistance to link experiences to the science concepts being explored and strategies that allow them to investigate ideas and to communicate scientifically will be useful in this respect. Sometimes teacher modelling and demonstration of scientific processes also will be appropriate. Opportunities for students to work scientifically in out-of-school settings will allow them to see how science works in daily life and society. Projects that encourage students to develop ways of acting responsibly help them apply their scientific understandings in relevant situations.

Connection and challenge

Learning experiences should connect with students' existing knowledge, skills and values while extending and challenging their current ways of thinking and acting.

Students' interpretations of new scientific experiences are influenced by what they already know. Often, the students' prior knowledge, which is used to deal with scientific phenomena in their everyday world, is not consistent with the explanations accepted by the scientific community. Sometimes students use a more scientifically acceptable framework in the science classroom in parallel with their own alternative frameworks. A considerable part of learning requires students to develop, change and expand their personal ways of thinking to become more consistent with scientific ways of thinking so that they can accept and apply scientifically valid ideas in appropriate contexts. To build concepts, patterns, structures and relationships about the workings of the physical, biological and technological world, students need to learn how to think and work scientifically.

People are more likely to learn scientific knowledge and processes if existing ideas are questioned and reflected upon in a supportive and creative manner. The natural world is a source of great wonder that can capture people's imagination, motivating them to be curious and ask questions. Students develop inquiry skills by trying to find answers to questions. Sometimes, they find unexpected results. Discovering something unexpected that challenges existing ideas is a necessary and accepted part of the learning process. Students should feel comfortable about unexpected discoveries because it helps them to rework ideas. At other times, students find that their current ideas cannot be applied to a solve a new problem. This will provide a challenge that should inspire further thought. Learning will occur more effectively in science if students are able to use such challenges to critically examine their existing concepts and to find ways to accommodate new perspectives or information. Constructing new ideas in science requires students to acquire and make sense of other, more powerful ideas.

Action and reflection

Learning experiences should encourage both action and reflection on the part of the student.

Students need to reflect on their own thinking processes. Working scientifically requires conscious reflection. Students should ask themselves questions about their own learning: 'What am I doing?' 'Is this the best way?' 'Do I understand?' 'What do I do next?' 'What evidence supports my conclusion?' Students are able to make connections between various concepts and contexts, thereby developing critical and analytical thinking skills, and building bigger ideas that deepen and broaden their understandings about the natural world.

Central to this process is the way students use a range of language forms and functions to refine existing conceptual frameworks. Teachers must help students to develop language skills to clarify their thinking and to report their work to others. Many scientific concepts are abstract and students must use language to express and communicate their understanding of them in written, spoken, symbolic and diagrammatic forms. Teachers should help students to recognise that science uses language in a precise way by encouraging them to critically analyse the words used to describe scientific concepts. Students need to become proficient at using the technical language of science and to recognise that science uses a variety of spoken and written genres.

Motivation and purpose

Learning experiences should be motivating and their purpose clear to the student.

Students are more likely to respond positively to tasks that they accept as purposeful. Science activities and investigations should be undertaken in contexts that have meaning for students, using issues that are relevant to their lives and local environments. Integrating science activities and content with other learning areas makes the process of learning science more relevant to students. The challenge for teachers is to present science in a way that continues to be interesting, challenging and rewarding for all students throughout their schooling. Being able to solve a range of problems in different areas using their critical thinking skills is rewarding and empowering for students.

Inclusivity and difference

Learning experiences should respect the individuality of students.

Students learn in different ways, and individuals bring to learning in science unique experiences, interests, motivations, capabilities and predispositions. Students have diverse backgrounds: they differ in where they live, the language and representations of their thinking, and the socio-cultural experiences that have supported them in developing understandings about their world. The different contexts in which students learn to think mean that individuals have preferred ways of learning and constructing new knowledge.

While students in a classroom will have much in common, they also have a range of different science-related experiences and world views that should be respected and accommodated. This means that teachers need to identify students' current ideas and understandings so that they can design activities that build on them. Science curricula that include a range of learning and teaching activities will connect with the variety of students' needs, abilities, interests and cultural backgrounds and challenge them to think in scientific ways. It is important to take into account that learning is a gradual, incremental process that takes time. Students' preferred ways to engage in a particular task will influence the amount of time and practice they need to construct and to accommodate new scientific ideas in their thinking.

Autonomy and collaboration

Learning experiences should encourage students to learn both independently and from and with others.

Learning science is a process that involves constructing and modifying ideas. While this can be a personal activity, learning is enhanced by collaboration with other people. Working scientifically with adults and peers allows students to test personal constructions of scientific concepts with the constructions of others.

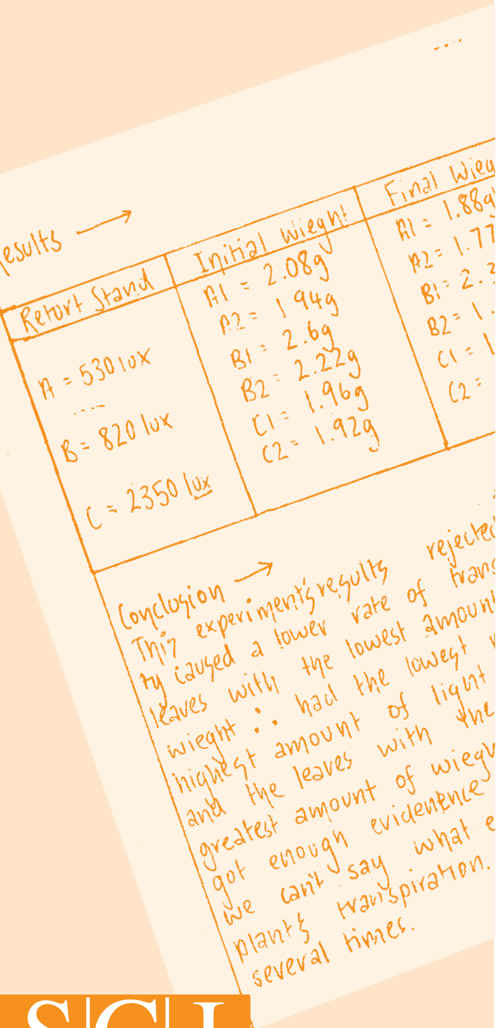
Those involved in the process of learning science will benefit from opportunities to interact with each other in a variety of ways to cater for diverse learning styles and to maintain dignity, interest and motivation. Feedback from others is an essential part of learning and so the quality of interaction between teachers, peers and others is vitally important. This interaction may take many forms, including questioning, cooperative learning, group work, peer debate or critical analysis of scientific investigations. Through opportunities to negotiate goals in a collaborative and supportive way students will be encouraged to accept responsibility for their own learning.

Supportive environment

The school and classroom setting should be psychologically and physically safe and conducive to effective learning.

Challenging but achievable tasks and the experience of success are crucial in building positive attitudes towards science, extending students' confidence in their own abilities and encouraging excellence. The development of science concepts can be a slow process. Concepts need to be continually revised, reconsidered, and reworked. Students intellectual progress will be supported when the diversity of their views and their experiences is recognised and valued. Because of this, it is important that learning environments are planned and structured so that all students feel comfortable with any uncertainties they may have about their scientific understandings. Students may be surprised (but should not feel threatened) to find that someone disagrees with their interpretations of a scientific situation. Encouraging students to use their own ideas is an excellent starting point for investigations. Classroom interaction should allow all points of view to be voiced in an environment free of harassment, so students feel confident to express their opinions freely.

Examination of issues about the care and ethical use of animals, resources and the environment will assist students to become responsible and compassionate practitioners of science. Also, it is essential to develop students' awareness of science safety issues in the classroom, laboratory, field and everyday life. Students need to be able to manage equipment safely, so that they may confidently take part in science experiments and investigations. The safe handling of chemicals is a particular issue. Students need to learn the importance of reading and understanding the labels on bottles and other containers and dealing with the contents accordingly. Teachers of science at all levels will find opportunities to have students practise using substances and materials safely and dealing with waste products responsibly.



ASSESSMENT

Assessment in science is the collection and interpretation of information about students' knowledge, understandings, skills and attitudes relating to the science outcomes. Assessment practice should be explicit, comprehensive and fair. It should be a collaborative process between students and teachers, and have educational value by providing feedback on both learning and teaching.

■ *Valid*

Assessment should provide valid information on the actual ideas, processes, products and values which are expected of students.

Assessment should monitor students' progress towards achieving the science learning outcomes. Students' conceptual understandings, abilities to investigate and to use and apply concepts develop over time, and assessment tasks should gradually increase in complexity to reflect students' progression in these areas. A variety of tasks in a range of different contexts should be used to provide samples of students' work so that valid judgements about progress can be made. To assess investigation competency, students will need to perform whole investigations of problems that are challenging which also allow them to experience success.

■ *Educative*

Assessment should make a positive contribution to students' learning.

Assessment provides feedback that informs the future actions of both students and teachers. Students should be helped to monitor their own learning in science. Teachers need to use the feedback to enhance science teaching programs. They do this by reflecting on their own teaching practice as well as examining the effectiveness of the curricula and resources they use.

Effective assessment in science involves the student as an active participant rather than a passive recipient. Opportunities can be provided for teachers and students to negotiate the assessment tasks and the ways in which they will be carried out. Skills for self-assessment should be developed so that students become more reflective and self-directed in their learning of science.

SCIENCE

■ *Explicit*

Assessment criteria should be explicit so that the basis for judgements is clear and public.

Assessment practice should make clear to students what is being assessed and how. It should provide a clear statement about progress in science to students, teachers, parents and others. The importance of the development of the processes involved in Working Scientifically as well as the construction of conceptual understandings will need to be made explicit to all those involved in the learning and teaching processes. Teachers will need to apply assessment practices that accommodate and explicitly acknowledge how conceptual understandings are developed and that allow students to use their tentative ideas and hypotheses as a starting point for investigations.

■ *Fair*

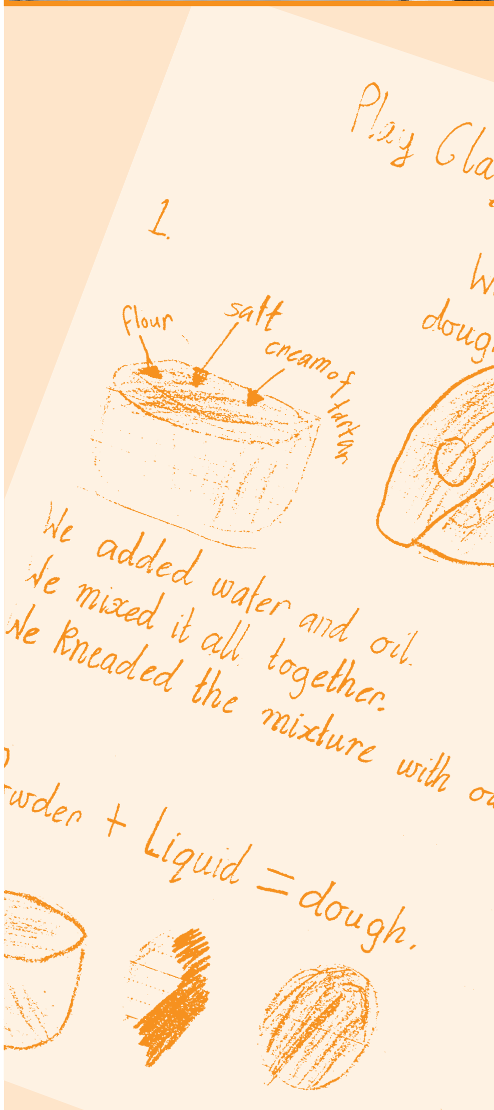
Assessment should be demonstrably fair to all students and not discriminate on grounds that are irrelevant to the achievement of the outcome.

In science, students should be assessed in ways that give them maximum opportunity to demonstrate their learning. To cater for the different needs and interests of students, assessment tasks should be varied. A variety of assessment tasks accommodates preferred learning styles and other differences among students, allowing all to show what they know and can do in science. Fair assessment often means assessing different outcomes in different ways for different students so that characteristics, such as language background, gender, ethnicity, socioeconomic status and disability, do not disadvantage performance.

■ *Comprehensive*

Judgements on student progress should be based on multiple kinds and sources of evidence.

Assessment in science should be designed to assess students' understandings and skills, not only their knowledge of facts. This can be achieved by using a range of evidence about students' progress collected in various situations at different times. It is important not to over-assess: the same assessment task can contribute information to more than one learning outcome.



Links Across the Curriculum

From a science perspective, integration across the curriculum needs to be balanced while retaining and maintaining the integrity of the discipline of science. Thus, the links between the Science and other learning areas should not be contrived: rather, they should support the learning of outcomes across the curriculum.

LINKS TO THE OUTCOMES IN THE OVERARCHING STATEMENT

In this section, the Overarching outcomes are listed in order. Under each outcome is a paragraph which illustrates how the achievement of Science Learning Area Statement outcomes contributes to the achievement of Overarching outcomes.

1 *Students use language to understand, develop and convey ideas and information, and interact with others.*

- In Science, students use language to communicate collaboratively and individually because language is central to thinking and problem solving, and in describing relationships within patterns and structures. Students learn to use metaphor and analogy appropriately to explain scientific concepts. The language of Science is international, with roots in many languages that help to enrich its conceptual power. This is particularly evident in scientific nomenclature and symbolism. (Outcome: direct 1, 2; indirect 3, 4, 5, 6, 7, 8, 9)

2 *Students select, integrate and apply numerical and spatial concepts and techniques.*

- In Science, students are encouraged to use mathematical processes and concepts. As students conduct scientific analysis and report results of scientific investigations, they are involved in processes such as measurement, modelling and quantification. (Outcomes: direct 1, 2, 3, 6, 7, 8, 9; indirect 4, 5)

3 *Students recognise when and what information is needed, locate and obtain it from a range of sources and evaluate, use and share it with others.*

- In Science, students develop skills to locate information, assess its suitability to help them frame their investigations and share this information with other members of their group or class. (Outcomes: direct 1, 2, 3, 5; indirect 4, 6, 7, 8, 9)

- In Science, as students gather and use information, conduct their activities and communicate their results, they make use of and adapt appropriate technologies. (Outcomes: direct 1, 2; indirect 6, 7, 8, 9)

4
Students select, use and adapt technologies.

- In Science, students learn that as well as the aesthetic appeal of the natural world, the beauty of science is found in the patterns and structures people construct from their understanding as they attempt to impose order on apparent chaos, and that this order has explanatory and predictive power. (Outcomes: direct 1, 3, 4, 5, 6, 7, 8, 9; indirect 2)

5
Students describe and reason about patterns, structures and relationships in order to understand, interpret, justify and make predictions.

- As students plan their investigations in Science, they are encouraged to propose a range of creative approaches to solving problems. Often they use physical and mental models as aids to planning and testing proposed solutions. (Outcomes: direct 1, 2, 3; indirect 5, 6, 7, 8, 9)

6
Students visualise consequences, think laterally, recognise opportunity and potential and are prepared to test options.

- Achievement of the Science outcomes contributes to students developing an understanding of the world around them. They learn to appreciate science as a human endeavour, to value the processes that support life on the earth and contribute to societal and personal well-being. They develop the skills and understandings necessary to make informed decisions about the world. (Outcomes: direct 1, 2, 3, 4, 5, 6, 7, 8, 9)

7
Students understand and appreciate the physical, biological and technological world and have the knowledge and skills to make decisions in relation to it.

- In Science, students work towards this outcome by acquiring an awareness of the geographical and historical contexts in which science has developed and is practised. They learn about the ways science interacts with the social, cultural and political worlds, thus contributing to their appreciation of the need to use their knowledge, skills and values to make sensible and responsible decisions in their lives. (Outcomes: direct 5; indirect 1, 2, 3, 7, 8, 9)

8
Students understand their cultural, geographical and historical contexts and have the knowledge skills and values necessary for active participation in life in Australian.

- An awareness that science is a human endeavour can lead students to appreciate the cultural diversity of people who have contributed to its development. Historically, these contributions typically have come from Arabic, Chinese, Greek and Hindu scholars. Students also learn that all cultures have constructed explanations for observable phenomena and so there is debate about the existence of one science or many sciences in the world. (Outcomes: indirect 1, 2, 5, 6, 9)

9
Students interact with people and cultures other than their own and are equipped to contribute to the global community.

10
Students participate in creative activity of their own and understand and engage with the artistic, cultural and intellectual work of others.

■ Science is a creative activity in which students explore their environment, test their ideas and devise explanations to interpret their results. Part of this activity involves using the creative intellectual work of others to enhance their explanations. (Outcomes: direct 1; indirect 2, 3, 4, 6, 7, 8, 9)

11
Students value and implement practices that promote personal growth and well-being.

■ While students are engaged in scientific activities, they acquire knowledge, skills and values to enable them to analyse critically the claims of researchers, organisations and the media. In particular, these skills help them to develop scientific understandings of personal health issues and to make informed decisions about leading managed, active and productive lives.
(Outcomes: direct 8; indirect 3, 4)

12
Students are self-motivated and confident in their approach to learning and are able to work individually and collaboratively.

■ In Science, students are encouraged to take responsibility for their own learning. As self-directed learners, students are motivated and confident in their ability to tackle tasks and problems. Depending on the context, they choose to work individually or collaboratively. (Outcomes: indirect 1, 2, 3, 4, 5)

13
Students recognise that each person has the right to feel valued and be safe, and, in this regard, understand their rights and obligations and behave responsibly.

■ In Science, students have the right to conduct their work in a safe and secure environment. They recognise the need for equitable access and sharing of resources to allow all students to participate in activities. Students are able to work cooperatively and safely and to be responsible for their actions.
(Outcomes: indirect 3 and 4)

LINKS WITH OTHER LEARNING AREAS

The processes of Working Scientifically and the Conceptual Understandings developed in the Science learning area interact dynamically with the skills and understandings of other learning areas. Links between learning areas can be identified through knowledge, competencies and skills, core values and social justice issues, and teaching and learning practices: for example, ideas about the environment, skills in locating and representing information, equality in career and work, and literacy and numeracy often provide alternative entry points for Science across the learning areas. In making links, teachers need to ensure that knowledge and skills are developed in a consistent way, phases of development of students are considered, the learning environment is flexible and resourced, and students are involved in identifying and planning the links.

The Arts

■ The Arts provide avenues for students to communicate their scientific understandings through forms that are not dependent on written language: for example, painting, drawing and three-dimensional models can be used to represent and communicate patterns and relationships associated with the earth and living things. Linking students' knowledge about the properties of materials enables them to make informed judgements about the design and creation of many of their arts works. Scientific understandings about space, sound, light, movement, energy, change and time can be applied in performances or visual arts creations.

English

■ Language is central to students' learning in Science. Students select appropriate language strategies and processes to explore, represent and communicate their scientific understandings and processes. As students construct and interpret the results of their Science activities, their communication skills are enriched through the development and use of a range of language modes to represent and respond to their scientific endeavours.

Skills of critical analysis and logical and reflective thinking about scientific ideas are supported by using the technical language of Science. Students who can express a scientific idea in several language forms deepen their conceptual understandings and broaden their skills in communicating their knowledge to others.

Health and Physical Education

■ In Science, students learn about physiological systems, the technical language that describes these systems, and how to apply this knowledge in their daily lives to achieve and maintain a healthy lifestyle. Energy and change, forces and levers, power and motion are all concepts that allow students to link their understandings to various sports to explore and develop their physical skills. Informed decisions about personal health, concerning exercise, diet, hygiene and disease, can be made when students are encouraged to link their scientific knowledge to their physical well-being.

Scientific knowledge about ecological systems that support life on the earth enables students to evaluate community health issues such as rubbish disposal, environmental waste and communicable diseases. Ethical considerations emerging from Science allow debate on other health issues, such as keeping animals as pets, genetic engineering and euthanasia. Students may take stances on such matters from individual or community perspectives using their scientific knowledge to think, speak and act responsibly.

Languages other than English

■ Many languages have contributed to the development of the conceptual richness of Science. As scientists endeavoured to propose rational explanations of the natural world, they developed the interrelated system of knowledge and processes that represents Science today. Part of Science is the technical language that derives its roots in other languages, particularly Arabic, Greek and Latin. The coming together of different languages in this way illustrates to students the value of knowing more about the structure of other languages.

Mathematics

- Clear links between Science and Mathematics should be made for students.

In Science, students apply Mathematics to assist them make meaning from their investigations by using number, measuring mass, length and time, interpreting chance data and using verbal, symbolic, tabular and graphical ways of representing information.

Students combine skills and understandings from Science and Mathematics to make sense of data, make decisions about patterns and structures, quantify relationships and communicate their interpretations in ways that others understand. Mathematics becomes increasingly important for students in higher levels of research and study in Science.

Society and Environment

- Links are made easily between Science and Society and Environment through students' awareness of the relationship between theory, observation and experiment. The planning and conduct of investigations, the collection and interpretation of information and the communication of findings are processes that students can be transferred between these two learning areas.

There are common conceptual understandings about the environment and natural systems relating to landforms, water and living things. Technical language that students develop in Science. Students can apply their knowledge about Science to enrich their appreciation of continuity and change and ecological sustainability, and, where appropriate, to initiate social action for change.

Technology and Enterprise

- Science links to Technology and Enterprise in the application of scientific knowledge to the development of new technologies to meet human needs.

The interaction between scientific and technological processes and understandings is exemplified when students work scientifically. Technology and Enterprise provides contexts for students to explore the scientific concepts of Earth and Beyond, Life and Living, Energy and Change and Natural and Processed Materials.

The interrelationships between Science, technology and society should be made clear to students through their science programs: for example, by using scientific understandings, students can assess the impact of technology on their daily lives and on the environment. Scientific understanding and technological know-how allow students to make use of limited resources in enterprising ways.