Science

Lower Secondary
Teacher Guide

Papua New Guinea
Department of Education

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Acknowledgments

The Lower Secondary Science Teacher Guide was written, edited and formatted by the Curriculum Development Division of the Department of Education. The development of the Teacher Guide was coordinated by Jane Yanimu Ecneme Pagelio.

Teachers, inspectors, tertiary educators, community members, representatives from non-government organisations, and the Science Subject Advisory Committee have assisted in the development of this teacher guide through meetings, workshops and consultations.

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Contents

Secretary's message

This Science teacher guide is to be used by teachers of science when implementing the Lower Secondary Science syllabus (Grades 9 and 10) throughout Papua New Guinea. The Lower Secondary Science syllabus identifies the broad learning outcomes for this level and the unit learning outcomes. The Science teacher guide gives more information for teachers of Science about what to teach, how to assess students' achievement of learning outcomes, and various strategies for facilitating teaching and learning.

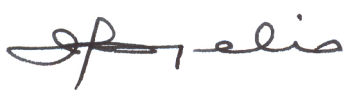
This teacher guide provides limited samples of teaching and learning strategies. It is therefore important that teachers of Science use their initiative and innovative minds to ensure the Lower Secondary Science syllabus is appropriately implemented. The many suggested teaching and learning strategies can be used to make meaningful student learning.

I challenge the teachers of Science to go beyond their own personal beliefs and understanding about the nature of science by researching and investigating today's scientific developments in order to promote how indigenous knowledge and practice blends with contemporary scientific knowledge, skills and values. Teachers of Science have an important role in ensuring that students understand that contemporary scientific knowledge is actually a hybrid knowledge, meaning all cultures have contributed to the development and acceptance of these knowledge, skills and values.

I encourage teachers of Science to thoroughly read through this guide and establish a sound understanding of how to use this document.

I further challenge the teachers of Science to provide realistic and hands-on practical activities both indoor and outdoor to enable students to experience the nature of science and provide explanations for various phenomena around them and the global environment.

I commend and approve this Lower Secondary Science Teacher Guide for use in all schools with Grades 9 and 10 students throughout Papua New Guinea.



DR JOSEPH PAGELIO
Secretary for Education

Introduction

The purpose of this teacher guide is to support you, the teacher of Science to implement the Science syllabus.

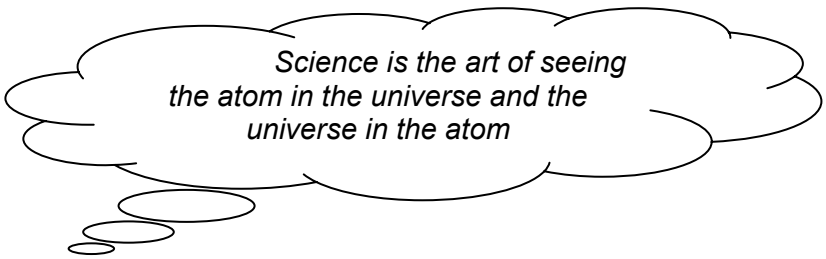
All lower secondary syllabuses use an outcomes approach to education. This simply means that teaching and learning is focused on student learning. Activities in the science room or laboratory are designed to help students to achieve the specified learning outcomes. The Science syllabus specifies the unit learning outcomes that students achieve at the end of each unit. The unit learning outcomes build towards the specified broad learning outcomes that students achieve at the end of Grade 10.

This Science teacher guide expands on the learning outcomes for each unit to help you plan unit activities and teaching strategies. It encourages you, the teacher of Science to develop activities that are appropriate and relevant to help students achieve unit learning outcomes by research.

Assessment of learning and assessment for learning are two important concepts in outcomes based education. This Science teacher guide provides further details of assessment tasks, and in most cases gives specific instructions as to how assessment tasks are to be undertaken. It provides elaboration of the assessment criteria and detailed performance standards which you must use when marking the specified assessment tasks.

Ideas, strategies and examples of activities that you, as a teacher of Science can use are provided for each unit. When appropriate, directions are given on how to undertake certain activities. Sample activities are outlined and elaboration of content and activities suggested.

This Science teacher guide will stimulate you to develop creative and meaningful teaching programs and lessons by enabling you to choose relevant and purposeful activities and teaching strategies. It will encourage you to research and look for new and challenging ways of facilitating students' learning.



Safety

Safety in the laboratory

Many experiments particularly in chemistry use potentially dangerous chemicals and procedures. Teachers of Science are responsible for ensuring the laboratory is a place where students can work safely and this responsibility has to be taken extremely seriously. Students must be told of any potential dangers in laboratory tasks, and you must explain what safe practices are required. Everyone must follow appropriate laboratory and safety rules in order to minimise risks associated with laboratory work. Most accidents in the laboratory can be avoided by following normal laboratory practices and being aware of potential hazards. Safety and safe use of equipment, in terms of personal use and storage of equipment, must be adhered to by both teachers and students.

The most common types of accidents are:

- chemicals in the eyes
- chemicals on the body
- cuts
- burns and scalds
- gravity effects – slipping/falling/dropping.

Others are:

- chemicals in the mouth
- fainting
- inhalation
- bites
- allergies
- electric shock
- fire and explosions.

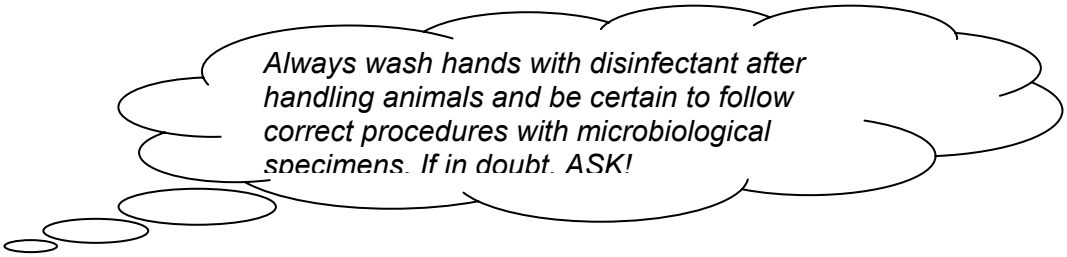
You must be able to prevent accidents in the laboratories through:

- relevant management skills
- appropriate knowledge
- safe storing of chemicals and maintenance of equipment
- appropriate attitudes to safety.

Some points to keep in mind are:

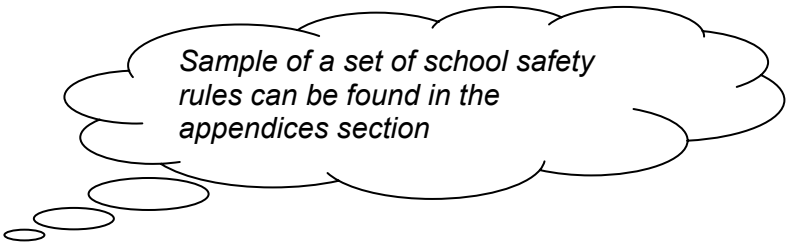
- always be on the lookout for unsafe procedures – explain and demonstrate the correct procedure
- check facilities, equipment and chemicals regularly.– a safety checklist is useful
- find out any potential hazards of chemicals before using them

- wear appropriate protective clothing and ensure that students do the same
- ensure sensible behaviour by consistently enforcing the laboratory rules (these should be known by students and prominently displayed)
- publicise safety – use commercial or students' own posters
- have safety equipment accessible, and know how to use all of it
- label all chemicals clearly, and attach hazards signs where necessary
- be familiar with the location of master controls for turning off gas and power.



Safety equipment in the laboratory should include:

- fume cupboards
- fire extinguishers
- fire bucket (with sand)
- fire blanket
- well stocked first aid cabinet/box
- student safety spectacles
- eye wash facilities
- gloves (disposable)
- safety screens for demonstration purposes.



Teaching and learning

A student-centred approach to learning

In this section some teaching and learning strategies that promote essential learning in Science are described. All teachers of Science are encouraged to use these when facilitating students' learning.

How students learn

There are many theories on how students learn but current educational research suggests that students learn better when they are actively engaged in interesting, challenging and relevant activities.

This teacher guide is based on the principle of learning and teaching by doing.

This is embodied in the Active Learning Credo statement by Silberman (1996) originally a Chinese proverb or maxim:

> "What I hear I forget
>
> What I hear and see I remember a little
>
> What I hear, see and discuss I begin to understand
>
> What I hear, see, discuss and do, I acquire knowledge and skill
>
> What I teach to another, I master".

It is further supported by other educational research findings that generally we remember:

- only 20% of what we hear
- only 40% of what we see
- but 90% of what we hear, see, say, do and or discover for ourselves.

This calls for changes in teaching approach where:

Less emphasis is on using typical teacher–cantered/directed strategies that include**:**	**More** emphasis is now placed on using student-centred strategies that include:
• treating all students alike and responding to the group as a whole • focusing on students acquisition of information • presenting scientific knowledge through lecture, text and demonstration • asking for acquired knowledge • testing students for factual information at the end of the unit or chapter • maintaining responsibility and authority • supporting competition • working alone • teacher talk, instructions, explanations, lectures or reading aloud • directed question and answer sessions – usually for revision • audio-visual presentations • text books or worksheets • directed assignments • demonstration and modelling • guest speakers • chalk/whiter pen and board • classroom displays, that are meaningless	• understanding and responding to individual student interests, strengths, experiences and needs • focusing on student understanding and use of scientific knowledge, ideas and inquiry processes • guiding students in active and extended scientific inquiry • providing opportunities for scientific discussion and debate among students constructing own knowledge • continuously assessing student understanding • sharing responsibility for learning with students • supporting a classroom community with cooperation, shared responsibility and respect • working with other teachers to enhance the science program • experiments/demonstrations in small group work • experiments/demonstrations as individuals • research/inquiry • problem-solving activities • question developing • activity centres/corners/areas • skills practice through manipulation of available technology/materials/equipment • educational games • presentations – written/oral/visual

Experience based learning

Experience based learning challenges students to learn and apply skills in activities that involve real life consequences. Experience based learning is based on the premise that to succeed in the future young people will need to know how to:

- access and process new information
- make and modify plans
- cooperate with others
- adapt to, and manage change
- apply what they have learned in new situations
- think globally
- work with technologies and systems not yet imagined.

Experience based learning involves the student in a wide range of activities both inside and outside of the science room/laboratory.

The role of the teacher is to manage the overall program and help to empower students to take responsibility for their own learning and level of success.

Teaching and learning strategies for Science

Introduction

It is important as a teacher of Science to reflect on how science has developed through time in order to move forward in teaching science. Science has developed:

- as a field of intellectual activity as people discern (distinguish/differentiate) and explain patterns of events and phenomena in the world around them
- progressively into a learning discipline with its own customs, procedures and fields of investigations
- as an accumulated body of knowledge that leads to explanations for a variety of phenomena and interactions in surroundings
- as investigative phenomena over a range of scales from subatomic to the cosmological, from events that take place instantaneously to processes that occur over millions of years, from origins of universe to contemporary phenomena and its extrapolation to future events
- as an attempt to provide students with a contemporary and coherent science education so they may better understand the natural and technological world in which they live, and make a positive contribution to decisions that shape it.

Context

Why contextualise science learning? Teachers of Science choose the context to:

- ensure student interest and motivation, conceptual understanding/literacy and/or confidence
- give coherence to the knowledge and understanding/skills and values and attitudes being developed
- encourage students to participate and engage in the learning process, identifying and extending connections between their learning and their experiences
- develop literacy skills, increase scientific literacy and increase their personal and community decision-making power in a broad range of situations.

Content

This identifies the different emphasis that is applied to learning experiences and:

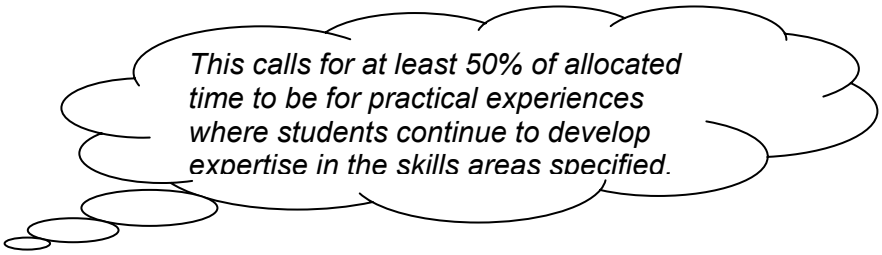
- assists students to develop understanding that scientific activity has become an integral part of the culture in which we live in and as such contribute to a distinctive view of the world
- increases students knowledge and understanding of science as:
- an ever-developing body of knowledge
- provisional in terms of scientific explanations
- a complex relationship between evidence and ideas which has an impact on society.

Process

Scientific skills include:

- developing competencies
- undertaking laboratory experiments
- undertaking field work
- researching through library/internet/CD–ROM/video
- extracting information and recognising information in the form of flow charts, tables, graphs, diagrams, prose and keys
- research projects.

These together will help develop the skills of students.



Science is investigating and problem solving

Science learning through investigative approaches is encouraged for student learning at this level. Science teaching in this sense involves students:

- understanding the nature of science
- engaging in working scientifically within the limits of experience and capacity
- contextualising knowledge
- appreciating alternative views and exploring advantages and disadvantages of different views.

Inquiry

Science as inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry is central to science learning and is more than science as a process. When engaging in inquiry, students:

- make observations by describing objects and events
- ask questions
- construct explanations
- plan investigations
- test explanations against current scientific knowledge
- use tools to gather, analyse and interpret data
- propose answers, explanations and predictions
- communicate their ideas to others
- identify their assumptions
- use critical thinking
- consider alternative explanations.

An inquiry-based/investigation teaching strategy will support meaningful learning and mastery of specific science skills identified in each unit. This means giving students lots of opportunities to discover information for themselves through practical and concrete activities including students finding answers to some of their own questions.

Teachers of Science encourage students to recognise that many scientific problems cannot be solved in one easy step. Students need to work through the problems one step at a time, starting from what they know, then developing a possible solution, testing it and analysing the results. If the test is fair, the results support the hypothesis and repeating the test gives the same result, then a solution is found. If not, the process is repeated.

The box below shows the scientific investigative process in sequence. The simple variations of the steps can be used depending on the nature and scope of an investigation. It can be as simple as a “Predict, Observe and Explain” as deliberated on page 12. This simply means breaking down the problem into manageable parts and then working through them one at a time following the investigative steps.

Steps in carrying out an investigations (from the bottom up)

4

Evaluate the investigation:

- Assess findings with original hypothesis
- Acknowledge any sources of error affecting results
- Go back to planning stage if experiment fails

3

Process data:

- Organise data: tabulate/graph/calculate
- Identify patterns or relations between variables
- Analyse/explain results using scientific knowledge

2

Conduct the investigation:

- Carry out experiment
- Make careful observations and measurements
- Record data

1

Plan the investigation:

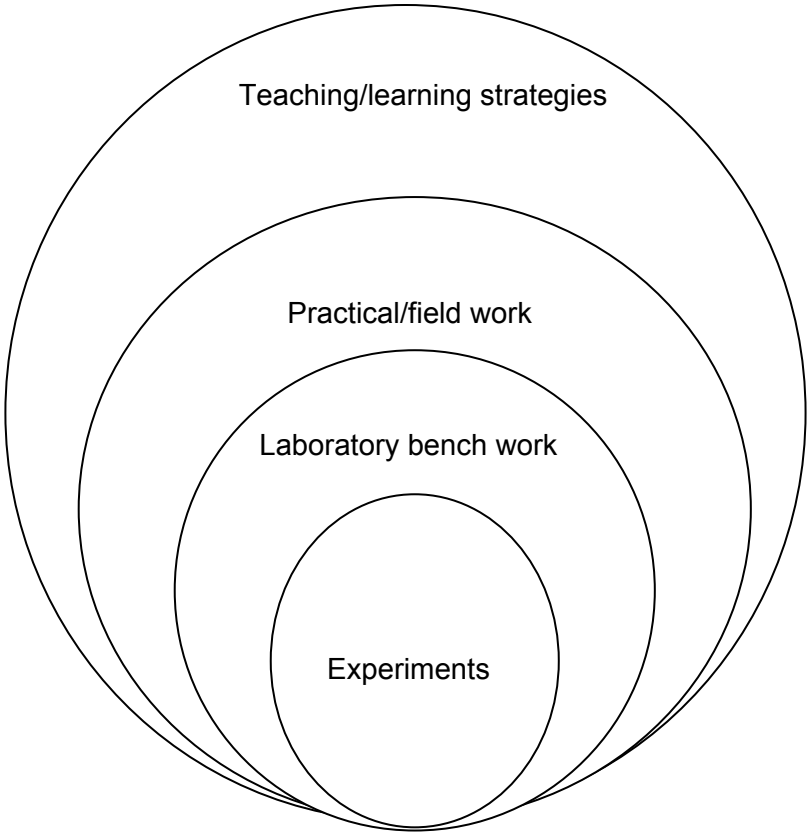
- Identify the problem
- Develop testable hypothesis
- Devise a method with available equipment
- Identify variable that will change
- Identify variable that will be controlled or remain the same
- Identify variable to be measured

Experiments

Experiments are an integral learning strategy in Science. Hypothesising and experimenting to substantiate evidence-based information is the core of any science lesson. It provides hands-on-practical- based activity opportunities for student learning and mastering of basic scientific skills. It may at times require specific manipulation of very delicate and dangerous equipment and hazardous chemicals. Therefore, safety and First Aid must be understood and practiced appropriately.

As emphasised, learning science should be something that students do, not something that is done to them.

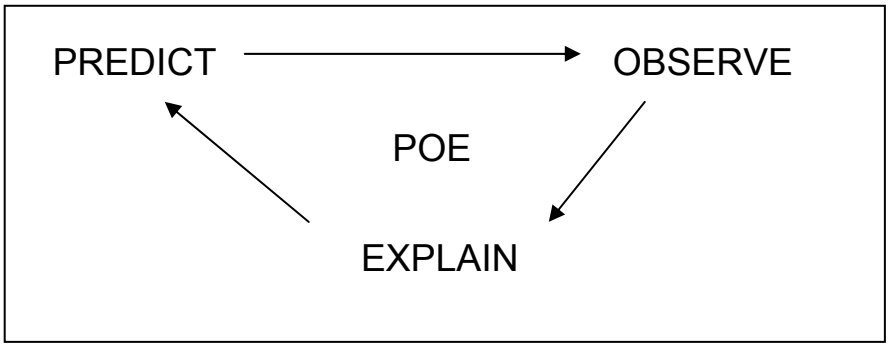
Hands on activities, while essential, are not enough; students must have *minds on* experiences as well through experimentation and investigations.



This diagram illustrates the practical nature of learning science and experimentation as the core strategy where learners can be engaged.

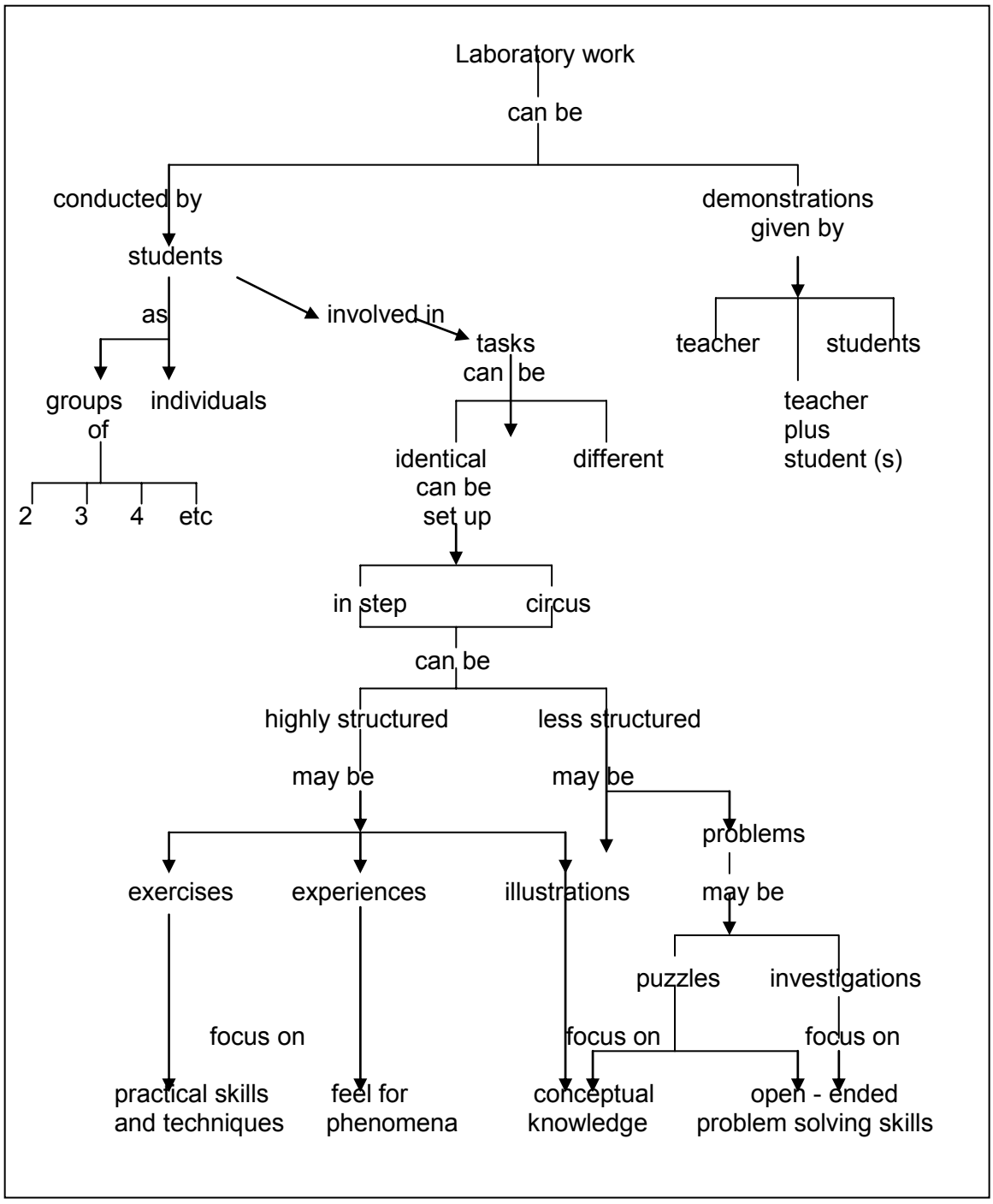
Predict–Observe–Explain

Predict–Observe–Explain (POE) is a strategy that is popular in implementing student-cantered activities. This simple student – cantered teaching strategy can be used when making field trips to a plantation, building site, fish pond, local beach, mangrove, industrial site etc.



Teaching in a laboratory – what does it mean?

Laboratory work at the Lower Secondary level is an essential part of good science teaching provided proper planning and selection of relevant and meaningful practical activities are done by the student/teacher. Laboratory work presents possibilities for a very wide range of approaches as shown by the diagram below;



Use of analogies, metaphors and examples (AME)

The use of analogies, metaphors and examples as teaching strategies in science learning is an emerging concept and is fast becoming successful world wide because it supports student-centred learning. Generally science knowledge is more abstract and difficult for students to understand. The use of analogies, metaphors and examples as teaching strategies can:

- help students develop reasoning skills
- help teachers where apparatus and equipment is lacking
- help both students and teachers where books are lacking
- enable students to be creative and imaginative
- provide practical activities for hands on learning
- provide visualising of the abstract
- encourage teachers to consider students' prior knowledge
- provoke student interest and therefore motivate them
- help individuals explain ideas to others
- reveal misconceptions in science concepts already taught.

Example of using analogy as a teaching strategy

Big idea	Experiment or demonstration	Relevant student experiences Examples
The atomic configuration of an element is how electrons are positioned in their shells around nucleus of an atom	Use of diagrams or poster to show electron arrangement around an atom. Electrons have restricted number for each row, e.g. 2, 8, or 2,8,8,2 etc	Think of electrons like chairs in an assembly hall. Students go in and fill up the first row and then fill up the next row and so on in their allocated grades. Students do not go and just sit anywhere.
Kinetic theory of matter. The kinetic theory of matter has three basic assumptions: ▪ All matter is made up of particles ▪ These particles are in constant motion ▪ Collision between them are elastic.	Demonstrate with three groups of students (1x10, 1X10, 1X10) representing the three states of matter occupying one marked out area at a time. The gas 'people' move around freely. The water 'people' move in limited space. The solid 'people' just jog on the spot.	Use 'people' instead of 'particles'. Avoid using the word 'particles' until at a later stage.

Using experiences/examples as a teaching strategy

Big ideas	Experiment or Demonstration	Relevant Student experiences /examples
Filtration is the scientific process where a mixture of insoluble solid and liquid is separated through a fine piece of paper or other materials	Mix some sand particles and salt solution and filter. Solid sand particles will collect on the filter paper and only the salt solution will pass through.	You may have seen how sago is made in the village. Fine fibres like the coconut fibres attached to the gutter-like sago branch stops or filters solid sago fibres and allows the solution or liquid to pass through. This liquid solution, left undisturbed allows sago starch to sink and collect at the bottom of a container/bowl/bucket etc. You may have also seen your mother or other people using hassin or natural coconut fibre to separate solid grated coconut from the actual coconut cream.
Sound is made by vibrating objects or fast moving columns of air particles	Pluck a guitar string and feel the vibrating strings or hit a tuning fork on the table top and observe. Play a bamboo flute/other flute/blow across a bottle mouth and observe the air flow out of the instruments.	You may have seen or played a kundu drum during a singsing (traditional dancing). You may have blown a bamboo flute if you are from inland places or a conch shell if you are from the coast. Use these experiences to enhance understanding of how sounds are made.

Using metaphor as a teaching strategy

In science teaching, metaphors are often used to help students understand complex phenomena, concepts, ideas and events that are abstract or unfamiliar. For example, 'nature' is compared to 'a book' or 'a mirror'. Remember, when using metaphors, appropriate prior knowledge is essential to make link from the known to the unknown. Some of the many reasons for using metaphors in science teaching and learning are that metaphors:

- provide ways of bridging the known and the unknown
- make existing concepts more flexible and versatile
- help students to visualise in their mind abstract ideas
- help students learn some of the many microscopic concepts of chemistry that they often find difficult
- help teachers of Science to make instructions more interesting and lively.

Some examples of metaphors are:

- atoms are 'building blocks' of matter

- protons, neutrons, and electrons are ‘the building blocks’ of the universe
- the spinal cord is a ‘an animal’s telephone wire’
- the solar system is the ‘the earth’s neighbourhood’
- blood, heart and blood vessels are ‘the human body’s transport system’.

How can you therefore teach with metaphors?

Metaphors used can be direct or indirect. For example, given a statement, ‘An electron cloud surrounds the nucleus of an atom’. (The metaphor very clearly states that the electrons make up the cloud). How can you analyse this statement?

You can do this by determining the topic and the vehicle, and listing the characteristics of the vehicle that demonstrate the concept. This is done by asking questions as shown below.

i) What is the topic? Electron clouds the nucleus of an atom.
ii) What is the vehicle? The dissimilar object/ concept that is used for making the comparison (cloud in this case is the vehicle)
iii) What are the similar features/characteristics of the vehicle? The list of features/characteristics of the dissimilar object/concept that can compare well to ensure understanding occurs
iv) What are dissimilar features/characteristics of the vehicle? The list of features/characteristics of vehicle that do not compare at all and therefore distinguish the differences establishing further understanding. So making the conceptual link to the unknown with the known.

Follow this simple procedure:

1: Determine the topic. The electron distribution in an atom

2: Determine the vehicle: A cloud in the sky

3: Make a list of all the known features/characteristics of the vehicle

i) a cloud is diffused and spread out thinly
ii) a cloud is hazy, with boundaries that are not well defined
iii) clouds are made up of moving water particles
iv) a cloud is usually white but sometimes black
v) a cloud drifts with the wind
vi) a cloud can sometimes produce rain, hail or snow.

4: Select from the list (above) features/characteristics of the vehicle that will distinguish the differences

i) a cloud is usually white but sometimes black
ii) a cloud drifts with the wind
iii) a cloud can sometimes produce rain, hail or snow.

5: Analyse the features/characteristics of the vehicle and identify those that compare well and those that don’t by giving supporting reasons. For example; the features/characteristics labelled i) – iii) compare well because

electrons also demonstrate those features while iv) – vi) will not compare well because the distribution of electrons:

- does not have a colour
- is not subject to macroscopic forces outside such as wind
- it cannot condense etc.

There are lots of similar metaphors used in science almost unconsciously and without considering how students take metaphors (even from science text books). You are therefore encouraged to use metaphors the examples given and help students sort out the information given in metaphors. However, do remember that metaphors like many other teaching and learning strategies, there are limitations.

Knowledge and skills development

Skills development is an integral part of teaching science but it cannot happen on its own. As teachers of Science, it is important to teach scientific knowledge and at the same time provide lots of opportunities for students to be engaged in performing some of the skills Science aims for students to achieve. Refer to pages 9–11 of the Lower Secondary Science syllabus for details. The four broad skills areas are:

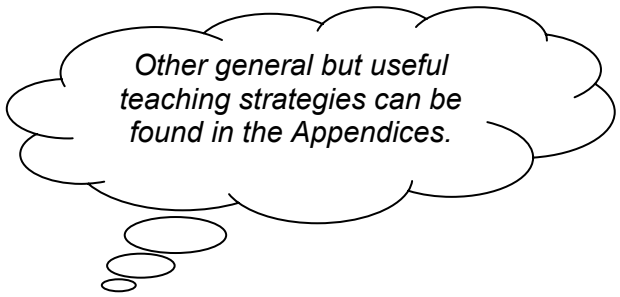
1. Knowledge
2. Attitudes and values
3. Process skills
4. General skills.

The broad areas are further specified and expanded to be taught and practised in the context of each of the twelve units.

Place of vernacular in Lower Secondary

Maintenance of the student's language is something that continues at Lower Secondary where and when required. At times it will be appropriate to use vernacular, Motu or Tok Pisin to explain complex concepts or ideas. For teachers of Science, it would be appropriate to use the vernacular, Motu or Tok Pisin when:

- completing activities in Unit 9.1 Traditional Knowledge and Practices
- finding information from local communities and environments
- involving village experts and elders for classification of plants and animals etc.



Assessment

In curriculum using an outcomes approach, internal assessment is critically important. Therefore, levels of achievement awarded should match the performance standards and descriptions. The assessment being emphasised is criterion referenced.

Assessment in Science measures students' achievement of the learning outcomes described in the Science syllabus. It is an ongoing process of identifying, gathering and interpreting information about students' achievement of the learning outcomes.

Assessment for learning and assessment of learning are two important concepts in outcomes based education. Assessment for learning is often called formative assessment that:

- evaluates and improves teaching and learning
- provides feedback to the student on their progress.

Assessment of learning is often called summative assessment that reports student achievement.

In Science the unit learning outcomes, which link to the broad learning outcomes, are assessed through specified assessment tasks using a range of assessment methods. Assessment criteria for each task provide clear indications of how, and to what extent, the achievement of the learning outcomes may be demonstrated. Performance standards provide a detailed marking guide for each task and assessment criterion.

The assessment tasks and criteria in each unit ensure that:

- internal assessment in Science is similar across schools
- a variety of tasks are specified to give students the opportunity to demonstrate all the unit learning outcomes in different ways
- the validity and reliability of the internal assessment is improved
- a variety of assessment methods are used across Grade 9 and Grade 10.

The assessment tasks stipulated in the units are to be carried out by students. However, teachers can design assessment tasks and set criteria for formative assessment for feedback purposes. Feedback is a very important element of assessment and should aim to give students guidance on how to improve learning in the future.

When setting a formative assessment task, ensure that:

- the requirements of the task are made as clear as possible to the student
- the assessment criteria and performance standards are provided to the student so that they know what it is that they have to do
- questions or activities chosen are relevant to the outcomes and allow students to demonstrate appropriate outcomes
- any sources or stimulus material used are clear and appropriate to the task

- the task is not too easy or too difficult
- there is a balanced selection of skills and knowledge being assessed
- achievement is measured in terms of more than one outcome
- instructions are clear and concise
- the language level is appropriate for the grade
- it does not contain gender, cultural or any other bias
- materials and equipment needed are available to students
- adequate time is allowed for completion of the tasks.

Why give feedback?

The significance of giving feedback is to help students understand the reasons for the results received and show them ways to do better next time. Therefore any feedback should be:

- constructive so that students feel encouraged and motivated to improve
- timely so that students can use it for subsequent learning
- prompt so that students can remember what they did and thought at the time
- specific to the learning outcomes so that assessment is clearly linked to a particular learning.

The types of feedback

The types of feedback teachers give can be:

- informal such as verbal feedback in the classroom and or personal consultation
- formal and in writing, such as checklists with written commentary
- direct – to individual students either in written or verbal form
- indirect – to the whole class
- formative – given during the topic with the purpose of helping the student know how to improve (assessment for learning)
- summative – given at the end of the topic with the purpose of letting the students know what they have achieved (assessment of learning).

Assessing Science

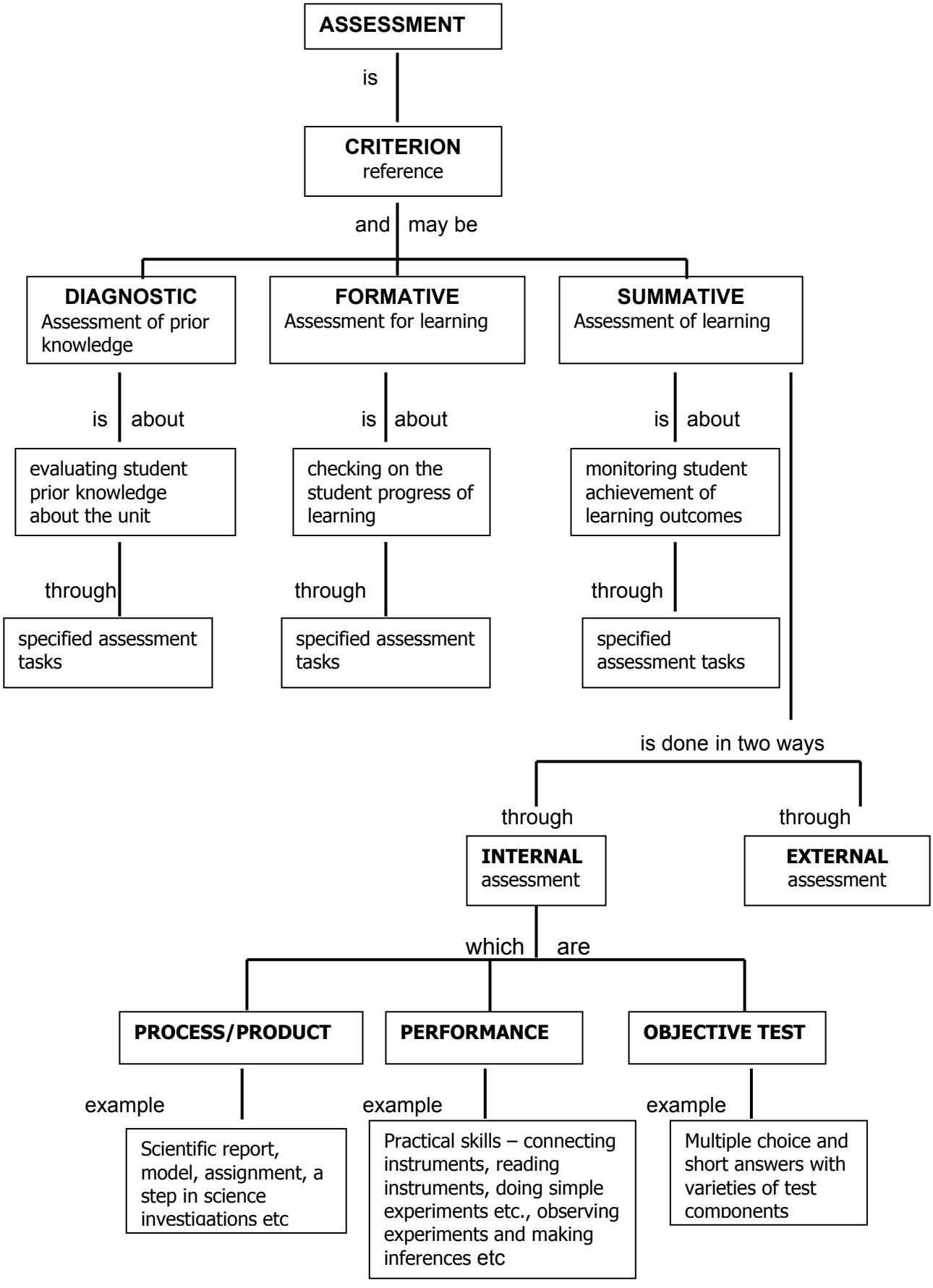
An outcomes approach curriculum demands a continuous assessment. Teachers of Science should therefore use diagnostic and formative assessment in order to measure student prior knowledge and or student progress in learning.

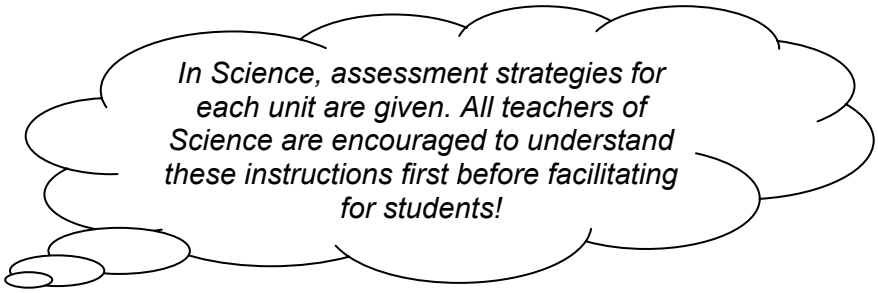
Assessment methods

Assessment methods teachers of Science use will depend on the activities or tasks students are undertaking. The assessment tasks prescribed for students to complete in this teacher guide will come from three main areas:

- process/product – includes posters, assignments, essays, models projects/investigations and reports (will each have their own criteria for marking)
- performance – includes practical activity similar to the Grade 10 Science practical test
- objective tests – involves answering/responding to combinations of questions; multiple choice, short answers, filling in blanks, defining terminologies, matching, short explanations etc. which may require a test specification.

The flow chart below illustrates assessment types, assessment processes and procedures from generic to science specific as prescribed in this teacher guide for lower secondary level.


ASSESSMENT
is
CRITERION reference
and may be
DIAGNOSTIC Assessment of prior knowledge
FORMATIVE Assessment for learning
SUMMATIVE Assessment of learning
is about
evaluating student prior knowledge about the unit
checking on the student progress of learning
monitoring student achievement of learning outcomes
through
specified assessment tasks
specified assessment tasks
specified assessment tasks
is done in two ways
through
INTERNAL assessment
through
EXTERNAL assessment
which are
PROCESS/PRODUCT
PERFORMANCE
OBJECTIVE TEST
example
Scientific report, model, assignment, a step in science investigations etc
example
Practical skills – connecting instruments, reading instruments, doing simple experiments etc., observing experiments and making inferences etc
example
Multiple choice and short answers with varieties of test components



Overview of Science assessment plan

This assessment plan is within the recommended sequencing of the units of work in Grades 9 and 10.

Grade 9 Assessment Plan

Unit	Assessment Methods and Assessment Tasks			Total Marks
	Process Product	Performance	Objective Test	
9.2. Working Scientifically	Report on Guided Investigations 30 marks	Practical Skills 30 marks		60
9.3 Ecology		Practical Skills– a case study 30 marks	Combine 9.3 and 9.4 Multiple Choice and Short Answer +20 marks + 30 marks	50
9.4. Our Body	Model making 30 marks			60
9.5 Atoms and The Periodic Table	Assignment 30 marks		Combine 9.5 and 9.6 Multiple Choice and Short Answer + 30 marks + 30 marks	60
9.6 Electricity		Practical Skills 30 marks		60
9.7 Earth and Atmosphere	Project 30 marks		Multiple Choice and Short Answer 30 marks	60
9.1 Indigenous Knowledge and Practices	Essay 25 marks	Oral presentation of poster or chart– 25 marks		50
Total				**400**

Grade 10 Assessment Plan				
Unit	**Assessment Methods and Assessment Tasks**			**Total Marks**
	Process/ Product	**Performance**	**Objective Test**	
10.2 Microbiology		Practical skills 20 marks	Multiple Choice and Short Answers 30 marks	50
10.3. Chemical Reactions		Practical skills 20 marks	Multiple Choice and Short Answers 30 marks	50
10.4 Light		Practical Skills 25 marks	Multiple Choice and Short Answer 25 marks	50
10.5. Communication		Practical skills 25 marks	Multiple Choice and Short Answer 25 marks	50
TOTAL				**200**
10.1. Working Scientifically Through Projects and Investigations	Project 50 marks			50
Science Practical Test	Investigation 20 marks	Basic Skills 30 marks (round robin)		50
Grade 10 Total				**100**
GRADE 9 AND 10 TOTAL				**700**

Planning and programming

The diagram below provides the four steps of the development cycle followed for all units in the Science teacher guide.

Note: This approach is slightly different from that taken in the other teacher guides.

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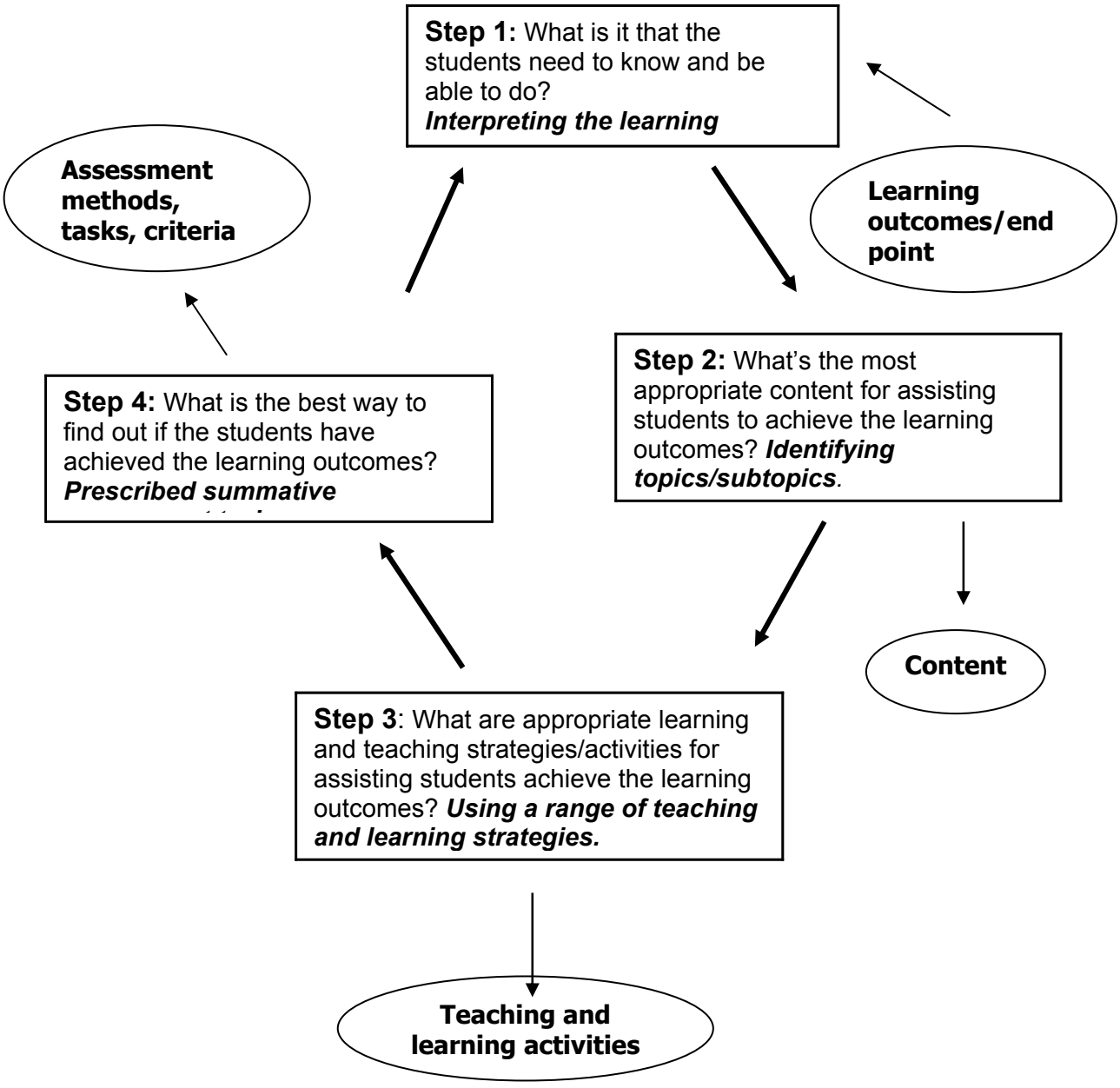


Points to consider when programming

Although most teachers of Science are familiar with planning and programming, the reform Science syllabus requires even more effective planning and organisation. These general questions will enhance your thinking into new and smart ways of planning for an outcomes approach to teaching and facilitating student learning.

- What is the purpose of this unit/topic/learning experience?
- Which learning activities will assist students to develop their knowledge and understandings, skills, and values and attitudes in the subject? Hence, achieve the learning outcomes?
- How do the learning experiences in the unit relate to students' prior knowledge and skills?
- How are individual learning needs be catered for?
- How can the learning activities be sequenced?
- How can school events and practices be incorporated into the program?
- What authentic links can be made with the content of other subjects?
- What are the indicators of student learning that you would expect to observe?

The main purpose of planning and programming is to help teachers of Science know what to teach and when to teach it. It is strongly recommended that you consult with the other teachers who teach the same grade. By planning together, you will make better use of your limited resources including time.

This is called collaborative planning!

Broad learning outcomes

The broad learning outcomes for Science are:

1. Demonstrate an understanding of fundamental scientific principles and models
2. Apply scientific thinking, process and motor skills to ask questions and find solutions
3. Compare traditional and contemporary science methods to generate and verify knowledge and explain natural phenomena
4. Communicate findings of scientific investigation in a variety of ways
5. Analyse past, present and future scientific developments and their socio-economic and environmental impact, and make informed decisions.

Refer to pages 16-18 of the Lower Secondary Science Syllabus where the links between the unit and the broad learning outcomes are

Overview of strands and units

The matrix below shows how aspects of general Science at the Lower Secondary level are integrated. The four major strands are interwoven to allow for conceptual links of the units to be either major or minor.

Strands / Units	1. Nature of Science	2. Life and Living	3. Matter and Energy	4. Earth and space
9.1 Indigenous knowledge and practices	Major link	Major link	Major link	Major link
9.2 Working scientifically	Major link	Major link	Major link	Major link
9.3 Ecology	Major link	Major link	Minor link	Minor link
9.4 Our Body	Major link	Major link	Minor link	Minor link
9.5 Atoms and The Periodic Table	Major link	Minor link	Major link	Minor link
9.6 Electricity	Major link	Minor link	Major link	Minor link
9.7 Earth and Atmosphere	Major link	Major link	Major link	Major link
10.1 Working scientifically through projects and investigations	Major link	Major link	Major link	Major link
10 2 Microbiology	Major link	Major link	Minor link	Minor link
10.3 Light	Major link	Minor link	Major link	Minor link
10.4 Chemical Reactions	Major link	Minor link	Major link	Minor link
10.5 Communication	Major link	Minor link	Major link	Major link

Units

Science is both an academic and a practical subject and students must be given opportunities to conduct experiments and undertake hands-on activities. All Science units require students to be actively engaged in learning, not just copying from the board or textbook. Make sure you select and develop a range of activities that suit all learning needs – mostly doing experiments or practical work, lots of observing and inferring, some reading and writing, some speaking and listening.

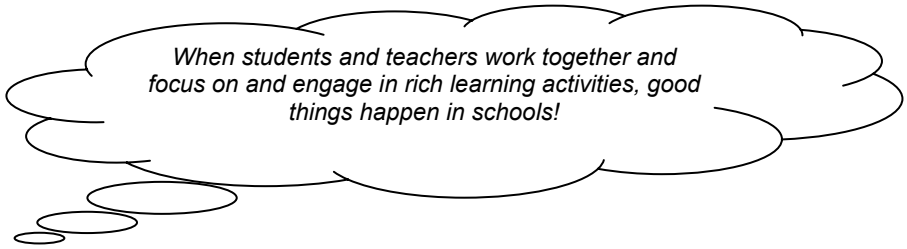
There are twelve units in Science; seven Grade 9 units and five Grade 10 units. All units are core units and must be studied consecutively except those noted below. Schools may develop their own schools based units for the end of Grade 10.

In Grade 9 students begin with the unit 9.2 Working Scientifically and finish with unit 9.1 Indigenous Knowledge and Practices. The rationale behind this is that students coming from different primary schools may have different science content knowledge and it may be asking too much from students to compare and contrast contemporary science with that of traditional knowledge.

Unit 10.1 Working Scientifically through projects and investigations is studied at the end of Grade 10 with the understanding that by then students will be able to carry out meaningful projects and make better use of the scientific skills used in other units.

The number of weeks given are only the suggested time frame for each unit. Teachers of Science may reduce or increase time for each unit depending on prior knowledge and skills of students. There are twelve units. But the length of time for actual teaching and learning is also determined by the number of learning outcomes for each unit.

It is important to select learning activities that will best provide students with the opportunity to learn the content and practice the appropriate skills and attitudes. Some major activities, for example, projects or research work can last several weeks and smaller activities can be completed in a single lesson.



Standard laboratory and standard equipment

It is necessary to have a standard science laboratory and standard equipment. This requires water taps with running water, gas and gas taps, and electricity and benches. Where there is no laboratory, a suitable room can be used with all the basic equipment necessary to complete all activities in each unit. .

Unit implementation sequence

The unit structure is given on page 19 of the Lower Secondary Science Syllabus. For implementation, follow the recommended unit sequence as shown below.

Grade 9 Core units		Grade 10 Core units	
9.2 Working scientifically	5–6 weeks	10.2 Microbiology	5–6 weeks
9.3 Ecology	4–5 weeks	10.3 Chemical reactions	5–6 weeks
9.4 Our body	5–6 weeks	10.4 Light	6–7 weeks
9.5 Atoms and The Periodic Table	4–5 weeks	10.5 Communication	5–6 weeks
9.6 Electricity	6–7 weeks	10.1 Working Scientifically through projects and investigations	5–6 weeks
9.7 Earth and atmosphere	5–6 weeks	School based units can be taught here.	
9.1 Indigenous knowledge and practices	4–5 weeks		

Essential resources for activities and assessment

Human torso
Standard laboratory equipment
Electricity kit
Rock and mineral kits
Large or medium size human skeleton
Weather instruments kits
Planetary kit
Light kit
Water quality test kit
Soil test kit
Eye ball model
Geological maps
Safety charts (wall)
Standard chemicals

Standard microscope and accessories – prepared slides
Standards measuring instruments (rulers, balances and scales)
Periodic Table Charts (1xwall and class set x A4measuring instruments

Grade 9 units

9.1 Indigenous Knowledge and Practices

This is a new unit to provide opportunities for both teachers and students to make links between contemporary knowledge and indigenous Papua New Guinea knowledge, skills and values practised and sustained over thousands of years. By doing so students, can value the science that has been practised in ancient times and to see the importance of maintaining some of these practices today. This unit is a five week core unit. It is recommended it be taught in Term 4 when students will have a sound understanding of Science to enable students understanding of both worlds.

Interpreting the unit learning outcomes

You always study the unit learning outcomes to determine what students know and are able to do by the end of the unit.

For each unit learning outcome, the scope of the content area to focus teaching and learning on is provided. Teachers of Science must ensure enough of these are selected and taught for students to achieve the particular unit learning outcome.

Outcome: 9.1.1: Students can demonstrate an understanding of traditional knowledge and practices

To help students achieve this outcome, they are provided with opportunities to research traditional practices and how this knowledge has been passed on by focusing on:

a. food choices, cooking methods, and preservations
b. agriculture, gardening and its dependency on weather
c. maintaining health, and use of medicines (herbal)
d. the extraction and use of pigments and dyes
e. technology for making various tools, canoes, artefacts, etc
f. communication, music and musical instruments
g. the use and classifying of resources.

Outcome: 9.1.2: Students can investigate the scientific principles underlying in some traditional practices

To help students achieve this outcome, they are provided with opportunities to examine these principles through investigations focusing on:

a. processes and procedures used for producing sago/salt/lime (calcium oxide)/coconut oil extraction:
b. properties and characteristics of materials selected for constructions of tools, canoes, grass skirts/cloth etc.
c. implications of these practices on people and different environments
d. whistling as a means of creating wind to cool off.

Outcome 9.1.3: Students can show how traditional knowledge and practices provide sustainable living

To help students achieve this outcome, they are provided with opportunities to learn about the environmental impact of traditional practices over the last 100 years by focusing on:

a. rationale of taboos related to various community activities based on use of resources
b. the significance of self – demarcation of territory
c. intellectual property rights of individuals, community and the nation
d. national development at the expense of long term sustainability – not ensuring selective foresting etc.
e. management of hunting and fishing.

Outcome 9.1.4: Students can present science as a human endeavour with contributions from around the world

To help students achieve this outcome, they are provided with opportunities to learn about traditional and contemporary knowledge systems and to research examples of the contributions made by different cultures of the world to scientific knowledge. This is done by focusing on:

a. traditional knowledge systems and contemporary knowledge systems
b. oral exchange, imitation, trial and error processes of knowledge transmission to written communication in the scientific and collaborative and competitive community
c. development of contemporary science and its potential for the future.

Outcome 9.1.5: Students can analyse interactions between scientific development and traditional beliefs

To help students achieve this outcome, they are provided with opportunities to explore differences between traditional beliefs of infinity and vastness and contemporary finite systems focusing on:

a. legality of agreements, contracts, covenants
b. need to formalise and maintain traditional practices of natural biodiversity, for example, maintaining value on natural biodiversity
c. assisting communities in leadership and development related decision making.

Programming a learning sequence

This sample unit plan provides a brief overview of the essential topics, approximate time required in weeks, sample activities and the suggestions for completing the assessment tasks.

Weeks 5 (Minimum)	Key Content Topics	Sample Activities	Assessment
1–2	Types of knowledge	Observe, discuss and reflect on indigenous knowledge and skills. The historical importance in relation to: processing and sustaining resources, classification/taxonomy, some natural processes and techniques of responsible harvesting from the environments. Where unwritten, students must record these in order to sustain them for many more people to use in many more years to come	Advise on assessment tasks (end of week 1)
3	Practice in passing on knowledge	Research how knowledge and skills were passed down through the generations in Papua New Guinea and how testing of this knowledge was done in order to confirm its reliability.	
4	Sustaining our resources and knowledge systems	Undertake a field trip and investigate local initiatives to preserve indigenous knowledge and practices at all levels (local, provincial/regional and national).	Complete Task1
5	Usefulness of knowledge systems	Investigate and construct a comparison chart to show how different societies in the past constructed roads, houses, drainage systems, bridges, gardens etc. based on the way they predicted the weather.	Complete Task 2

Elaboration of content and activities

Once you have mapped out your program for the year and term you can then develop more detailed plans for each topic in the unit.

All units require students to be actively engaged in learning not just copying from the board or the text book. Make sure you develop a range of activities (including experiments/laboratory bench work/field trips) that suit all learning, some observing (demonstrations) and doing.

In this unit students have to be involved in many simple practical activities as much as possible. Safety is an important part of all activities especially when handling live animals and toxic plants.

Activities

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

- Create an indigenous centre in the science laboratory or a room with student collections and displays of traditional artefacts, products and photograph/pictures of; technology, musical instruments, clothing, models of village houses, canoes, bilums, baskets, Kundu drums,

carvings, cooking utensils, e.g. clay ports, paintings etc. for student' reference throughout the duration of this unit.

- Interview older community members about techniques used to cook and preserve foods or other traditional activities.
- Collect examples of herbal medicines and complete a table listing their ingredients and what they are used for.
- Collect natural products used to produce pigments and dyes and draw diagrams to explain the extraction processes and procedures.
- Brainstorm types of natural phenomena such as time, earthquakes, floods and find out how people in their areas explain these phenomena.
- Research ecological management (techniques of looking after environment).
- Compare traditional classification/taxonomies with contemporary science.
- Draw annotated diagrams to describe the technology for making various tools, canoes, artefacts etc. and describe the characteristics of materials used.
- Develop a classification table based on traditional knowledge.
- Explain and demonstrate the process of passing on knowledge in Papua New Guinea.
- Investigate usefulness of knowledge systems.
- In groups research the processes /procedures use for producing /sago, salt/lime/oil etc. and identify the science.
- Compile data on different ways of looking after the environment, for example, how people collect food from the environment , how much they collect at one time, how food and resources are shared, shift gardening, selecting only bigger trees for houses, hunting and fishing at certain times.
- Identify traditional ways of sustaining resources, e.g. crop rotation.
- Research traditional taboos and explain the rationale behind them.
- Research local initiatives available to promote the sustainability of local knowledge and practices.
- Invite a guest speaker to explain the impact of resource contracts on traditional practices and different environments.
- Read different stories about the origins of life and compare with scientific explanations.

The following table gives elaboration of some selected activities from the above list.

Activities	Elaboration of activities
Compare traditional classifications /taxonomies with contemporary science	Divide students into groups to compile a list of traditional medicine or technology used in the area and state what these medicines or technologies are used for. Students use a chart or a table to classify medicines for example (taken by mouth) and those applied directly to body parts. Traditional technology could be sorted into tools for gardening, tools for hunting, tools for fishing, tools for building. Traditional classifications/taxonomies can then be compared with contemporary science by adding another column to the chart or table which lists the contemporary alternatives.
Explain and demonstrate the process of passing on knowledge in Papua New Guinea	Research how knowledge and skills were passed down through generations in Papua New Guinea by: • interviewing or designing a questionnaire for local elders, any older person in the community, parents, elderly teachers, or teachers with village backgrounds • collecting and analysing examples of stories, legends, and rituals that have been passed on orally • listing and describing traditions that have been passed on through observations, imitations and trial and error, for example making a canoe. Discuss traditional and scientific ways of testing knowledge, for example, the scientific method, trail and error.
Research local initiatives available to promote the sustainability of local knowledge and practices	Undertake a field trip to investigate local initiatives to preserve local knowledge and practices, for example: • translation of local languages , recording of local songs on cassettes, CDs, films and documentaries of some cultures in Papua new Guinea • national parks and reserved areas for protection of animals and plants, which are unique or may become extinct • use of traditional techniques, to produce clay pots grass skirts, bilums, baskets, carvings headdresses.
Research ecological management (techniques of looking after environment)	Students should now have available data from the past activities. They then carry out further research and compile data on different ways of looking after the environment. They could mention ways people collect food from the environment, how much do they collect at one time, sharing of food and resources, manageable family sizes so less resources used, shift gardening, selecting only bigger trees for houses, hunting and fishing at certain times. They then present the data as a written report, on chart, poster or give an oral presentation.
Investigate usefulness of knowledge systems	Use information collected from libraries and resource books to construct a comparison chart to show how different societies in the past constructed roads, houses, drainage systems, bridges, gardens and garden fences, or how they predicted the weather. Societies studied could include Israelites, Egyptians, Romans, Aztecs, Chinese, Japanese, Vikings, Anglo-Saxons etc.

Resources

Some of the required resources to teach this unit are provided below. There are many more resources teachers and students will need to find according to the local context and situation in each school.

- Village elders
- Parents and grand parents
- Village medicine man
- Written stories/legends/ poems about origins of phenomena
- Story boards indicating plant and animal life and diversity
- Materials used for arts and crafts e.g. Carvings
- Materials used for tools, e.g. traditional canoes, rope bridges, stone axes, bows and arrows and clothing etc.
- Medicinal herbs and other useful herbs etc.
- Musical instruments e.g. kundu/garamut/clay pots
- Tapa cloths
- Traditional fishing nets
- Traditional fire making equipment
- Traditional gardens
- Traditional worship places (sacred places)

Assessment

There are two summative assessment tasks prescribed for this unit that all students are required to complete and the marks must be recorded towards internal assessment:

Task 1: Oral presentation about traditional knowledge (25 marks)

Task 2: Written story about traditional knowledge – an essay on a traditional knowledge in the context of contemporary science (25 marks).

Ensure that you understand these first and include them in your planning. Then make a list of your own diagnostic and formative assessment tasks in the plan.

Remember that in an outcomes approach, the assessment is ongoing to check on students meeting the learning outcomes of each unit. This is done through regular diagnostic and formative assessments.

Instructions for task 1

This assessment task requires students to do the following:

i) select or choose any traditional or locally produced knowledge or process
ii) collect information about it from several reliable sources such as local community members, story boards or library resources
iii) Identify scientific principles and processes
iv) find out how it has been generated, tested and passed on through the generations
v) interpret and organise the data graphically where possible
vi) summarise data or findings on charts or posters – prepare a poster or a chart to describe the process/knowledge

vii) orally present the findings (analysed information) to the class or any preferred audience using v) and vi) as visual aids for presentation.

This assessment task must be given to students at the beginning of week 1 together with the assessment criteria. Discuss with students the weighting of each criterion so that students will see the importance of managing their time giving more time to criteria that have more marks, for instance.

You will assess task 1 on the extent to which students can meet the criteria as stated in the Science syllabus. The same criteria are in the first column of the assessment performance standard rubric.

The performance standards are actually 'descriptors' which do several things:

- suggest the extent to which the student has met the criteria enabling you to give the required mark
- provide the key features of performance for each level of achievement
- act as your marking guide, for example, in this unit, high achievement descriptors describe what students must do in order to get a 'high achievement' related mark for each assessment criteria.

9.1 Performance standards for assessment task 1: Oral presentation about traditional knowledge 25 marks

Performance Criteria	Very High Achievement (22–25)	High Achievement (18–21 Marks)	Satisfactory Achievement (12–17 Marks)	Low Achievement (0–11 Marks)
Show an example of locally produced knowledge or process (3 marks)	Give realistic examples of any locally produced knowledge or processes with 3–4 reliable sources to support their examples (3 marks)	Give a realistic example of any locally produced knowledge or process with 2–3 reliable sources to support their examples (2 marks)		Give an example of at least 1 or no examples of locally produced knowledge or process without any reliable sources for support (0–1 marks)
Demonstrate how this knowledge was generated and tested for its reliability (7 marks)	Explain in detail how traditional knowledge was generated and tested and to provide clear documentation of their sources of information with the references confirming the source. The sources are reliable and evidence of this has been provided. (7 marks)	Explain clearly how traditional knowledge was generated and tested and to provide some documentation that has less than 4 sources that are not clearly supported. The sources are reliable but the evidence provided is incomplete and not convincing. (6 marks)	Explain how traditional knowledge was generated and tested but provide little documentation most of the sources not supported. The sources may not be reliable and little or no confirmation of them. (5 marks)	Unable to clearly explain how traditional knowledge was generated and tested. Students provide documentation but it is not complete with 1 or 2 not supported. The sources are reliable but there is little evidence to support their reliability. (0–4 marks)

Identify any scientific principles evident in the knowledge (7 marks)	Identify all of the relevant scientific principles within the traditional knowledge. Their presentation of this is clearly explained and at an appropriate level for their audience (7 marks)	Identify most of the relevant scientific principles within the traditional knowledge. Their presentation of this is clearly explained and at an appropriate level for their audience (6 marks)	Identify some scientific principles but not all may be directly related to the traditional knowledge. The explanation is presented at an appropriate level but may be incomplete (5 marks)	Present some scientific principles but they may be unrelated or incorrectly related to the traditional knowledge. The presentation is not well prepared and does not convey the message clearly (0–4 marks)
Explain how this knowledge was passed on from generation to generation (4 marks)	Provide Clear detailed explanation with support documentation and examples indicating the actual process used to pass this knowledge from one generation to another generation (4 marks)	Provide Clear explanation with some documentation and examples indicating the actual process used to pass this knowledge from one generation to another generation (3 marks)	Provide an explanation with some evidence to support their explanation of the process used to pass this knowledge from generation to generation (2 marks)	Unclear or confused and incorrect information and with little or no evidence to support their explanation of the process used to pass this knowledge from generation to generation (0–1 marks)
Argue for the usefulness or otherwise of this knowledge (4 marks)	Present a clear argument that is logical and supports their point of view with effective examples which are relevant (4 marks).	Present an argument which has logic and structure with examples which are related to the topic and support their point of view (3 marks)	Present an argument which has been organised with some logic and structure and examples that are related but not directly (2 marks)	Present an argument with logic and structure but unrelated information and the examples that do not support the argument in a meaningful way (0–1)

Instructions for task 2

This assessment task requires students to do the following:

i) identify any traditional knowledge of their choice that is more friendly to the environment
ii) gather relevant information from several reliable sources including village elders, elderly teacher, story boards, library resources, documentary films etc.
iii) write an essay describing how that particular traditional knowledge differs from the contemporary science through comparing and contrasting several practices, ideas and or concepts
iv) submit a well informed and structured written essay of 3–5 pages.

It is important that students are given in the beginning, the required criteria and the weighting of each criterion for assessment task 2. Discuss these with students so that they are fully aware of the requirements. Give a limit of 3 – 5 pages for essays. This means students will need to hand in a well

informed and organised essay with only the essential information as guided by the given six criteria.

You will assess task 2 on the extent to which students meet the criteria as prescribed. The same assessment criteria for task 2 from the Science syllabus are in the first column of the assessment performance standard rubric.

9.1 Performance standards for assessment task 2: An essay on traditional knowledge against contemporary science 25 marks

Performance Criteria	Very High Achievement (22–25 marks)	High Achievement (18–21 marks)	Satisfactory Achievement (12–17 marks)	Low Achievement (0–11 marks)
Show that some traditional knowledge and practices are more friendly to the environment (3 marks)	Identify three or more practices that are more friendly to the environment when compared with the relevant contemporary approach. The evidence supplied is relevant and is supported by more than one reliable source (3 marks)	Identify two practices that are more friendly to the environment when compared to the relevant contemporary approach. The evidence supplied is relevant and is supported by more than one reliable source (2 marks)		Identify one practice that is more friendly to the environment when compared with a contemporary approach that is related. The evidence supplied is not complete and source is not identified or not reliable (0–1marks)
Demonstrate that contemporary science may produce fast economic growth but not sustainability for the environment (5 marks)	Show by using relevant and recent examples in their local area where sustainability of the environment has been compromised as a result of fast economic growth. The students are also able to link this to a national and global context (5 marks)	Use relevant and recent examples from the local context where sustainability of the environment has been compromised as a result of fast economic growth. The students are able to link this to a national perspective not global (4 marks)	Use some general examples from the local context where sustainability of the environment has been compromised as result of fast economic growth that are related to the local context but not to national or global context (3 marks)	Use general examples of where sustainability of the environment has been compromised as a result of fast economic growth. The examples are not specific and not related to local, national or global context (0–2 marks)
Recognise the limitations of traditional knowledge (3 marks)	Provide 4 relevant examples from either the health or communications area and present clear arguments that support their point of view. (3 marks)	Provide 1–2 examples from either the health or communications area and present arguments that support their point of view. (2 marks)		Provide an example from either the health or communications area but are unable to present arguments that support their point of view. (0–1 marks)

Recognise the usefulness of contemporary science in areas such as health or communication (5 marks)	Provide 3 different areas present a clear argument and supports their point of view with effective examples which are relevant to either health or communication (5 marks).	Provide 2–3 different areas present an argument which has some structure and some examples which are related to health or communication (4 marks)	Provide 2 different areas present and argument which has been organised but with little structure and the examples are related but not directly (3 marks)	Provide 1 area argument lacks structure has unrelated information and the examples used do not support the argument in a meaningful way (0–2 m arks)
Make choices and decisions that are ethical and sustainable| (4 marks)	Provide 4 examples of well informed decisions/choices they have made explaining why they are ethical and sustainable (4 marks)	Provide 2–3 examples of decisions/choices they have made explaining why they are ethical and sustainable (3 marks)		Provide 1 example but are not able to establish either the ethics or sustainability of their decision/choice (0–2 marks)
Identify the effects of contemporary science on traditional societies (5 marks)	Identify both positive and negative effects of contemporary science using both local and global specific examples. (5 marks)	Identify both positive and negative effects of contemporary science using specific local and national examples (4 marks)	Identify both positive and negative effects of contemporary science using general local and national examples (3marks)	Identify positive or negative effects of contemporary science but show confusing examples from non specified areas (0–2 marks)

The total assessment for this unit is 50 marks.

9.2 Working Scientifically

This is a core unit and the minimum time requirement is 6 weeks. It is recommended that this unit be taught first so that scientific skills from upper primary is reflected upon, enhanced and further developed in this unit. Students are then better equipped to use them in other units for learning.

Interpreting the unit learning outcomes

You always study the unit learning outcomes to determine what students will know and be able to do (content) by the end of the unit.

For each unit learning outcome, the scope of what content area to focus the teaching and learning on is provided. Teachers of Science must ensure enough of these are selected and taught for students to achieve a particular unit learning outcome.

Outcome 9.2.1: Students can assess the nature of a particular procedure or instrument and take responsibility for its safe and accurate use

To help students achieve this outcome, they are provided with opportunities to:

a. make judgments about the suitability of particular procedures or instruments for given tasks
b. observe safe and responsible use of scientific instruments and practise handling and using instruments correctly (e.g. thermometers, measuring cylinders, rulers)
c. manipulate complex and delicate instruments (e.g. microscopes, scales, balances, stop watches, Bunsen Burners).

Outcome 9.2.2: Students can demonstrate mastery in the use of equipment and handling of data

To help students achieve this outcome, they are provided with opportunities to:

a. follow a sequence of instructions
b. read scales and manipulate equipment
c. collect, interpret and communicate data
d. convert between units.

Outcome 9.2.3: Students can identify information needed and undertake a scientific project in order to make an informed decision

To help students achieve this outcome, they are provided with opportunities to:

a. identify an issue or problem
b. gather relevant information
c. apply problem solving processes and procedures to verify independent and dependent variables

d. set up control experiments
e. carry out a small scientific investigation in order to come to conclusion.

Outcome 9.2.4: Students can identify work done by Papua New Guinea scientists

To help students achieve this outcome, they are provided with opportunities to:

a. undertake research on how scientists work
b. read about different scientists working in Papua New Guinea
c. visit a scientist working in the field.

Programming a learning sequence

This sample unit program provides a brief overview of the essential topics, approximate time required in weeks, samples activities and the suggestions for completing the assessment tasks.

Weeks 5 (Minimum)	Key Content Topics	Sample Activities	Assessment
1–2	Measurement	Observe, discuss, reflect on arbitrary units, and then compare the disadvantages of using arbitrary units to the metric system or Si units Use a variety of instruments to measure length, time, weight/mass, force, air pressure and volume of objects etc. and correlate instruments qualities and units List safety rules and describe reasons for following all laboratory rules and procedures carefully, particularly for using and handling of delicate and hazardous chemicals and apparatus. For example , the correct procedure for diluting or mixing acid is to ALWAYS pour Acid into Water and NEVER the other way round (remember A first and W last). Students investigate parallax errors by taking many different readings (large and small quantities together) Students measure their heights with a meter rule, weight themselves on a bathroom scale, take body temperature, tabulate results, draw graphs, interpret and communicate conclusions to others.	Advise on assessment tasks (end of week 1). Complete Task 1 (end of week 3)
3–5	The scientific approach	Demonstrate, observe, discuss and apply the scientific way of learning by investigating and problem solving following the four major Steps of; identifying a problem, conducting an investigation, organising data and assessing the findings with the original hypothesis to put it simply. Students carry out guided experiments and demonstrations identifying the experiment variables, and controls and to write a scientific report. Carry out a case study on Papua New Guinea scientists and discuss tasks different scientists are doing different jobs and their importance, including the kind of technologies they are using.	Complete Task 2 (end of week 5)

Elaboration of content and activities

In this unit students have to be involved in as many simple practical activities as possible. Students use a lot of instruments in this unit and therefore you must teach safety and First Aid procedures and preventative measures. Safety is an important part of all activities, especially in handling glass, hot test tubes, and sharp and delicate instruments. Students must be taught how to use these instruments correctly and safely so that they do not injure themselves. Safety warning signs and symbols should be introduced and emergency procedures practiced, such as fire drills, volcano eruption drills, what to do in case of a blood spill or mercury spill.

Activities

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

- Compare and contrast arbitrary units and metric systems–comparison table.
- Discuss the disadvantages of using arbitrary units.
- Use a variety of instruments to measure length, time, weight/mass, force, air pressure and volume.
- Work out scale divisions and write units for each instrument
  e.g. Force = Newtons
- measuring lengths of irregular shaped solids/materials, 2 square shaped boards e.g. match boxes, ruler.
- Displacement methods
- Familiarise students with a wide range of scientific equipment. This will involve naming instruments and explaining their uses.
- Read scales divisions on instruments such as thermometers , scales, rain gauge
- use different equipment to make accurate readings and collect data, data can be converted to graphs and presented to whole class
- Measure density using correct formula

  $$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \quad \text{or} \quad \text{g/cm}^3 = \text{g/cm}^3$$

- Identify different scientific instruments by sorting into function.
- Investigative procedures and scientific reports.
- Make accurate readings from instruments and record data.
- Demonstrate correct procedures and safety in handling science equipment.
- Demonstrate first aid and safety procedures.
- Observe, demonstrate and discuss safety rules and procedures referring to poster of laboratory safety e.g. Regarding gas taps, water taps, Bunsen burner e.g. always point the test tube away from your peers when heating things in the test tubes, carrying and handling microscopes etc.
- Students write their own rules.

- Observe and make predictions using instruments.
- Introduce students to make predictions using data from their readings. For example, what will happen to the temperature of water if it is heated? What will happen if you over eat?

The following table gives elaboration of some selected activities from the above list.

Activity	Elaboration
Measure, read and record body heights, temperature, weight of all students in class	Students measure their height with a meter ruler, weigh themselves on a bathroom scale, take body temperature Students can be grouped to act out real life situation unconsciousness, cuts and burns so that the ideas of first aid and safety procedures can be demonstrated
Measuring length and volume of irregular shaped (solid) objects	Students place object (stone) to be measured between two boards/boxes. Place the ruler and take reading from ends of the stone and board. Turn stone three times and repeat reading Calculations: 1st reading……...cm 2nd reading ……cm 3rd reading……..cm Average ……..cm length of stone Measuring Volume of solids – displacement Students use any container with calibration and numbers Method: Measure water and take the reading. Put object into water and take the reading 1st reading ……mL without object 2nd reading ……..mL with object Difference…… cm^3 volume of solid
Carry out case study of work done by scientists in Papua New Guinea	Plan and carry out a case study on work done by scientists in the area and collect information from books, papers, and complete a case study. In addition students observe the equipment and kind of technology scientists use in their area, e.g. generators, soil testing kit, chain saws, surveying kits, medicines, microscopes, tape measures. Some examples of scientist are doctors, agricultural officers, foresters, botanists, chemists, a geologist and volcanologist, vetenarians, nurses etc.

Resources

- standard laboratory equipment/instruments/materials eg rulers, measuring cylinders, tape measures, metre rules, scales, stop watches, beakers, thermometers, volt meters, beam balances, spring balances, ammeters, volt meters, rain gauge, empty tin can, plastic bottles, barometer etc.
- village elders and experts.
- containers: cordial/soft drink bottles, tin fish cans, boxes, match boxes, biscuit cartons
- cardboard
- old folders

- safety glasses, goggles, spectacles
- hand gloves
- jacket where possible.
- local scientists: doctors, agriculturists, officers from the Department of Primary Industry, teachers – science, foresters, works engineers, surveyors, chemists, botanists.

Assessment

There are two summative assessment tasks prescribed for this unit that all students are required to complete and marks recorded towards internal assessment.

Task 1:	Practical skills (30 marks)
Task 2:	Report on guided investigation – general investigations (30 marks)

Ensure that you understand these tasks first and include them in your planning. Then make a list of your own diagnostic and formative assessment tasks in the plan.

Remember that in an outcomes approach, the assessment is ongoing to check on students meeting the learning outcomes of each unit. This is done through regular diagnostic and formative assessments.

Instructions for task 1

The teacher

You must identify relevant practical activities (similar to ones students experienced in this unit) depending on your resources and the class size

You could organise this task in two ways:

i) organise 10–15 small stations (round robin) for all students (2 – 3 marks each depending on the nature of each activity). For marking, you must use the assessment criteria and performance standard prescribed
ii) check that all stations' set up are left in order before the next class.

The students

This assessment task requires students to do the following:

i) carefully follow all instructions given by the teacher
ii) within the given time limit, (3–4 minutes per station), begin at one station and move to the next station clockwise, until you complete all labelled activities at each station
iii) hand in the completed practical test paper and leave quietly
iv) leave things as they are for the next class.

9.2 Performance standards for assessment task1: Practical Skills				30 marks
Performance Criteria	**Very High Achievement (27–30 marks)**	**High Achievement (20–26 marks**	**Satisfactory Achievement (15–19 marks**	**Low Achievement (0–14 marks)**
Estimate measurements to some degree of accuracy without using equipment (5 marks)	Estimate length, area, volume, mass and time to with an accuracy of + or – 10 percent	Estimate length, area, volume, mass and time to with an accuracy of + or – 30–40 percent		Not able to estimate length, area, volume, mass and time to with an accuracy of + or – more than 40 percent
Identify the appropriate equipment needed for a range of measurements (4 marks)	Select the most appropriate equipment needed for a wide range of measurements	Select most appropriate equipment needed for a range of measurements		Not able to select appropriate equipment for a narrow range of measurements
Use and manipulate equipment safely (6 marks)	Demonstrate the handling and use of a wide range of both simple and complex equipment taking into consideration personal and equipment safety	Demonstrate the handling and use of a range of both simple and some complex equipment taking into consideration personal and equipment safety	Demonstrate the handling and use of a range of simple equipment taking into consideration personal and equipment safety	Not able to demonstrate the handling and use of some simple equipment but is not fully aware of personal and equipment safety
Measure accurately (9 marks)	Measure a range of quantities accurately within the constraints of the measuring Instruments and quantity being measured and identify possible sources of errors and give an indication of the magnitude of the error	Measure a range of quantities accurately within the constraints of the measuring instruments and quantity being measured and identify possible sources of error	Measure a range of quantities accurately within the constraints of the measuring instruments and quantity being measured and identify some sources of errors)	Not able to measure accurately within the constraints of the measuring instruments and quantity being measured
Apply correct and appropriate units of measurement. (6 marks)	Identify, read and record appropriate units of measure for a range (4 –5) of quantities	Identify, read and record appropriate units of measurement for 2–3 quantities		Identify, read and record appropriate units of measure only for 1 quantity or none at all

Instructions for task 2

This is a guided investigation report where students follow the scientific approach as stipulated on page 13 of this teacher guide.

Discuss the report with students and allow them to identify a problem, hypothesise, plan and investigate, collect data, interpret and discuss data collected and present findings in a scientific report..

The students

This assessment task requires students to:

i) identify a problem or an issue with the teacher
ii) find information and resources needed for the investigation
iii) follow the general investigation steps and do the investigation
iv) use the assessment criteria as a guide for which investigation processes will be marked
v) complete the investigation as planned
vi) present a scientific report of the investigation.

9.2 Performance standards for assessment task 2: Report on guided investigation 30 marks				
Performance Criteria	**Very High Achievement (27–30)**	**High Achievement (20–26 Marks)**	**Satisfactory Achievement (15–19 Marks)**	**Low Achievement (0–14 Marks)**
Identify information (data) and equipment needed for the investigation (4 marks)	Identify all the appropriate information and equipment required before the investigation (4 marks)	Identify most of the appropriate information and equipment required before the investigation (3 marks)	Identify some of the appropriate information and equipment required before the investigation (2 marks)	Identify a few aspects of appropriate information and equipment for the investigation (0–1marks)
Recognise terms such as hypothesis, observation, control, conclusion etc (4 marks)	Identify and use all the scientific terms like hypothesis, observation, control, and conclusion appropriately in their investigation And scientific report (4 marks)	Identify and use most of the scientific terms like hypothesis, observation, control, and conclusion appropriately in their investigation and scientific report (3 marks)	Recognise and use some of the scientific terms like hypothesis, observation, control, and conclusion appropriately in their investigation And scientific report (2 marks)	Recognise and use a few of the scientific terms like hypothesis, observation, control, and conclusion but may not be appropriately used in their investigation (0–1 marks)
Present data in different ways such as tables, graphs (5 marks)	Organise, interpret data and present in a wide range (4–5) of forms (5 marks)	Organise, interpret data and present in a range (3–4) of forms (4 marks)	Organise, interpret data and present in a range (2–3) of forms (3 marks)	Organise, data and present in a range (1–2) of forms (0–2 marks)
Plan and follow the correct order of steps to carry out and report on an investigation (8 marks)	Use the four scientific investigation steps and follow fully the structure when presenting a scientific report (7–8 marks).	Use the four investigation steps and follow most aspects of the structure when presenting a scientific report (5–6 marks)	Use the four investigation steps and follow some aspects of the structure when presenting a scientific report (4–5 marks)	Use scientific investigation steps and structure when presenting a scientific report (0–3 marks)
Evaluate the processes and procedures used and suggest improvement (5 marks)	Identify all possible sources of error in the processes and procedures used and list ways of improving them (5 marks)	Identify most sources of error in the processes and procedures used and list ways of improving them (4 marks)	Identify some sources of error in the processes and procedures used and list ways of improving them (3 marks)	Identify 1 or 2 sources of error in the processes and procedures used but may or may not be able to list ways of improving them (0–2 marks)
Use appropriate mathematical formulae to solve science problems (4 marks)	Select, apply, manipulate, substitute and operate appropriate maths formulae correctly to solve science problems (4 marks)	Select, apply, substitute and operate appropriate maths formulae correctly to solve science problems (3 marks)	Select, apply and operate appropriate math formulae correctly to solve science problems (2 marks)	Select, apply and operate only one appropriate maths formula with some accuracy to solve science problems (0–1 mark)

The total assessment for this unit is 60 marks.

9.3 Ecology

This is a five to six week core unit. Teach this unit following the recommended sequence.

The unit outcomes

For each unit learning outcome, the scope of what content area to focus the teaching and learning is provided. Teachers of Science must ensure enough of these are selected and taught for students to achieve a particular unit learning outcome.

Outcome 9.3.1: Students can demonstrate an understanding of the natural processes that are essential for the survival of biotic life in an ecosystem

To help students achieve this outcome they are provided with opportunities to:

a. define different ecosystems and their components
b. explain photosynthesis and respiration processes in any ecosystem in their locality
c. describe the nutrient cycles of carbon, nitrogen and evidence of their presence in any ecosystem
d. discuss the implications of human activities on any ecosystem.

Outcome 9.3.2: Students can investigate natural and human-made changes on ecosystems and make suggestions to preserve the natural environment for all living things

To help students achieve this outcome they are provided with opportunities to:

a. explain use of fossil fuels and their effects on any ecosystem
b. describe acid rain and its effects on ecosystems
c. discuss logging/mining of natural resources and their limitations and impacts on the wider environment
d. debate impacts of human activities on the wider environment
e. identify and describe the importance of management systems for the preservation of the wider environment.

Outcome 9.3.3: Students can identify how ethical application of knowledge can contribute to economic growth as well as sustain different ecological systems

To help students achieve this outcome they are provided with opportunities to:

a. differentiate between ethical and unethical behaviour in terms of allowing for development
b. identify examples of where ethical practice have resulted in sustaining profitable activities

c. identify un-damaged ecological systems, both large/small .and explain reasons for their existence.

Programming a learning sequence

This sample unit program provides a brief overview of the essential topics, approximate time required in weeks, samples activities and suggestions for completing the assessment tasks.

Weeks 5 (Minimum)	Key Content Topics	Sample activities	Assessment
1	Ecology	Investigate, identify and record in different ecosystems, e.g. beach, mangrove, mine site, small industrial site, road side, fish pond, drain, school garden, etc the populations and species of plants and animals; their inter-dependence on each other (photosynthesis); the important roles and maintenance of decomposers, carbon/nitrogen cycles and nutrition cycles. Study a particular habitat and record populations of biological species, construct food chains food webs and food pyramids, label using appropriate words: producers, herbivore, omnivore, consumer; state reasons for their interdependence on each other and discuss what happens if one organism dies in the food web/chain from decomposer and their role.	Advice on assessment tasks
2–3	Ecological issues	Research recycling of paper, plastics, bottles, scrap metals, cans etc. Record findings of data and communicate implications and recommendations to the local community. Compare kinds of technologies used by humans to change the ecosystem analyse effects of mono cultural farming.	Complete Task 1 (end of week 3)
4–5	Maintaining balance	Research major influences on any eco-systems and how to minimise the effects brought about by humans through mining, logging destructive fishing and invasive species Students in groups/pairs discuss ways humans influence the balance of nature/ecosystem, logging, and developments. Differentiate between renewable and non renewable resources. Individual students carry out a project on one of the topics: state advantages and disadvantages of logging, mining, population increase, industries, use of fertilisers, pesticides and organic farming green house effect.	Complete Task 2 (end of week 5)

Elaboration of content and activities

Once you have mapped out your program for the year and term you must then develop more detailed plans for each topic in the unit.

All units require students to be actively engaged in learning not just copying from the board and or the text book. Make sure you develop a range of activities (including experiments/laboratory bench work/field trips) that suit all learning, some observing (of demonstrations) and doing.

All Science units require students to be actively engaged in learning, not just copying from the board. Make sure you develop a range of activities that suit all learning needs – some reading and writing, some speaking and listening, some observing and doing.

In this unit students have to be involved in many simple practical activities as much as possible. Safety is an important part of all activities especially when handling live animals and toxic plants.

Activities

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

- Investigate and Identify different ecosystems eg beach, mangrove, mine site, small industrial site, road side, fish pond, drain, school garden, etc.
- Students draw carbon and nitrogen cycles and use them.
- Observe local populations and species of plants and animals.
- State reasons for their inter-dependence on each other (photosynthesis).
- Investigate the importance of roles and maintenance of decomposers, carbon/nitrogen cycles and nutrition cycle Research and draw carbon cycle.
- Undertake a case study on pollutants.
- Define and differentiate physical and biotic factors of any environment of choice.
- Research on various influences on ecological systems.
- Investigate national species of animals and plants.
- Investigate and identify different ecosystem.
- Discover that decomposers are part of the ecosystem. Specify types of micro-organisms and their role compare kinds of technologies used by humans to change the ecosystem.
- Students draw carbon and nitrogen cycles and use them.
- Students in groups/pairs discuss ways human influence the balance of nature/ecosystem, logging, and developments.
- Differentiate between renewable and non renewable resources.
- Plan and carry out a project on one of the topics state advantages and disadvantages of logging, mining, population increase, industries, use of fertilisers, pesticides and organic farming green house effect.
- Identify sustainable management practices for maintaining balance of nature.

- Write down factors which limit growth and reproduction in nature, e.g. plant and animal disease, limiting factors such as diseases, natural fires.
- Define ecological succession.
- Do experiments on photosynthesis.
- Undertake water quality tests.
- Investigate different ecological systems.
- Observation of local eco-system such as a road side, creek or drain.

The following table gives elaboration of some selected activities from the above list.

Activity	Elaboration
Investigate different ecological systems	Project on recycling of paper, plastics, bottles scrap metals, cans etc. Study a particular habitat and record populations of biological species. Use data to construct food chains food webs and food pyramids, label using appropriate words: producers, herbivore, omnivore, consumer; state reasons for their interdependence on each other. Discuss what happens if one organism dies in the food web/chain (8.2 How Animals Feed).
Research on various influences on ecological systems	Research major influences on any eco-system and how to minimise the effects brought about by humans through mining, logging destructive fishing and invasive species. Analyse effects of mono cultural farming and or gardening.
Case study on pollutants	Cary out a case study and analyse information on the use of • persistent organic pollutants • pesticides, insecticides, weedicides • gas emissions, green house effects and acid rain • atmospheric pollution, radiation and measurement.
Investigate national species of animals and plants	Investigate current practices including work of ecologists in sustaining endemic species of fauna and flora, endangered, and threatened species. Students visit a garden site and observe different stages of ecological succession. Draw a flow chart to explain stages Research and compile information on the national animals of Papua New Guinea, national parks, wide life management areas, Bulolo, Wau, botanical gardens, coral reefs, selective logging, Greenpeace.

Notice that students are required to do a lot of practical activities such as small field trips as the part of the activities. This means that you must comply with all the DOE regulations when you undertake a field trip.

Resources

Charts on classification of plants and animals

Posters on carbon/nitrogen cycles if available

Assessment

There are two summative assessment tasks prescribed for this unit that all students are required to complete and the marks recorded towards internal assessment:

Task 1:	Case Study – Human impact on ecosystems (30 marks)
Task 2:	Objective test – Multiple choice and short answers (20 marks)

Ensure that you understand these first and include them in your planning.

Instructions of task 1

The teacher

i) for this assessment task, you must ensure that students in small groups or individually identify any local environment where humans have direct impact.
ii) give instructions to students what and how to go about doing the case study.
iii) give them date to complete and hand in the case study.
iv) Mark their work according to the criteria given in the performance standard rubric.

The students

This task requires students to:

i) follow all instructions carefully from the beginning to the end of the study.
ii) carry out a case study on any ecosystem.
iii) compare and contrast with examples of the cause and effects of a particular issue or a problem in the ecosystem caused by human activity.
iv) describe the characteristics or conditions of the ecosystem.
v) provide reasons for the interactions and natural balance of that ecosystem.
vi) provide statistics and photographs to support their case study where possible.
vii) display in the laboratory or the science room as source of information for other students in the school and the general population of the school.

9.3 Performance Standards for assessment task 1: Case Study – Human impact on ecosystems 30 marks				
Performance Criteria	**Very High Achievement (27–30 marks)**	**High Achievement (20–26 marks)**	**Satisfactory Achievement (15–19 marks)**	**Low Achievement (0–14 marks)**
Identify a local environment issue and ask appropriate questions (5 marks)	Finds information about a local environmental issue and formulate clear and testable hypothesis for investigation (5 marks)	Identifies from a range of environmental issues, testable hypotheses (4 marks)	Identifies from an environmental issue a testable hypothesis (3 marks)	Finds limited information about a local environmental issues but not able to fully formulate hypothesis for investigation (0–2 marks)
Investigate, collect, analyse and infer to answer question (8 marks)	Follows investigative procedure, collect and analyse data and relate findings to hypothesis being investigated in objective and systematic ways (7–8 marks)	Shows clear evidence of experimentation of investigation, interpreted data and inferred well (5–6 marks)	Shows some evidence of some analysing of data and some inferring (3–4 marks)	Follows investigative procedure systematically and conclusions are not supported by data (0–2)
Identify any scientific principles evident in the knowledge (7 marks)	Extracts and states the full scope of scientific principles evident with supporting evidence (7 marks)	Extracts and states the some scope of scientific principles evident with many supporting evidence (6 marks)	Extracts and states the scope of scientific principles evident with supporting evidence (5 marks)	Unable to show any aspect of science principles evident in the knowledge or only limited aspects (0–4)
Recommend some practical solutions to reduce impact on environment (6 marks)	Shows a highly comprehensive list of viable recommendations to reduce impact on environment (6 marks)	Shows a moderate comprehensive list of viable recommendations to reduce impact on environment 5 marks)	Shows a low comprehensive list of viable recommendations to reduce impact on environment (4 marks)	Shows a limited list of recommendations to reduce impact on environment, some of the recommendations being not viable (0–3 marks)
Evaluate investigative methods followed for improvement (4 marks)	Identifies limitations of the investigative methods followed and suggest viable alternative ways for improvement (4 marks)	Identifies some limitations of the investigative methods followed and suggest viable alternative ways for improvement (3 marks)	Identifies a few limitations of the investigative methods followed and suggest viable alternative ways for improvement (2 marks)	Unable to identify relevant limitations of the investigative methods used (0–1 mark)

Instruction for task 2

The teacher

This assessment task requires the teacher to:

i) use the test specification table below that provides the cognitive skills to guide you write a balance objective test

ii) the test should comprise of simple questions from knowledge/fact recalls to more complex higher order questions

iii) the performance criteria will provide the content area you should write questions about

iv) you must always write a test specification plan where a task is an objective test

v) mark, record and give back feed back as soon as you can (within a week).

The students

This assessment task requires students to:

i) be informed of the test details in advance

ii) comply with all instructions and complete the test within the set time

iii) respond to feedback as soon as marking and recording is completed.

Sample test specification table				
Performance Criteria	**Knowledge**	**Comprehension**	**Higher process (application/analysis/ evaluation)**	**Total %**
show understanding of natural processes such as photosynthesis				20%
identify stages of nutrient cycles such as carbon, nitrogen cycles				25%
recognise the impact of pollutants on natural processes and energy chains				25%
interpret diagrams, tables, graphs related to ecology				30%
Total (5)	20%	50%	30%	100%

For this sample objective test the test components are:

- 4 questions on knowledge recall of facts etc
- 10 questions on comprehension
- 6 questions on higher processes (2 questions on application; 2 questions on analysis and 2 questions on evaluation).

Very high achievement	21 – 25 marks
High achievement	15 – 20 marks
Satisfactory achievement	10 – 14 marks
Low achievement	0 – 9 marks

The total assessment for this unit is 50 marks

9.4 Our Body

This is a five to six weeks core unit and must be taught following the recommended sequence

The unit outcomes

For each unit learning outcome, the scope of what content area to focus the teaching and learning is provided. Teachers of Science must ensure enough of these are selected and taught for students to achieve a particular unit learning outcome.

Outcome 9.4.1: Students can describe the basic structures and functions of systems in the body

To help students achieve this outcome, they are provided with opportunities to:

a. explain physical appearance, internal structures and functions
b. investigate what, where, how and why of skeletal, muscles/tendons, bones and the four types of joints, bone breakages and healing, general health and care of bones
c. identify heart and circulation, including blood vessels and blood cells and heart/blood related problems
d. show respiratory system – inhaling/exhaling and way the gases exchange in the lungs
e. analyse excretory systems – the skin and the kidney – the waste products of urea and CO2
f. discuss healthy habits/hygiene/care and the effects of malfunction of one system consequently affecting other systems.

Outcome 9.4.2: Students can investigate how the structure of organs enables them to perform their functions

To help students achieve this outcome, they are provided with opportunities to:

a) explain human heart/blood vessels/circulation/blood cells and their constituents
b) show how the lungs perform inhale/exhale/exchange of O2 and C02
c) discuss the skin and wastes/sweat (CO2 and urea)
d) describe kidney and waste urea in urine/water balance
e) analyse heart/lungs/skin/kidney related problems.

Outcome 9.4.3: Students can examine how proper diet, habit and exercise keep the body healthy

To help students achieve this outcome, they are provided with opportunities to:

a. explore the use and effects of alcohol, drugs, smoking, chewing of betel-nut etc. on the human body
b. assess the intake of nutrient from some of the common foods eaten regularly in homes, school and villages
c. investigate the importance of having proper diet and regular exercise

Programming a learning sequence

This sample unit plan provides a brief overview of the essential topics, approximate time required in weeks, samples activities and the suggestions for completing the assessment tasks.

Weeks 6 (Minimum)	Key Content Topics	Sample Activities	Assessment
1–2	Skeletal and muscular system	Students construct, observe and discuss a working model of a human body part like the arm, its structures and functions.	Advise on assessment (end of week 1)
3	Circulatory system	Students research the different blood vessels and blood cells defining their structures, roles and specific functions.	Complete Task 1
4	Respiratory system	Demonstrate through experimentation the process of photosynthesis working out the: • process of respiration indicating the types of gases produced • how and where it enters the lungs, during respiration • the interconnectedness of these systems.	
5–6	Excretory system	Students observe and discuss functions of skin on the hand and general skin of the body and how different types of wastes are removed.	Complete Task 2 (end of week 6)

Elaboration of content and activities

In this unit students have to be involved in many simple practical activities as much as possible. Safety is an important part of all activities especially when handling live animals and toxic plants.

Activities

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

- Construct a model: human body from appearance and its internal structures and functions.
- Observe and compare similarities between human organs and organs of other animals.
- Teachers provide diagrams, posters, charts of organs of different animals for students compare similarities using the model.
- Constructed in activity one with the organs of other animals.

- Investigate the skeletal system, bones, joints and the movements of muscles and tendons by looking at chicken legs, and wings.
- Draw diagrams of heart; label the structures and functions of heart.
- Do research into blood vessels and different blood cells.
- Draw diagrams of a human heart, label the structures and functions.
- Dissect chicken, sheep cow or goat heart from the butcher shop or an abattoir, especially in city schools or a model of a heart to investigate the internal structures and chambers of a heart.
- Observe blood moving in the capillaries of a tadpole under a microscope.
- Study poster on respiratory system and mechanics of gas exchange.
- Research into the importance of respiration process. Activity 1: Study poster on respiratory system and the mechanics of gas exchange.
- Use a poster or chart if available or any models for class discussion and label parts of respiratory system and explain their functions.
- Measure heart rate by students observing pulse before and after a vigorous activity e.g. running around the school oval once.
- Discuss the mechanics of gas exchange in the lungs and complete worksheet exercise on formula of respiration.
- Research the importance to the human body as a system.
- Discussion the importance of healthy diet, habits and exercises for the whole human body or system.
- Examine different layers and functions of skin and means of removing waste and types and names of wastes removed by the skins.
- Investigate functions, structures and the role of kidney – types of wastes and how wastes are removed.
- Investigate functions, structures and the role of kidney.
- Discuss waste types removed through the skin and completion worksheets on the skin structures and functions.
- Students research into the role of kidney as an excretory organ.
- Students use the human body model created earlier to complete the whole systems studied.

- The following table gives elaboration of some selected activities from the above list.

Activity	Elaboration
Construct a model of a human body	Students discuss and complete a cross-sectional wall size human model either using cardboard, butcher paper, wood or other suitable materials. The parts of the human internal organs can then be made or drawn and pasted onto the body model. Functions of each part could also be written and glued onto each part. Students use human skeletal models, make models of different bones using wood, cardboard, plasticine, plastics using bones to show different types of joints, muscle movements. Tendons could be observed with students performing different movements such as walking, lifting, jumping and chewing.
Research into blood vessels, and blood cells of the circulatory system	Students research, discuss and communicate with peers about blood cells and blood vessels, their particular structures and functions either individually or in groups. Organise and share information found with the groups and the class as a whole. Compare information about the blood vessels and blood cells with the prepared slides/specimens under a microscope. Students use the microscope appropriately. **NOTE:** **DO NOT HANDLE FRESH HUMAN BLOOD**
Experiment on photosynthesis and test for carbon dioxide (what gases we breathe in and out during respiration)	Demonstrate, observe and discuss the importance of photosynthesis and respiration processes and link to the structures and functions of lungs and how oxygenated and deoxygenated blood is maintained in the lungs
Examine different layers and functions of skin and removal of wastes by the excretory system	Students use hand lenses to observe and discuss skin on palms, fingers and the back of hands, the specific roles each play, fingerprint their fingers and label layers of skin and functions using a worksheet.

Resources

Model of human skeleton

Torso

Posters of some human organs e.g. skin

Charts on human organs e.g. kidneys

Collection of different animal bones (not human)

Slides

Assessment

There are two summative assessment tasks prescribed for this unit that all students are required to complete and the marks recorded towards internal assessment:

Task 1:	Model – Make working model of a part of body systems (30 marks)
Task 2:	Objective test – Multiple choice and short answers (30 marks)

Instructions for task 1

The teacher

This assessment task requires the teacher to:

i) inform students early about this assessment task as suggested in the overview plan for programming
ii) discuss the marking criteria with the students beforehand so that students are aware of the different weightings for each criteria
iii) allow students to select their own models to construct using locally available materials such as card board, plastics, papers etc
iv) challenge students to design and construct a working model of any organ or of any body part
v) remind students to test their models to see it works before they hand in their completed product
vi) construct and display a sample model, for example, a human arm showing the humerus, radius, ulna and the carpals, metacarpals and phalanges with the biceps and triceps muscles attached to the humerus to demonstrate its function etc.

The student

This assessment task requires the student to:

i) research and select a part of a human system/organ
ii) select suitable materials to use
iii) construct a working model
iv) use materials that will cost nothing or very little cost involved
v) design and construct a model, e.g. build a model of human breathing system out of a plastic bottle, straw and balloons
vi) display the model constructed for others to use to learn something about the function of a breathing system.

Performance standard for assessment Task 1: Make a working model of a part of a body system				30 marks
Performance Criteria	**Very High Achievement (27–30)**	**High Achievement (20–26)**	**Satisfactory Achievement (15–19)**	**Low Achievement (0–14)**
Demonstrate an understanding of how the system works (5 marks)	Identify a system and clearly and in detail state its basic function (5 marks)	Identify a system and clearly state its basic function (4 marks)	Identify a system and in some detail state its basic function (3 marks)	Identify a system but some details may be irrelevant (0–2 marks)
Identify and label parts correctly (10 marks)	Label all parts correctly without spelling errors (9–10 marks)	Label most parts correctly without spelling errors (7–8 marks)	Label some parts correctly with a few spelling errors (5–6 marks)	Label one or two parts with lots of spelling errors (0–4 marks)
Describe the functions of the system (10 marks)	Give a very thorough description of functions of the selected system (9–10 marks)	Give a clear description of the functions of the selected system (7–8 marks)	Give a short description of functions of the selected system (5–6 marks)	Give a short description which was incomplete in many respects (0–4 marks)
Recognise similarities between the body system and simple machines (5 marks)	Identify all instances of similarities between the body system and simple machines (5 marks)	Identify most instances of similarities between the body system and simple machines (4 marks)	Identify some instances of similarities of body systems and simple machines (3 marks)	Identify a few instances of similarities between the body system and simple machines (0–2 marks)

Instructions for task 2

The teacher

Follow the sample assessment specification given on page 55 and write a test specification for this task

Ensure that the assessment criteria for this task is given to students prior to the test date as planned in the over view of planning for programming of this unit.

Assess task 2 on the extent to which students can meet the given performance criteria below:

- show understanding of the structure and function of body systems
- describe how poor diet, bad habits and lack of exercise lead to poor health
- recognise similarities in the body system of humans and other animals
- interpret diagrams, tables, graphs related to body systems and their structure.

Very high achievement	21 – 25 marks
High achievement	15 – 20 marks
Satisfactory achievement	10 – 14 marks
Low achievement	0 – 9 marks

The total assessment for this unit is 50 marks

9.5 Atoms and The Periodic Table

This is a new unit introduces in Grade 9. It is a four to five week core unit. Teach this unit following the recommended sequence.

The unit outcomes

Outcome 9.5.1: Students can demonstrate an understanding of the basic structure of atoms

To help students achieve this outcome, they are provided with opportunities to:

a. reflect on their prior knowledge about the three states of matter and properties of matter
b. explain the atom and its structure
c. describe sub atomic particles – electrons/protons/neutrons
d. identify the characteristics of electrons/protons/neutrons
e. explain atoms and elements and classification from a historical perspective.

Outcome 9.5.2: Students can investigate the relationship between the properties of atoms and their structure using their location in The Periodic Table

To help students achieve this outcome, they are provided with opportunities to:

a. explain the structure of any atom consisting of nucleus – protons and neutrons; shells, consisting of electrons and their properties
b. explain elements and their classification
c. understand and explain different atoms have different number of protons etc.
d. make connections between chemical properties of some common elements and their organisation and arrangement on The Periodic Table
e. explain how The Periodic Table classifies elements systematically
f. explain The Periodic Table showing main classifications of elements into metals and non-metals according to properties
g. explain how from the location of an element on The Periodic Table its structure and properties can be inferred.

Outcome 9.5.3: Students can use combining power concept of atoms to write chemical formula of compounds leading to chemical equations

To help students achieve this outcome, they are provided with opportunities to:

a. use combining power concept to establish the combination of elements in given compound

b. use or make models to determine the type and number of elements in a given formula of compounds
c. use chemical formulae to explain chemical reactions
d. balance equations – no new matter created but reorganisations of atoms during chemical reactions
e. explain how compounds/molecules are formed–bonding concepts
f. write formulae of simple compounds applying the combining power procedures assisted by The Periodic Table.

Outcome 9.5.4: Students can explain how and why the atomic model has evolved over centuries

To help students achieve this outcome, they are provided with opportunities to:

a. describe historical development of The Periodic Table
b. understand and explain horizontal rows–periods/vertical columns–groups
c. explain groups–classifying atoms of elements going down The Periodic Table.
d. discuss with reasons where on The Periodic Table metallic/non-metallic elements/atoms are placed
e. explain why atoms of certain elements are grouped together in one group
f. identify properties of metals

Programming a learning sequence

This sample unit program provides a brief overview of the essential topics, approximate time required in weeks, samples activities and the suggestions for completing the assessment tasks.

Weeks 5 (Minimum)	Key Content Topics	Sample Activities	Assessment
1–2	Introduction to atomic theory	Construct models of the first 20 atoms/elements and show their atomic structure and the three different particles of each atom/element.	Advise on assessment tasks (end of week 1)
3–5	Development	Research the development of The Periodic Table and explain how and why the periodic table evolved identifying scientist(s) responsible for its discovery and consequent evolution.	Complete Task 1 (end of week 3) Complete Task 2 (end of week 5)

Elaboration of content and activities

Activities

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

- Students can construct a wall Periodic Table using plywood and pieces of timber with symbols of elements on them with wood glue or cardboard if there is no plywood.
- Use combining powers to write formulae of simple compounds.
- Identify and list physical properties of substances.
- Investigate, role play and describe the three states of matter – gas, liquids, solid, particles with concrete examples of matter.
- Show variations in sizes of atom structures with different objects e.g. stones, balls (ping pong), beads etc.
- Define, explain and construct models of atoms/elements and their structures using the chemical terms such as nucleus, protons etc.
- Introduce students to atoms and display samples of different models of atoms. Students participate in making models of atoms and discuss the atomic structure.
- Examine and describe the different features of The Periodic Table; the horizontal rows (periods) and it's relationship to the number of shells in pairs, groups in class.
- Reconstruct a Periodic Table using pieces of paper cut into circles and coloured into different colours and paste them in appropriate groups and periods.
- Models of atoms can be reused with parts made up from papers, wood, cardboard or plasticine to illustrate their different states and sizes etc.
- Construct a table comparison between properties of metals and non-metals describe the parts of an atom.
- Students should be able to create models of the atomic structure by using different colours and sizes of stones, beads other similar materials to represent protons, electrons and neutrons. Different members of groups are shaded using different colours. State of elements can be coloured (all gases white, liquid blue, metals yellow etc. in order to identify their locations on The Periodic Table.
- Use different models and substances like coloured papers or mol beads to work out formulae of compounds such as magnesium oxide, calcium oxide, aluminium iodide and sodium oxide.
- The combing powers can also be exchanged between students showing atoms combining and exchanging of powers. Formulae can be derived from these simple games. Students should then be able to complete worksheets exercises on formulae writing.
- Construct a table of comparison between properties of metals and non-metals.
- Physical properties of metals can be investigated by students collecting or observing different samples of metals from their localities such as school grounds, home, town or surroundings environment. Metals such as iron from construction sites (with prior permission sought), or nails,

aluminium from soft drink cans, foils, louvre frames, copper from copper pipes, keys etc.

- Non-metals can also be collected or observed such as carbon (charcoal, graphite in pencils).
- A variety of metals and non-metals from the laboratory chemical stock can be used for students to compare weight/density/mass, strength, appearance, colour, melting and boiling points (melting points and boiling points can be shown by heating and boiling piece of metals).
- Teacher to make available copies of combining powers in class sets on (A4) paper. Class discussion using The Periodic Table especially on groups and periods and combining powers.

The following table gives elaboration of some selected activities from the above list.

Activity	Elaboration
Reconstructing a Periodic Table for the first 20 elements	In small groups students investigate, classify, explain and arrange at least the first 20 atoms by groups and periods. (H He Li B Be C N O F Ne Na Mg Al Si P S Cl Ar K Ca)
Research on how The Periodic Table was developed or conceptualised and evolved through centuries	In small groups students do research into the historical development of the Periodic Table, who and how it was first designed and how it developed over time. Students provide a time line of its development. The information can then be shared and the summary displayed around the class room.

Resources

Periodic Table charts, (wall, and A4 for class sets), plasticine and wire for model making, samples of metals and non-metals, match sticks

Assessment

There are two summative assessment tasks prescribed for this unit that all students are required to complete and the marks recorded towards internal assessment:

Task 1: Assignment – History of atomic models and The Periodic Table (30 marks)

Task 2: Objective test – Multiple choice and short answers (30marks)

Instruction for task 1

The teacher

i) inform students early about this assessment task as suggested in the unit overview plan
ii) discuss the assessment criteria with students so that they are well aware of the weightings of the different criteria beforehand
iii) mark the assignment and give students feedback as soon as the marking is completed.

The student

This assessment task requires students to:

i) individually find out the historical development of The Periodic Table
ii) show how and why different atomic models were identified at different times
iii) structure the assignment well as guided by the performance criteria given
iv) submit a completed assignment on time.

9.5 Performance standard for assessment task 1: History of atomic models and The Periodic Table				30 marks
Performance criteria	**Very High Achievement (27–30)**	**High Achievement (20–26)**	**Satisfactory Achievement 15–19)**	**Low Achievement (0–14)**
Show knowledge of the origin of the idea of atoms (5 marks)	Give clear and detailed explanation of how and why it became necessary to conceptualise the idea of an atom with a very good number of instances (5 marks)	Give clear explanation of how and why it became necessary to conceptualise the idea of an atom with a good number of instances (4 marks)	Give explanation of how and why it became necessary to conceptualise the idea of an atom the idea of an atom with a good number of instances (3 marks)	Give unclear and or confusing explanations of how and why it became necessary to conceptualise the idea of an atom without instances (0–2 marks)
Demonstrate understanding of the evolution of atomic models over the ages (5 marks)	Show with examples how and why the atomic models evolved over time conceptually and why or how the concept of the atom evolved over time with 3 models (5 marks)	Show with examples how and why the atomic models evolved over time conceptually and why or how the concept of the atom evolved over time with 2 models (4 marks)	Show with examples how and why the atomic models evolved over time conceptually and why or how the concept of the atom evolved over time with one model (3 marks)	Show with examples how and why the atomic models evolved over time conceptually and why or how the concept of the atom evolved over time with no models. (0–2 marks)
Describe the origin and characteristics of the periodic table (6 marks)	Describe in detail well how the periodic table evolved and what it represents (6 marks)	Describe very well how the periodic table evolved and what it represents (4–5 marks)	Describe how the periodic table evolved and what it represents (3 marks)	Give some confusing descriptions about how the periodic table evolved and what it represents (0–2 marks)
Demonstrate how atoms fit into the locations allocated on the periodic table (maximum 8 marks)	Demonstrate accurately how the characteristics of the periodic table allocates elements to specific locations (7–8 marks)	Demonstrate how the characteristics of the periodic table allocates elements specific locations (5–6 marks)	Show how the characteristics of the periodic table allocates elements specific locations (3–4 marks)	Show how the characteristics of the periodic table allocates elements specific locations but with a lot of difficulty. (0–2 marks)
Explain that scientific models change as further knowledge is gained (6 marks)	Show at least 4 examples of the tentativeness of scientific models with reasons (6 marks)	Show at least 4 examples of the tentativeness of scientific models with reasons (5 marks)	Show at least 4 examples of the tentativeness of scientific models with reasons (3–4 marks)	Show with one or no examples of the tentativeness of scientific models with unclear or without any reasons (0–2 marks)

Instruction for task 2

The teacher

i) follow the sample assessment specification plan given on page 54 and write a test specification for task 2
ii) ensure that the assessment criteria for this task is given to students prior to the test date as planned in the over view of planning for programming for this unit.
iii) set questions within the boundaries of the given assessment criteria below.

Assess task 2 on the extent to which students can:

i) draw the atomic structure of any of the first 20 elements
ii) recognise a stable atomic structure
iii) explain the features of The Periodic Table
iv) compare the physical properties of metals and non-metals
v) write chemical formulae of simple molecules using combining power concept.

Very high achievement	21 – 25 marks
High achievement	15 – 20 marks
Satisfactory achievement	10 – 14 marks
Low achievement	0 – 9 marks

The total assessment for this unit is 50 marks

9.6 Electricity

This unit is a six to seven week practically oriented unit. It is recommended this unit be taught after unit 9.5 Atoms and The Periodic Table.

The unit outcomes

Outcome 9.6.1 Students can demonstrate an understanding of electricity and electromagnetism

To help students achieve this outcome, they are provided with opportunities to:

a. explain how electricity both statistic and current is generated
b. set up simple circuits
c. draw and read circuit diagrams
d. measure current and voltage, relate them to resistance and operate the formula V = I x R and P=V x I
e. illustrate heating, lighting, magnetic and chemical effects in simple settings
f. perform experiments to investigate factors affecting the strength of electromagnets
g. recognise short-circuits and demonstrate safe handling and use of electrical equipment/devices.

Outcome 9.6.2: Students can construct different types of circuits and recognise their application in household electricity

To help students achieve this outcome, they are provided with opportunities to:

a. set up series and parallel circuits
b. explain the application of circuits in lighting and power, the use of switches and fuses in household circuits, the role of live, neutral and earth wires and the safety measure of 'only qualified electricians deal with household circuits'
c. draw, read and describe a simple outline of a household electrical circuit system
d. use and operate the formula P = V x I; and E =P x T
e. calculate cost of electricity using the formula,

cost = kWh x Rate

f. describe importance of energy conservation as cost saving and eco-friendly measures.

Outcome 9.6.3: Students can investigate and explain energy transfers and efficiency of devices

To help students achieve this outcome, they are provided with opportunities to:

a. explore and explain the efficiency of fluorescent tubes and incandescent bulbs in terms of energy changes and transfers
b. identify and describe energy changes in simple cells, solar cells and car batteries leading to energy changes in electrical circuits
c. set up circuits to investigate the energy efficiency of different size dry cells and how the life span of simple cells and car batteries can be prolonged
d. experiment with the magnetic effects of electricity and its application in electric motors to improve life in homes and work places
e. practise safe handling and use of electrical equipment and devices, acid batteries in particular).

Outcome 9.6.4: Students can compare different methods of generating electricity and the environmental impact of each

To help students achieve this outcome, they are provided with opportunities to:

a. investigate the difference between DC and AC
b. explore the use of transformers at voltage stations, the need to generate electricity and its importance for development, resource use in thermal and hydro power stations and the importance of alternate energy sources
c. describe energy changes both in a thermal power and a hydro power station.

Programming a learning sequence

This sample unit program provides a brief overview of the essential topics, approximate time required in weeks, samples activities and the suggestions for completing the assessment tasks.

Weeks 6 (Minimum)	Key Content Topics	Sample Activities	Assessment
1	Types of electricity	Students do simple experiments to identify static and current types of electricity discuss their differences and explain methods of production and contextualise their applications.	Advise on assessment tasks.
2–3	Circuits	Students: • in groups or pairs set up simple circuits correctly: • connect commonly used components in series and parallel circuits • describe the operations of direct current (DC) • describe the operation series and parallel, using terms such as current and voltage • identify from circuit diagrams those circuit elements that are connected in series and those that are connected in parallel • relate the brightness of torch bulb to the magnetite of the current in it and the voltage across it • link the brightness of two or more bulbs in series and parallel circuits to the magnitude of the voltage and current	
4	Uses of electricity	• Students: • describe through experimentation the heating and lighting effects and magnetic effects of electricity • investigate and describe the effects of magnetic attraction and repulsion forces on an object and describe simple magnetic and electromagnetic effects in terms of a field model • construct simple electromagnets and identify its applications • through investigations identify resistance wire and its application in useful electrical devices.	Complete task 1 (end of week 4)
5	Household electricity	Students: • construct a house circuit model and describe its function and safety • demonstrate the role of fuse in a home electrical circuit and explain the importance of using the right size of fuse wires describing short circuits • use Math formula to calculate costs of electricity and practice cost saving measures when using electrical appliances.	
6	Generating electricity	Students: • research and compile information on the different ways of producing electricity • discuss the importance of using environmentally friendly ways of producing electricity on a large scale.	Complete task 2 (end of week 6)

Elaboration of content and activities

In this unit students have to be involved in as many simple practical activities as much as possible. Safety is an important part of all activities especially when handling electrical components.

Activities

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

- experiments with static electricity
- experiments in current electricity
- introduction to safety and draw a safety poster
- simple experiments with series and parallel circuits, and observe current and voltage
- experiments using resistance wires
- build a model of a house lighting circuit
- experiment with electromagnets
- do a home energy audit
- research into other ways of generating electricity.

The following table gives elaboration of some selected activities from the above list.

Activity	Elaboration
Experiments with static electricity.	Students explore generation of static electricity by friction; attraction and repulsion; principles of lightning conductors; watch and discuss demonstration with Van Der Graff generator (if available)
Experiments in current electricity	Students experiment with conductors and insulators, and set up simple working circuits. Students learn about components of electric circuits and use a range of components in the circuits they set up. Students should then construct a simple circuit with a light build battery and switch and use this to test various materials to see if they conduct. Use a table to record results using the brightness of the battery as an indicator of how good a conductor the various materials are.
Introduction to safety and draw a safety poster	Class discussion of safety aspects of using electricity particularly from the mains and why certain materials are used to carry current etc Discuss roles of fuses and fuse wires. First Aid in context of electric shock and electricity/water related accidents Students draw safety poster

Simple experiments with series and parallel circuits, and observe current and voltage	Introduce concept of a circuit and demonstrate clearly, a complete circuit, short circuit and a broken circuit through a range of experiments. Teachers demonstrate construction and representation of simple circuits with batteries (dry cells), switches, light globes, resistance wires, insulated copper wires, ammeters and voltmeters, buzzers/bells. Make and read/interpret circuit diagrams using standard symbols. Students construct simple parallel and series circuits and measure variations in current and voltage and relate them to Ohm's law. Students draw circuit diagrams as representations.
Experiments using resistance wires	Students experiment with the heating effect of current travelling through a resistance wire, evident in lighting (torches, electric bulbs) and heating (toasters, hair dryers, electric stoves) in the home and other areas. Measure voltage and currents to investigate Ohms Law (V=IR) Explore the use of different resistance wires in daily situations
Build a model of a house lighting circuit	As an extension activity students could build a working model of a housing circuit and read the circuit components.
Experiment with electromagnets	Students experiment and analyse lighting effects, heating effects and electromagnetism. Students construct small electromagnets by wrapping wires around a nail and observe the magnetic effects and link to solenoids, speakers, electric bells. Students set up simple electromagnets and investigate factors that affect their strength.
Do a home energy audit	Students demonstrate through calculations how to both read a power meter, the energy ratings of electrical appliances and how to calculate using power and at the same time investigate and analyse the conservation of electrical energy. P= V x I and Energy using formula E= P x T. Students carry out an energy audit either of the home, school, local business, boarding house etc and do cost calculations using current prices. Read meters and calculate power usage and look at power rating of some electrical appliances. Calculate cost of running electrical appliances and ways of conserving power and so cutting costs.
Research into other ways of generating electricity	Students do research projects examining the alternatives available in the local regions e.g. hydro, solar, wind etc. Research on other methods of generating electricity not available in the local area. Students investigate through projects energy conversions.

Resources

Examples of equipment required for this unit. Ensure that an adequate number of items (equipment/materials) are available for the size of the class.

dry cell dry cell holder bulbs (3.5 V) connecting wire switch nichrome wire crocodile clip ammeter demonstration ammeter voltmeter old dry cell fluorescent tube Newspaper Steel wool watch glass hacksaw blade l clamp stand boss head clamp electromagnet	metre of thin insulated wire nail (15 cm) nail (13 cm) nail (6 cm) electric bell iron filings overhead projector demonstration electric motor bar magnet magnetic needle test tube cork insulated bell wire copper electrode zinc electrode dilute sulphuric acid nails sizes, 6cm, 13cm and 15cm beaker (250 mL) lemon fruit	cutting boar balloon lead electrode DC power supply car battery galvanometer bicycle dynamo solar light meter iron wire old car generator small hand generator wall chart of Ramu hydro-electric scheme silver paper (from cigarette packets) scalpels scalpel blades
selection of 240 V bulbs of various power ratings bulb holder flex and three-point plug for 240 V bulbs metal bar (about 20 cm long) old household appliances with the cords removed e.g. toaster, iron, shower heater, stove element, jug etc		

Assessment

There are two summative assessment tasks prescribed for this unit that all students are required to complete and the marks recorded towards internal assessment:

Task 1: Practical skills – Set up electrical circuits (30 marks)

Task 2: Objective test – Multiple choice and short answers (30 marks)

Instruction for task 1

The teacher

For this assessment task you must ensure the following:

i) Talk to students about the task early as suggested in the sample unit plan

ii) All the required materials must be on hand and readily available beforehand

iii) You can decide to do two small activities at two different times or do one big activity as suggested. However, the total mark must be 30 as stated above.

The students

This task is seeking evidence that students:

i) can set up series or parallel circuits as instructed
ii) demonstrate safe layout
iii) connect ammeter and voltmeter correctly in a circuit
iv) measure current and voltage accurately using correct units in a working circuit
v) show magnetic effects of electric currents.
vi) demonstrate the factors affecting the strengths of an electromagnet.

9.6 Performance standards for assessment task 1: Set up electrical circuits				30 marks
Performance criteria	Very High Achievement (27–30)	High Achievement (21–26)	Satisfactory Achievement (15–20)	Low Achievement (0–14)
Set up series or parallel circuits as instructed, demonstrating safe layout (6 marks)	Complete more than two complex tasks including correct and safe connections of all components and devices showing complete circuits with no errors.	Complete two complex tasks including correct and safe connections of all components and devices, showing complete circuits, with no errors	Complete at least two simple tasks including safe connections of components and devices and showing complete circuits, with no errors	Make some connections correctly but not completely. Some errors as evident in unsafe layout
Measure current and voltage accurately using correct units in working circuits (10 marks)	Connect the meters into the circuit efficiently Record current and voltage using correct units and symbols	Connect the meters into the circuit Record current and voltage using correct units and symbols	Students are able to connect only one of the meters correctly and record units and symbols	Students are able to connect meters into the circuit incorrectly Records reading incorrectly And uses incorrect units and symbols
Show magnetic effects of electric current (6 marks)	Effectively demonstrate evidence of magnetic effect of an electric current in more than one way	Demonstrate evidence of magnetic effect of electric current in several ways	Demonstrate evidence of magnetic effect of an electric current in one way	Not able to Demonstrate effects of an electric current
Demonstrate the factors affecting the strengths of an electromagnet. (8 marks)	Demonstrate three factors affecting the strength of an electromagnet	Demonstrate two Factors affecting the strength of an electromagnet	Demonstrate one factor affecting the strength of an electromagnet	Unable to demonstrate factor affecting an electromagnet

Instruction for task 2

The teacher

i) use the sample test specification on page 55 and write a test specification for this task.
ii) inform students about the task in advance
iii) discuss with students the assessment performance criteria before hand
iv) mark students' papers as soon as you can and give feed back to students.

Assess task 2 on the extent to which students can:

- explain energy conversions involved in the generation and application of electricity
- interpret circuit diagrams
- identify variations in voltage, current and resistance
- use formula V = IR and P = VI for calculations
- describe and explain safety precautions in household electricity
- use mathematical calculations for cost of electricity
- analyse environmental impact of methods of generating electricity.

Very high achievement	21 – 25 marks
High achievement	15 – 20 marks
Satisfactory achievement	10 – 14 marks
Low achievement	0 – 9 marks

The total assessment for this unit is 50 marks

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9.7 Earth and Atmosphere

This is a new unit inclusive of the previous 'Air around us' and 'Geology' units. This is a six to seven week core unit. This unit must be taught following the recommended sequence.

The unit outcomes

Outcome 9.7.1: Students can describe the structure of Earth and its atmosphere and their role on life on Earth

To help students achieve this outcome, they are provided with opportunities to:

a. identify characteristics of crust, mantle, core and inner core
b. explain activities of magma and its effects on the crust
c. give details of volcano formation as a result of crust and magma movements
d. describe the role of the active atmosphere such as troposphere/stratosphere/ionosphere on life on earth.

Outcome 9.7.2: Students can investigate factors affecting weather, weathering and rock formation

To help students achieve this outcome, they are provided with opportunities to:

a. examine activities of rock cycles and rock formations leading to fossils and the characteristics of sedimentary, igneous and metamorphic rocks
b. observe rock cycles and formation processes of rocks/fossils/minerals
c. differentiate between physical and chemical weathering and discuss methods of determining age of rocks
d. show effects of altitude/temperature/speed on air pressure
e. analyse effects of radiation on land and water leading to formation of convection currents/formation of land and sea breezes, orographic and convectional precipitation.

Outcome 9.7.3: Students can compare traditional and contemporary scientific methods of predicting and explaining natural phenomena

To help students achieve this outcome, they are provided with opportunities to:

a. explain how weather is predicted by both traditional and contemporary means and the reliability of these methods
b. compare traditional and contemporary explanations of night and day, eclipses, tides (low/high), feasting at full moon, and traditions of planting, general farming, specific farming, hunting ,fishing, rainbow after a shower etc.

c. compare ways of telling weather patterns, forecasting rainy/dry seasons
d. explain weather – convection currents/weather charts.

Outcome 9.7.4: Students can set up and use weather equipment to record and describe local weather patterns

To help students achieve this outcome, they are provided with opportunities to:

a. set up a weather screen
b. apply meteorological processes with standard weather instruments
c. measure minimum and maximum temperature, rain or precipitation, wind speed and direction, cloud cover and sun light intensity
d. identify weather patterns.

Programming a learning sequence

This sample unit program provides a brief overview of the essential topics, approximate time required in weeks, samples activities and the suggestions for completing the assessment tasks.

Weeks 7 (Minimum)	Key Content Topics	Sample activities	Assessment
1	Structure of earth	Students construct a model of the earth's four main structures/layers and discuss characteristics of each layer.	Advise on assessment tasks.
2	Rock cycle and weathering	Students: • identify lithosphere where as the region of the earth where rocks are formed • distinguish between sedimentary, igneous and metamorphic rocks, on the basis of their formation and composition • describe ways of to estimate age of rocks and explain the rock cycle • describe properties of sedimentary, igneous, and metamorphic rocks in terms of composition, grain size, colour and texture • describe the relationship between rocks ores and minerals and explain why igneous, sedimentary and metamorphic rocks are used for different purposes.	Begin Task 1 and continue for the duration of the unit or the term to complete.
3	Structure of atmosphere	Students: • identify the structure of the atmosphere focusing mostly about the different regions of the atmosphere and the particular roles each region of atmosphere plays • experiment on the composition of the atmosphere and discuss the role different gases play.	
4–5	Active atmosphere	Students • identify regions/layers within the atmosphere and describe natural events and their association with atmospheric changes • carry out different experiments on composition of air, air pressure, such 'candle in the wind', friendly apples or other spherical, floating ball, upside fruits and discuss importance of the composition of air and their usefulness particularly for sustaining life on the planet earth.	

6	Weather	Students: • describe weather and climate and various technology used for monitoring different factors of weather • set up an weather screen and keep a record of weather over a period of a month or two, interpret and organise information on tables, graphs etc. and communicate information to selected audience. •	Complete Task 2 (End of week6)

Elaboration of content and activities

Activities

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

- Construct a model of the earth's structure.
- Investigate and explain the cycle and formation of igneous rocks, sedimentary and metamorphic rocks.
- Describe and identify fossils and minerals.
- Investigate and explain physical and chemical weathering.
- Use and explain methods of determining the age of rocks and fossils.
- Explain the activity of magma and its effect on the crust.
- Investigate troposphere, stratosphere and ionosphere.
- Describe the characteristics of its layers.
- Explain how atmosphere protects Earth.
- The active atmosphere – troposphere – explain why air has pressure and how it is measured.
- Describe the effects of altitude, temperature and speed or air pressure.
- Investigate how birds, insects and aeroplanes take off and fly.
- Convectional currents experiment – demonstrate the effects on land and water
- Discuss how convectional currents form.
- Describe the formation of land and sea breezes and the formation of orographic and convectional precipitation.
- Construct weather charts or examine one.
- Identify and use weather instruments to measure weather factors.
- Set weather equipment and record weather data.
- Present weather data in variety of ways.
- Predict the weather.
- Apply ways of predicting weather patterns with traditional knowledge and scientific method.
- Identify and manipulate where possible all available weather instruments.
- Use weather instruments to measure different factors of weather.
- Observe types and shapes of cloud, feel breeze, hot/cold, rain/dry.
- Discover layer of atmosphere using books/charts.
- Discuss characteristics of each layer.

- Write essay on how atmosphere protects earth and radio transmission (teacher to check).
- Students – contribute to discussion on photosynthesis, respiration, rusting particle theory of matter.
- Experiment on air has mass.
  - weigh inflated and deflated balloons. Record findings/results.
  - make see-saw and balance balloons.
- Experiment on air exerts pressure.
- Discuss land, sea, mountain and valley breezes.
- Measure and record air pressure in millibars using aneroid barometers; draw isobars.
- Discussion topics: What happens to temperature and air pressure as attitude increases? Essay: Boiling point of water in Hagen/Port Moresby.
- Experiment: String table tennis balls, stand
  - method: tie tennis balls 2–3 cm apart from stand, blow between the balls using straw, record observations
  - conclusion: still/slow moving air – high pressure; fast moving air – low pressure
- Design a model of an aeroplane using cardboard and scissors and assemble parts ailerons, rudder, elevators.
- Explain the terms convection current.
- Experiment different heating rates for soil and water.
- Research trade winds in PNG and the global wind patterns.
- Explain types of precipitation, draw diagrams of water cycle and label.
- Explain orographic and convectional precipitation.
- Bring newspaper cuttings of weather forecast, learn weather symbols and interpret weather conditions for places (map with main centre of PNG).
- Record aspects of weather using appropriate weather instruments. Details:
  - maximum and minimum temperature, air pressure, humidity, wind speed, wind direction, cloud cover, rainfall
  - students measure and record
  - analyse data in line column or bar graphs.
- Explain ways of drawing a climograph.
- Visit a volcano observatory/study pictures and draw diagrams, do research on volcanoes.
- Construct models and describe rock cycle and weathering, observing the characteristics of the Earth’s layers.

The following table gives elaboration of some selected activities from the above list.

Activity	Elaboration of activities
Structure of earth of the earth Explain the activity of magma and its effect on the crust	Students read about and construct models/posters of the four main layers of the Earth structures, name and describe the characteristics of each structure and its effect on the crust.
Construct models and describe rock cycle and weathering and observing the characteristics of the Earth layers	Students • bring samples of rocks and classify them into igneous, sedimentary or metamorphic • complete rock cycle posters/diagrams and communicate to peers • use teacher displayed charts on rock cycle/minerals, samples of rocks and make fossil models with clay/plasticine in a mould • do other extension work on such concepts like, uses of rocks/fossils/minerals, radio carbon dating of rocks and communicate with others • carry out simple acid tests to identify different rock types and discuss the differences between chemical weathering and physical weathering process.
Describe structures of the atmosphere and investigate importance of troposphere, stratosphere and ionosphere	Students • identify the structure or the regions of the atmosphere using photographs, books/charts or teachers take students outside to observe types and shapes of cloud, feel breeze, hot/cold, rain/dry etc • discuss characteristics of each layer and write research on how atmosphere protects Earth • demonstrate the process of photosynthesis and respiration and discuss their interactions and interdependence • further experiment on air mass/weight/pressure using inflated balloons, boiled eggs/upside down glass of water etc, and discuss the importance and effects of air pressure • further measure and record air pressure in millibars using aneroid barometers/draw isobars • discuss the relationship between altitude/air pressure and temperature using concrete examples such as finding out the temperature of boiling water • discuss convection currents and their influence on weather patterns and climate and technology associated with the study of meteorology.
Describe the formation of volcanoes	Students • organise a visit a volcano observatory/study pictures and draw diagrams, do research on volcanoes • discuss the formation and activities of volcanoes analysing effects of earthquakes and eruptions on the environment and people.

Resources

Volcanologists

Diagrams/pictures of volcanoes

Diagrams of subduction zones

Rock samples

Rock charts

HCl, and Calcium carbonate

Space views

Diagrams /charts of coast–sea/land breezes

Diagrams/charts of mountain valley breeze

Weather instruments

Climographs

Folk lore

Village elder

Meteorologists

Rain gauge, measuring cylinder, thermometers, balloons, weather maps/symbols, wind vane, anemometer, radiometer, barometer, wet and dry bulb hygrometer, maximum and minimum thermometers, humidity meter, local meteorologist.

Assessment

There are two summative assessment tasks prescribed for this unit that all students are required to complete and the marks recorded towards internal assessment:

Task 1:	Practical skills – Setting up a weather screen and recording weather over a period of time (30 marks)
Task 2:	Objective test – Multiple choice and short answers (30 marks)

Instructions for task 1

The teacher

i) for this task ensure in advance that all the necessary weather instruments are available
ii) allow students to construct some themselves such as wind vane which are quite easy to construct
iii) set up the weather equipment in a fenced or otherwise safe area, away from trees, buildings, animals and people
iv) keep a regular check on the set up perhaps on a daily basis
v) put up a time sheet in the classroom for students to take the weather instrument reading at the same time each day.

The students

This assessment task requires students to:

i) set up a weather screen in the beginning of the unit when students are familiar with the weather instruments and their uses. Then
ii) keep a daily record of the weather over a period of three to four weeks
iii) organise the data into tables and graphs
iv) present the information for assessment as a summary on a chart/poster or a written report
v) communicate findings to others
vi) display on notice board for others.

9.7 Performance standards for assessment task 1: Setting up a weather screen and recording weather over a period of time 30 marks				
Performance criteria	**Very High Achievement (27–30)**	**High Achievement (20–26)**	**Satisfactory Achievement (15 – 19)**	**Low Achievement (0 – 14)**
Demonstrate an understanding of factors affecting weather (6 marks)	List all factors affecting weather	List most factors affecting weather	List some factors affecting weather	List a factor or none affecting the weather
Recognise and use appropriate weather instruments (5 marks)	Accurately use all selected weather instruments appropriately without any assistance	Accurately use many of the selected weather instruments appropriately without any assistance	Accurately use some of the selected weather instruments appropriately with minimum assistance	Use a few of the selected weather instruments appropriately but with a lot of assistance
Measure weather factors such as air pressure, temperature, wind speed and direction, precipitation, cloud cover, humidity (10 marks)	Measure easily and accurately air pressure, temperature, wind speed and direction, precipitation cloud cover, and humidity and express them in correct units.)	Measure easily and accurately air pressure, temperature, wind speed and direction, precipitation cloud cover, and humidity with minor assistance with correct units.	Measure accurately air pressure, temperature, wind speed and direction, precipitation cloud cover, and humidity with some assistance with correct units.	Measure accurately a few of these but with a lot of assistance with correct units.
Present weather data in a variety of methods including a weather map. (9 marks)	Present weather maps, charts, table, graph with appropriate interpretation.	Present weather maps, charts and tables only with appropriate interpretation	Present weather maps and tables only with appropriate interpretation	To present weather maps only with little or no appropriate interpretation

Instruction for task 2

The teacher

i) start task 2 early as suggested in the sample plan for this unit
ii) use the sample test specification plan on page 55 and write a test specification plan for this unit
iii) discuss the assessment criteria for the task beforehand
iv) mark students' test and provide feed back to students as soon as you can

Assess task 2 on the extent to which students can fulfil the performance criteria given below.

- show an understanding of the structure of earth and its atmosphere
- identify the role and components of each layer of the Earth and region the atmosphere
- recognise factors affecting weather and weathering
- interpret charts, graphs related to any aspects of this unit, classification charts for rocks and other related data

- identify the role of the active atmosphere in natural processes and protecting life
- identify traditional ways of explaining natural phenomena.

Very high achievement	21 – 25 marks
High achievement	15 – 20 marks
Satisfactory achievement	10 – 14 marks
Low achievement	0 – 9 marks

The total assessment for this unit is 50 marks

Grade 10 units

10.1 Working Scientifically Through Projects and Investigations

This is a new five to six week core unit. It is recommended that this unit be taught last, at the end in Term Three of the school year. This will enable students to do a lot of hands on activities and practice leading to doing well the practical test. However, aspects of working scientifically should be integrated into all units.

The unit outcomes

Outcome 10.1.1: Students can apply scientific skills competently to carry out integrated projects or investigations

To help students achieve this outcome, they are provided with opportunities to:

a. apply safe procedures in and outside of science laboratory/room etc.
b. engage with investigative processes – steps 1–4 (break down the problem to manageable parts, then work through them one at a time as illustrated on page13 of this teacher guide)
c. devise technology, rules and mathematical formulae to find solutions
d. discuss evidence to reach a logical conclusion and communicate such information to others
e. perform skills of drawing to scale, making models and prototypes and schematic diagrams etc.
f. use learning strategies; cooperation, collaboration, corroboration.
g. interpret tables, charts or graphs in different contexts.

Outcome 10.1.2: Students can assess implications of the findings of a project in relation to people, their environment and ethical considerations.

To help students achieve this outcome, they are provided with opportunities to:

a. view problems from different perspectives
b. discuss their intended projects or investigations, explaining their proposals and suggestions to all the people that may be affected as a result of their activities
c. outline the possible effects, whether negative or positive, of their investigations on people and/or the environment
d. work backwards to eliminate other possibilities and select the most likely
e. appreciate the sources of error and take precaution to minimise error
f. apply ethical consideration when assessing implications of project findings.

Programming a learning sequence

This sample unit plan provides a brief overview of the essential topics, approximate time required in weeks, samples activities and the suggestions for completing the assessment tasks.

Weeks 6 (Minimum)	Key Content Topics	Sample activities	Assessment
1	Working safely	Students discuss and enhance safety practices when handling live animals, toxic plants, hazardous and poisonous chemicals, delicate and sharp tools or equipment. Students identify universal symbols for such things as flammable, explosive, poisonous, toxic etc. Students rehearse procedures for treating simple burns, cuts, acid spills on skin or clothes, etc. and invite a trained health worker to demonstrate resuscitation procedures in case of unconsciousness or electric shock. Students list safe ways of doing practical activities both inside and outside laboratories.	Advise on assessment tasks.
2–3	The scientific approach	Students discuss investigation steps and practise designing hypothesis and identifying variables and fair testing procedures, and explain what it means to be a scientist. Students follow investigation procedures and plan their project activities identifying issues and problems to investigate.	Start planning for Task 1 (week 2)
4–6	Undertake a scientific project	Students undertake project activities as planned keeping journals and recording data as they progress. Students analyse data collected, interpret and discuss findings. Following the investigation steps students write and submit a scientific report of their particular project. Students communicate their findings to different audiences of students, other classes, teachers of the school, local community etc.	Complete Task 1 (end of week 6)

Elaboration of content and activities

In this unit students have to be involved in many simple practical activities as much as possible. Safety is an important part of all activities especially when handling live animals and toxic plants.

Activities

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

- Demonstrate scientific skills in avoiding danger and ensuring safety in science activities.
- Apply and show correct first aid procedures competently.
- Display correct use of safety equipment and develop new safety rules.
- Demonstrate scientific skills in avoiding danger and ensuring safety in science activities.
- Display an attitude of safety by demonstrating how to handle dangerous chemicals and reactive substances.

- Apply and show correct first aid features competently.
- Revise and reinforce the scientific approach.
- Design plan and carry out scientific projects.
- Research and design solutions for issues at community level.
- Undertake a scientific project (in groups or individually).
- Set up a drinking water purification process for a community living near murky river water.
- Listen to a qualified health worker (nurses, doctors, St John ambulance staff) and watch them demonstrate resuscitation procedures in case of electric shock or unconsciousness.
- Define the scientific approach.
- Study and design solutions for issues at community level.

The following table gives elaboration of some selected activities from the above list.

Activity	Elaboration of activities
Working Safely–apply and show correct first aid features competently	Students use their prior knowledge from unit 9.2 Working Scientifically in handling scientific equipment and following procedures correctly and safely. Teacher can first demonstrate lighting a Bunsen Burner correctly and heating a mixture in a test tube, then get students to repeat in order to reinforce their capabilities. Students practise safety in heating things in a test tube and handling of hot equipment. Divide students into groups of 5 or 6 and get them to practise using other equipment, such as reading correctly thermometers, balances, voltmeters, microscopes etc. undertaking correct procedures in handling and using this equipment. Students list and discuss first aid procedures and correctly show how to treat minor injuries such as cuts, burns and bruises.
Design plan and carry out scientific projects	Students explain or use a worksheet on scientific approach using a problem solving process. **Example of problem solving** Sometimes egg whites will stiffen when whisked and other times they won't. Identify the problem– Why won't an egg white become stiff after being whisked? List observations– In this case, difference between previous successful attempt and this unsuccessful attempt. - there was some egg yolk mixed with egg whites - the bowl was slightly wet. Make an inference or inferences - egg whites will not stiffen when whisked if some egg yolk is mixed with them - egg whites will not stiffen when whisked if the bowl is wet - egg whites will not stiffen when whisked if both situations are present. Test your inferences. To test inference 1 Carefully crack an egg separating the white from the yolk so that there is some yolk present. Whisk the mixture and record results. To test inference 2 Carefully crack an egg separating the white from the yolk. Place the white in a damp bowl. Whisk the mixture and record results. To test inference 3 Carefully crack an egg separating the white from the yolk so that there is some yolk present. Place the white in a damp bowl. Whisk the mixture and record results.

	Test 4 Whisk an egg white in a dry bowl, making sure the egg white is free of egg yolk. Students then use a similar method to solve some simple issues. Students collect data about issues in the community, such as: - growth of plants in different soils - food in the mess tastes bad - Omo washes out dirt better than other detergents - firewood from casuarina trees produce more ash then pine trees, oaks and walnut. Students then make inferences about the problem. Then proceed to test their inferences. Finally make conclusions about the issue. Presentation of data can be orally, poster display, or written reports. Students should now under take a scientific project (more information on projects can be obtained from grade 9 projects hand book developed by Curriculum Development Division in 1998). Some examples of projects are: - assessing water quality - assessing effects of industrial waste (any industry large or small) - testing strengths of different detergents - making a solar hot water system - collect and display different types of rocks in their area - study and report on healthy habits and cleanliness in their areas. Here is an example of a special investigation or a project report a student could do: The task–Prepare a report on a metal produced commercially in your locality. If there is no specific metal then consider an alloy or a non-metal like cement. Student report should cover as many of the following aspects as are appropriate: • natural occurrence • where found, how abundant, what minerals are important? • mining • what mining methods are used, why employ these methods, where it is mined In Papua New Guinea? • processing from ore to metal • how is the ore concentrated, what physical properties are significant, how is the metal extracted, what chemical properties are significant? • important chemical and physical properties • what are the physical properties of the metal, what are the chemical properties? • uses • how has this metal been used in the past, what are the current uses of the metal? • environmental implications • are there any pollution problems associated with the mining, processing or uses of this metal, what precautions must be taken to minimise these risks? • economic importance? • how important is it to your local economy, how important is it to our national economy? • social importance? • how would your life be affected if this metal was unavailable, what alternatives could be used? • discuss with students the criteria which will be used to if its going to be used for summative assessment purposes

Resources

Necessary science equipment, chemicals,

First aid kits

Library

Local environment

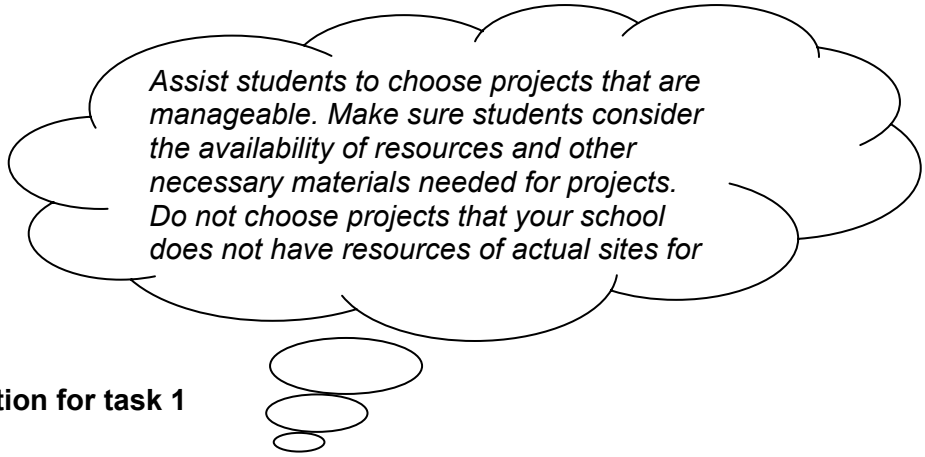
People

Practicing scientist

Assessment

There is one summative assessment task prescribed for this unit that all students are required to complete and the marks recorded towards internal assessment:

Task 1: Project – Students select own community related issue/problem to solve (50 marks)



Instruction for task 1

Teacher

i) inform students early about this task as suggested in the unit overview of plan for programming
ii) help students to select practically doable problem to solve
iii) discuss the performance criteria with students especially the weighting for each criterion
iv) make clear to students what particular investigating steps will be assessed in the beginning of the project
v) explain to students the time for different stages of the project to be completed and reported including the time for final submission of the project
vi) mark this task using the performance standards
vii) ensure ethical and safety issues are clearly understood and applied

The students

This task requires students to:

i) follow all instructions and advice carefully
ii) select and conduct any projects of interest
iii) ensure resources required are available from the start of the project
iv) take note of the time frame given and stick to it as much as possible
v) choose a real community related problem so that more realistic and meaningful activities are done to provide solutions for community improvement
vi) apply scientific investigation procedures as much as possible
vii) stick to time and submit the completed project on time
viii) be aware of safety issues
ix) be aware of ethical issues when dealing with the community.

Assess this task on the extent to which students can produce work complying with the assessment criteria below:

- plan scientifically accepted methods, procedures, equipment and resources precisely to collect accurate data
- document clearly scientific methods used (collect and record data)
- support and justify interpretations through specific data and results
- communicate accurate, relevant and in-depth information to communicate in a variety of ways
- identify issues raised in relation to the implementation of the project
- identify possible sources of inaccuracy.

Performance standard for task 1: Project – Students select own community related issue/problem to solve		**50 marks**
Assessment criteria	**Specific criteria for**	**Marks (50)**
Plan scientifically accepted methods, procedures, equipment and resources precisely to collect accurate data (10 marks)	**Planning** ▪ background knowledge – getting started–propose a project ▪ identification and understanding of an issue – carry out background research on issue and state information sources ▪ either: design/write interview/survey questions needed– guess/predict what might happen, decide what will be observed/collected, decide what will be made/designed etc ▪ list resources needed ▪ list safety precautions if needed ▪ choose appropriate tasks – choose what to do and how it will be done – write permission letters ▪ ask questions – develop testable hypothesis ▪ identify variables that will change and what will be a control ▪ identify variables that will be measured ▪ identify appropriate methods/procedures to be used ▪ set timeline	
Document clearly scientific methods uses (collect and record data) (10 marks)	**Conducting the task/researching** ▪ carry out tasks/projects in appropriate manner decided earlier in planning such as gather data/experiment techniques/record observations and measurements/classify collections/make models or even test designs ▪ keep an ongoing record of findings and data ▪ keep record of sources of data and results ▪ explain observations/data using scientific knowledge	
Support and justify interpretations through specific data and results (10 marks)	**Analysing results/products** ▪ finish models, tests, test designs and working with data ▪ organise results in table/graphs/scientific report ▪ analyse any data/explain and demonstrate models ▪ compare with similar designs if possible ▪ identify patterns and relations between variables ▪ interpret results using scientific principles/knowledge	
Communicate accurate, relevant and in-depth information to communicate in a variety of ways (10 marks)	**Reporting** ▪ report methods/procedures used ▪ present data and results in an understandable form, tables/graphs/written/finished model ▪ include references ▪ report scientific method used to get information ▪ demonstrate understanding of concepts and principles	
Identify issues raised in relation to the implementation of the project (6 marks)	**Conclusion** ▪ infer and draw conclusions ▪ make generalisations ▪ make recommendations for future analysis	
Identify possible sources of inaccuracy (4 marks)	**Evaluation** ▪ assess findings with original hypothesis/design/pattern and relationships ▪ give a general impression of the project ▪ acknowledge what went wrong and state the cause of error ▪ suggest corrective measures for further testing etc.	

10.2 Microbiology

This is a five to six weeks core unit. It is recommended that this unit be taught first in Term 1.

The unit outcomes

Outcome 10.2.1: Students can describe and explain the role of microbes in the living world

To help students achieve this outcome, they are provided with opportunities to:

a. understand the characteristics and features that determine classification, e.g. algae, bacteria, fungi, protozoa and virus of microbes
b. describe the role of microbes in circulating nutrients in nature
c. give details of how microbes cause diseases noting the microbes' features and feeding/reproduction patterns
d. recognise most useful and most harmful microbes
e. understand prevention and/or cure procedures and products available for particular microbe(s)
f. explain reasons for immunisations against different microbes.

Outcome 10.2.2: Students can safely and correctly use a microscope to observe, measure and show the characteristics of micro-organisms

To help students achieve this outcome, they are provided with opportunities to:

a. manipulate microscope to observe the minute and microscopic things
b. apply safety procedures and safely handle delicate microscopes and accessories
c. describe various microscopic organisms in words and diagrams recognising their unique features
d. use mathematical formula to calculate the sizes of microbes.

Outcome 10.2.3: Students can demonstrate how useful and harmful activities of microbes can be utilised for food processing and healthy living

To help students achieve this outcome, they are provided with opportunities to:

a) identify different activities of some common types of microbes , e.g. decomposers
b) describe microbes in various contexts; food production and protection such as:
   - bacteria for yoghurt/cheese production
   - medicines and good health supplements, e.g. penicillin from fungi
   - preservation of food, e.g. traditionally; smoked food which prevents microbes growing by removing moisture, and contemporary;

freezing or adding preservatives which prevents microbes like fungi and bacteria growing and destroying the food

- feeding styles of microbes, e.g. fungi feeding styles break down dead matter and release nutrients to the environment for the survival of other lives (interdependency)

c) explain how healthy habits and life styles of individuals can promote healthy living for themselves, communities and the world from a traditional and a contemporary perspective

d) explain he relationship between sexually transmitted disease and HIV/AIDS

e) describe the consequences of contracting HIV/AIDS

f) identify causes, remedies and prevention of diseases like:

- gastro –intestinal and water related diseases
- contagious diseases.

Programming a learning sequence

This sample unit program provides a brief overview of the essential topics, time required in weeks, samples activities and suggestions for completing the assessment tasks.

Weeks 6	Key Content Topics	Sample activities	Assessment
1	Introduction to microbiology	Students observe drops of pond or drain water using a microscope and observe different microbes that are not visible to the naked eye. Students then discuss other microbes and classify them into the five main groups as determine by their different characteristics. Students observe other microbes on prepared slides if available or find them diagrams or photos of them in text books.	Advise on assessment tasks.
2–3	Useful microbes	Students identify useful microbes and discuss the reasons by looking at the way they feed and reproduce. Students find out where in real life situations these useful microbes are used and describe their functions. Students construct a chart and list the functions of useful microbes to display in their classroom. Students can visit any institution or factory near the school to see for themselves where and how some of these useful microbes are used, such as ice cream factory, beer factory, freezers and bread factory etc. Write a scientific report.	Start planning for assessment 1 in week 2 continues……
4–6	Harmful microbes	Students identify harmful microbes by determining their feeding patterns and reproductive functions. Students research where in real life situations certain microbes have actually brought harm and destruction to different organisms both plants and animals particularly the human body. Students list preventative measures and discuss cure and preventative measures in place. In particular, students discuss the issue of microbe transmission through sexual activities leading to HIV/AIDS. Students explain the dangers of HIV/AIDS and discuss preventative methods knowing that there are no cures available.	Complete Assessment 1 (end of week 6)

Elaboration of content and activities

Activities

- A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.
- Demonstrate safe handling and setting up of a microscope.
- Identify parts and functions of a microscope.
- Observe parts of a microscope and work out their functions using research notes and discuss how to handle microscopes safely.
- Research in the library on terms and definitions and make notes on the five types of microbes.
- Identify useful microbes in food industry and medicines.
- Visit a food processing factory, e.g. bakery, fish cannery etc near the school.
- Identify harmful microbes that cause all kinds of diseases.
- Collect statistics/data on common diseases and compare with other local communities and other provinces.

The following table gives elaboration of some selected activities from the above list.

Activity	Elaboration of content activities
Safely handle and use a microscope	Students: • use microscopes safely as an instrument for observing micro-organisms and define terms such as microbes and microbiology • follow given instructions and observe pond water to see living organisms that they normally cannot see with their naked eye • identify the five groups of micro-organisms and discuss and explain their different characteristics • search books to find pictures of the five groups of microbes and display on information boards • in small groups discuss parts and functions of a microscope and practice using it to observe pollen grain • draw diagrams of what they see under the microscope while teacher supervises.
Identify useful microbes in food industry and medicines Medical uses of microbes	Students: • in small groups discuss how food industries process some food items such as milk, yoghurt, cheese, bread and beer and wine etc. and make a list of types of microbes that are used for these processes • describe how food in general are preserved listing reasons for doing such as; smoking, drying, salting, and freezing • listen to an invited community member talking on traditional method of fermentation, production and preservation of food and take notes and discuss reasons in class • research in the library terms such as fermentation, production and preservation • in groups demonstrate, observe and discuss making bread using Home Economics stoves or in the science lab if there is a stove or even on an outside fire with hot charcoal etc • visit food processing factory, e.g. bakery, fish cannery, to observe or identify different methods of production and preservation • write a field report and present

	• discuss the usefulness of some microbes in medical fields such as penicillin • research the historical aspects of penicillin, how it was discovered and by whom and communicate the information to peers and others • listen to an invited health worker on the uses of modern drugs and their side effects when not used according to instructions • in groups produce and display information of other useful microns as well.
Identify harmful microbes that cause all kinds of diseases.	Students: • in small groups or as a class brainstorm and list harmful microbes that they are aware of such as those that cause food and water diseases, airborne diseases, contagious diseases, vector diseases, sexually transmitted diseases, HIV/AIDS and others diseases for example, SARS, bird flue, swine flue etc • then research in detail some of these harmful microbes, their reproduction and feeding processes to determine the harm they cause on other living things particularly humans • invite a community member to talk on traditional herbs/medicine • also research and present a pamphlet on traditional herbs/drugs used in their different societies for sharing with others • work in groups and interview a health worker or collect information about a common health problem in an area such as a settlement, village, a town etc. and present findings in the form of graphs, charts poster drama to the class, school or community concerned • discuss dangers and preventative measures of sexually transmitted diseases and how HIV/AIDS is contracted and cured and other related issues • in groups interview a health worker or collect data on STD and HIV/AIDS from the nearest health centre or other sources carefully and with due care considering ethical issues and human right issues. They can summarise data with other areas or provinces, nation and the world • communicate their findings in the form of drama, charts, posters, graphs to the class, school or local community as awareness.

Assessment

There are two summative assessment tasks prescribed for this unit that all students are required to complete and the marks recorded towards internal assessment:

Task 1: Practical skills – Set up and view slides using a microscope (20 marks)

Task 2: Objective test – Multiple choice and short answers (30 marks)

Instruction for task 1

The teacher

i) inform students early about this task as suggested in the unit overview of plan for programming

ii) ensure all the required materials are on hand and available for the task beforehand

iii) ensure soap and water are available when needed

iv) remind students of safety requirements

v) select from the alternatives given below for marking. You can use a checklist or a performance standard rubric to mark this task.

The students

This assessment task requires students to:

i) carefully follow all instructions given
ii) correctly and safely use a microscope
iii) prepare slides
iv) view invisible microbes such as plant/animals parts, for example pollen grains
v) leave all equipment clean and set
vi) wash hands when finish and before you leave the room.

Assess task 1 either using the performance standards or the checklist below. You can select what method of marking you prefer.

Performance standards for assessment task 1: Practical skills – Set up and view slides using a microscope 20 marks

Performance Criteria	Very High Achievement (18–20)	High Achievement (15–17)	Satisfactory Achievement (11–14)	Low Achievement (0–10)
Prepare slides to be viewed through a microscope (5 marks)	Prepare three to five slides by following correctly all the set procedures with due care and safety and without asking for assistance (4–5 marks)	Prepare two slides by following correctly all the set procedures with due care and safety with no assistance (3 marks)		Prepare a slide by following set procedures with a lot of assistance (0–2 marks)
Set up microscope to view slides at the required magnification. (5 mark)	Set up a microscope with correct magnification and light intensity without assistance (5 marks)	Set up a microscope with correct magnification and light intensity with minimum assistance (3–4 marks)		Not able to set up a microscope on their own and require assistance at key points (0–2 marks)
Draw diagrams of objects seen through the microscope (5 marks)	Make clear and realistic diagrams of a range of objects in the field of view (5 marks)	Make clear and realistic diagrams of some objects in the field of view (3–4 marks)		Not able to make clear and realistic diagrams of objects viewed (0–2 marks)
Show care and safety when handling slides and microscopes (5 marks)	Show high level of healthy habits before and after handling activity (4–5 marks)	Show good level of healthy habits before and after handling activity (3 marks)		Show little or no level of healthy habits before and after handling activity (0–2 marks)

Marking guide for assessment task 1: Set up and view slides using a microscope			
Criteria No.	**Students have demonstrated that they can perform steps 1–14**	**Mark 20**	**Score**
4	1. Carry a microscope safely	1	
4	2. Use a glass slide and cover slip safely	1	
4	3. Explain the safety aspects of using a microscope	2	
4	4. Explain the safely aspects of working with micro organisms	1	
2	5. Unpack and prepare microscope for use, including setting mirror for light	1	
2	6. Put a pre prepared slide on stage and start focus from close to slide	1	
2	7. Select a set magnification	1	
1	8. Calculate magnification from lens details (using both lenses for calculation)	2	
2	9. Focus on subject of the slide	1	
3	10.Identify and describe key features of subject matter	3	
1	11.Create a wet mount slide with no air bubbles that interfere with viewing area	1	
1	12.Use stain correctly	1	
3	13.Use grid/ ruler to approximate size	1	
3	14.Sketch what is visible so that the main features are recognisable	3	
Total		20	

Instructions for task 2

The teacher

i) use the sample test specification plan on page 55 and write a test specification plan for this objective test
ii) inform students and discuss the assessment criteria for this task
iii) mark, record and provide students the feedback right away

Assess task 2 on the extent to which students can meet the assessment criteria prescribed below:

- show understanding of characteristics of microbes
- identify, useful and harmful activities of microbes
- explain cause, spread and prevention of common diseases
- interpret tables, graphs, investigation data related to microbes and diseases.

Very high achievement	21 – 25 marks
High achievement	15 – 20 marks
Satisfactory achievement	10 – 14 marks
Low achievement	0 – 9 marks

The total assessment for this unit is 50 marks

10.3 Chemical Reactions

This is a five to six week core unit. Teachers of Science must read the short description of this unit in the Science Syllabus to set the scene before actually teaching this unit.

The unit outcomes

Outcome 10.3.1: Students can show understanding of the characteristics of chemical change and factors influencing change in materials

To help students achieve this outcome, they are provided with opportunities to:

a) explain characteristics of a chemical change from formation of simple oxides, decomposition of simple compounds and formation of precipitates
b) investigate and describe the properties of acids and their reactions with bases, metals and carbonates forming new products/compounds
c) analyse chemical reactions in respiration/fuel burning (petrol/diesel) and oil formation/extraction/refining/crude oil.

Outcome 10.3.2: Students can investigate specific reactions of acids and bases and write balanced equations

To help students achieve this outcome, they are provided with opportunities to:

a) perform safe use and storage of acids and bases
b) actively perform or demonstrate different chemical tests such as flame test/pH test on local dyes and pigments/acid and lime water tests/ glowing splint test/burning splint test
c) write balanced equations.

Outcome 10.3.3: Students can present an investigative report on at least one chemical process involved in industries in Papua New Guinea

To help students achieve this outcome, they are provided with opportunities to:

a) investigate
    - factors affecting corrosion and its prevention in industries and homes
    - copper ore processing and production either small scale and on a large scale
    - water treatment and purification
    - sewerage collection and treatment
b) prepare an investigative report on one of the above
c) present it in a written form.

Programming a learning sequence

This sample unit program provides a brief overview of the essential topics, approximate time required in weeks, samples activities and the suggestions for completing the assessment tasks.

Weeks 6 (Minimum)	Key Content Topics	Sample activities	Assessment
1–2	Chemical changes	Students identify and define chemical reactions through carrying out various experiments such as burning magnesium, making lime, making lime water go milky, neutralising acids and bases, making hydrogen gas and testing, corrosion and displacement reactions. Students identify chemical change by observing the presence of new substances during reactions. Students describe chemical changes that are encountered in everyday life. Students also compare the difficulty of reversing a chemical change to reversing a physical change.	Advise on assessment tasks(end of week 1)
3–4	Analysing matter	Students perform different chemical tests such as the flame test, acid and base test using pigments/dyes/universal indicators etc, acid and limewater test, burning splint test for gases such as oxygen and hydrogen. Students observe, infer and analyse different substances involved in the tests and relate this to natural phenomena and their usefulness in life.	Complete Task 1 (end of week 3)
5–6	Corrosion	Students investigate discuss and explain the process of corrosion and identify factors that effect corrosion. Students construct and display a reactivity series table. Students observe and describe preventative measures for controlling corrosion in industries, homes and the natural environment.	Complete Task1 (end of week 6)

Elaboration of content and activities

Activities

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

- Analyse natural processes such as respiration as examples.
- Investigate formation of precipitates in experiments.
- Investigate decomposition of simple compounds.
- Investigate the formation of simple oxides for example burn magnesium in oxygen.
- Investigate the reactions of; Acids with bases, metals and carbonates, acids and base etc. For example, Hydrochloric acid + Sodium hydroxide; Sodium Chloride + water.
- Research on:
  - formation and use of crude
  - distillation of crude oil
  - how crude oil was formed.

- Conduct test for carbon dioxide, hydrogen and oxygen.
- Perform reactions of organic substances.
- Conduct acid test with carbonates, metals etc.
- Investigate and describe how corrosion occurs.
- Discuss and list factors effecting corrosion in nature, industries and homes.
- Perform displacement and reaction experiment and analyse results.
- Write and explain chemical reactions in universal language of chemical formula.
- Write word equations for burning and rusting.

The following table gives elaboration of some selected activities from the above list.

Activity	Expanded elaboration
Chemical reactions	Students: • begin discussions about chemical reactions and changes that occur in nature and reflect on the concepts and definitions of physical and chemical changes. For example, describe how lime (calcium oxide), salt and other things are made in Papua New Guinea or how home-brew is made of precipitates in experiments discussing the dangers of, safety and healthy habits in the making and taking of home-brews • revise and reinforce safety in the beginning in order to avoid accidents at all cost • experiment on making limewater goes milky. Observe Calcium carbonate precipitate. Write word equations and balanced equations of magnesium and oxygen • perform simple chemical reactions, observe and identify reactants and products of the following: calcium carbonate heated to produce calcium oxide and carbon dioxide, calcium hydroxide and limewater reacting to form calcium carbonate and hydrogen oxide (water), test acid with metals for example; Zinc + Hydrochloric acid → zinc chloride + hydrogen • test carbonates with acids. For example; Calcium carbonate + hydrochloric acid → calcium chloride + carbon dioxide + hydrogen • students/teacher write formulaic equations and balance equations on experiments carried out • students write formulaic equation and balance • students research and find out for themselves: - formation, mining and extraction and use of crude - distillation of crude oil
Analysing matter through a variety of tests.	Students: • carry out other simple tests such as flame test, test for presence of metal calcium, copper, sodium, iron, and barium in respective compounds • record their discoveries and analyse results • do hydrogen and oxygen gas, carbon dioxide, perform tests using universal indicator solution compare colour change to pH chart, and state: whether substance is acid or base and its pH value.
Factors that cause corrosion	Students: • investigate how corrosion occurs • do an experiment with nail, in boiled/unboiled water with wet iron wool observe results and analyse • research on how corrosion can be prevented using oil, paint, coating, galvanising etc. relating to realistic situations • displace reactions, observe, discuss, collects and display elements from most reactive to least reactive following guided questions.

Resources

Resources for this unit will mostly be chemicals such as common metals, acids and bases and others as listed below and others found in nature that students can reflect on such as beetle-nut chewing, fruits ripening, wood burning etc.

Standard chemicals and accessories

Common metals
Hydrochloric acid – HCI (concentrated)
Copper sulphate (sulfate)
Zinc granules
Universal indicator
Magnesium ribbon
Scirrors
Gas lighter guns
Bunsen burners
Litmus papers
Safety goggles
Wire loop
Test tubes
Tongs
Lime water (calcium hydroxide)
Straw or glass blow tube
Spirit burners

Local stores and environment

Vinegar
Lime
Candle
Kerosene
Bread
Rice
Table salt
Fruit juices
Toothpaste
Cooking oil
Bleach
Clean nails
Candle/fire
Gas/kerosene stoves
Shells/limestone(calcium carbonate)
Coral
Limestone
Rusty metal
All types of plastic
Diesel
Firewood
Steel wool
Shampoo
Axiom
Steel wood
Cooking oil
Matches

Charts – Teacher/students produced

Safety procedures poster
Reactivity series chart
Valence table
Valiancy table of elements
Data recording sheet
Ph charts
Oil chart

Fields/institutions

Moran gas field
Napa refinery

Assessment

There are two summative assessment tasks prescribed for this unit that all students are required to complete and the marks recorded towards internal assessment:

Task 1:	Practical skills – Perform simple chemical reactions and tests (20 marks)
Task 2:	Objective test – Multiple choice and short answers (30 marks)

Instructions for task 1

The teacher

i) inform students early about this task as suggested in the sample unit program
ii) discuss with students the assessment criteria
iii) ensure all the required materials and chemicals are on hand and available
iv) ensure students observe safety procedures in place
v) break the tasks into several manageable parts for different times or set round robin for all students to do at one set time
vi) ensure all materials and chemicals are left clean and set for the next class
vii) assess this task using the marking guide or the performance standards below.

The students

This assessment task requires students to:

i) Follow all instructions carefully and correctly
ii) Apply safety practice when using and handling chemicals
iii) Carry out acid tests, base tests, metal tests and gas tests
iv) Manage your time well and rotate when instructed by the teacher
v) Leave materials and stations clean for the next class
vi) Wash hands before leaving the room

Marking guide for assessment task 1: Perform simple chemical reactions and tests		
Criteria	**Students have demonstrated that they can**	**Mark (20)**
Perform simple tests to identify acids, bases, gases and metals (5 marks)	Perform simple tests to identify acids	1
	Perform simple tests to identify bases	1
	Use natural pigment –indicators to identify acids and bases	1
	Perform tests to identify a gas	1
	Perform tests to identify a metal	1
Make observations of reactions (3 marks)	Identify a formation of a gas in a reaction	1
	Identify the formation of an aqueous product	1
	Identify the formation of a precipitate	1
Make inferences from a chemical reaction. (4 marks)	Make correct inference from a positive test result	2
	Make correct inference from a negative test result	2
Recognise the pattern and characteristics of some chemical reactions (4 marks)	Reaction between dilute acids and metals generally produced hydrogen gas	1
	Reaction between acids and carbonates produce carbon dioxide	1
	Reactions between acids and bases produce salt and water	1
	Carbon dioxide turns clear lime water milky	1
Show safety measures to be considered when dealing with chemicals and reactions (4 marks) *Could be assessed by devising an observation and interview scheme while students are carrying out practice work.*	Demonstrate or explain safety measures when handling dangerous chemicals	1
	Demonstrate or explain safety measures when carrying out a reaction	1
	Recognise and follow safety warning symbols and or instructions given on reagent bottles	1
	Show or explain safety precautionary measures when diluting concentrated acids.	1

10.3 Performance standards for assessment task 1: Perform simple chemical reactions and tests 20 marks				
Performance criteria	**Very High Achievement (18–20)**	**High Achievement (15–17)**	**Satisfactory Achievement (10–14)**	**Low Achievement (0–9)**
Perform simple tests to identify, acids, bases, gases and metals (5 marks)	Identify correctly all of one or the other substances as; acids or bases; gases–oxygen or hydrogen or carbon dioxide; metals or non-metals without difficulty	Identify correctly most of one or the other substances of acids or bases; gases–oxygen or hydrogen or carbon dioxide; metals or non-metals without difficulty	Identify some of one or the other substances of acids or bases; gases–oxygen or hydrogen or carbon dioxide; metals or non-metals without difficulty	Identify only several of the substances of acid or base; gases oxygen or hydrogen or carbon dioxide; metals or non-metals but with difficulty
Make observations of a chemical reaction (3 marks)	List all reactants and products of a chemical reaction and clearly give a reasons why that it is a chemical change	List most of reactants and products of a chemical reaction and clearly give a reason why it is a chemical change		List all reactants and products of a chemical but with confusions and without a supporting reason
Make inferences of a chemical reaction (4 marks)	Make 3–4 inferences from any of the chemical reactions	Make 3 inferences from any of the chemical reactions	Make 2 inferences from any of the chemical reactions	Make one or no inferences from any of the chemical reactions
Recognise the pattern and characteristics of some common reactions. (4 marks)	List 3 clear patterns or characteristics of some common reactions, e.g. bubbles/fizzing, fumes, residues/precipitates and a change of colour	List 3 clear patterns or characteristics of some common reactions, e.g. bubbles/fizzing, fumes, residues/precipitates and a change of colour	List 2 clear patterns or characteristics of some common reactions, e.g. bubbles/fizzing, fumes, residues/precipitates and a change of colour	List 1 clear pattern or characteristic of some common reactions e.g. bubbles/fizzing, fumes, residues/precipitates , and a change of colour
Show safety measures to be considered when dealing with chemicals and reactions (4 marks)	Apply all appropriate safety requirements during chemical reactions without any reminder by the teacher	Apply all of the appropriate safety requirements during chemical reactions with some reminders from the teacher	Apply all of the appropriate safety requirements during the chemical reactions with several reminders from the teacher	Apply all appropriate safety requirements during chemical reactions with frequent reminders from the teacher

Instruction for task 2

Objective Test: Multiple choice and short answer (30marks)

The teacher

i) inform students about this task early as suggested in this sample unit program
ii) discuss with students the assessment criteria beforehand
iii) use the sample test specification plan on page 55 of this teacher guide to write a test specification for this task
iv) ensure all students sit for the test at the same time
v) mark and give feedback to students as soon as you can.

Assess task 2 on the extent to which students can meet the assessment criteria given below:

- explain and show understanding of the general characteristics of a chemical change and factors influencing changes in materials
- write word and formulaic equations of common reactions
- calculate number of atoms and formula mass of molecules
- appropriately match names and formulae of chemicals or compounds
- show understanding of an industrial reactions and its environmental implications.

Very high achievement	21 – 25 marks
High achievement	15 – 20 marks
Satisfactory achievement	10 – 14 marks
Low achievement	0 – 9 marks

The total assessment for this unit is 50 marks

10.4 Light

This is a six to seven week core unit. Teach this unit in sequence as recommended.

The unit outcomes

Outcome 10.4.1: Students can demonstrate an understanding of the particle model and wave model of light energy in its propagation and effects

To help students achieve this outcome, they are provided with opportunities to:

a) describe and explain wave properties of light
b) observe and explain light transmission through different mediums
c) experiment with lenses and mirrors
d) discuss light as one form of energy
e) infer and explain particle properties of light.

Outcome 10.4.2: Students can investigate and explain the properties of images formed by optical devices

To help students achieve this outcome, they are provided with opportunities to:

a) investigate images and types of images formed by mirrors and lenses
b) link observations/conclusions of investigations to every day applications.
c) show how human eyes detect light and explain different eye defects and ways to correct them.

Outcome 10.4.3: Students can use wave model of light to explain its place in the electromagnetic spectrum

To help students achieve this outcome, they are provided with opportunities to:

a) compare and contrast characteristics of electromagnetic waves
b) explain concept of wavelengths and frequency and their relationship to wave speed
c) locate light within the electromagnetic spectrum in terms of wavelengths/frequencies and characteristics.

Outcome 10 4.4: Students can analyse the impact of optical inventions and associated major discoveries

To help students achieve this outcome, they are provided with opportunities to:

a) manipulate a range of optical devices such as telescopes, periscopes, eye glasses, binoculars, spot light, dentists mirrors etc.
b) discuss a world without these inventions
c) analyse underlying scientific principles.

Programming a learning sequence

This sample unit program provides a brief overview of the essential topics, approximate time required in weeks, samples activities and the suggestions for completing the assessment tasks.

Weeks 7 (Minimum)	Key Content Topics	Sample Activities	Assessment
1	Light energy	Students brainstorm to identify and list light sources that are known and categorise them as natural and non-natural. Students observe, describe and explain light as rays/beams. Using a ray box students carry out simple experiment and describe transmission of light through different objects and explain terms such transparent, translucent, opaque etc. leading to the formation of shadows, and natural phenomena such as eclipses. Students demonstrate and explain light, both the wave nature and particle nature of light.	Advice on assessment tasks.
2	Reflection and refraction	Students carry out simple light ray activities and describe, discuss and explain how light is reflected and refracted by smooth and rough surfaces of different objects. Students discuss and explain the laws of reflection and refraction identifying incident rays/reflected rays and measure the angles of incidence and reflected/refracted rays leading to their applications in every day life.	
3	Images	Students observe, infer, describe and explain images and types of images formed by mirrors and lenses (both plain and curved mirrors and lenses). Students measure properties of light such as focal length and size of images. Students describe, explain and list the many uses of mirrors and lenses today. Students define scientific terms such as virtual and inverted images.	Complete Task 1
4	The eye	Students construct a model of an eye and describe different structures and functions of an eye. Students then compare and contrast the human eye against a camera, identifying the similarities in structures and functions and discuss the defects and correction procedures involved with human eyes in particular.	
5	Dispersion of light and colours	Students investigate, observe and explain the composition of 'white' light and how it is located in the electromagnetic spectrum. Students observe, describe and explain how light is absorbed and reflected by objects and how it affects the appearance of surfaces, and how the appearance of surfaces is effected by coloured lights.	
6–7	Useful inventions and applications of light	Students investigate the useful inventions and applications of light in every day life. Students discuss light as a renewable source of energy. Students construct optical devices such as a periscope and explain their functions and usefulness	Complete Task 2 (in week 7)

Elaboration of content and activities

Activities

A range of activities can be used to ensure students learn the content and knowledge of this unit. Some are identified and elaborated below.

- Identify, demonstrate and explain luminous/non-luminous objects, absorption, transmission, reflection, production of light rays and properties of light.
- Experiment on reflection of light to identify the relationship between the incident and the reflected light.
- Perform simple ray experiments and trace reflected/refracted rays and confirm the laws of reflection and refraction.
- Experiment with images produced by a variety of mirrors and lenses.
- Investigate reflection and refraction and relationship between incident and reflected/refracted rays.
- Compare and contrast human eye against the camera in terms of their structures and functions.
- Discuss and explain problems associated with human eyes.
- Experiment with prisms to produce rainbows and identify the colour spectrum, mixing colours and reflecting colours.
- Investigate one invention where application of light is important
- Experiment with reflection and refraction of light and distinguish incident and reflected/refracted rays.

The following table gives elaboration of some selected activities from the above list.

Activity	Expanded elaboration
Identification, demonstration and explanation of luminous/non-luminous objects, concepts such as absorption, transmission, reflection, production of light rays and properties of light.	Students: • reflect on prior knowledge about light as a form of energy and importance of 'seeing' • identify different sources of light both natural and invented ones and define luminous and non-luminous objects • produce single and multiple light rays using a ray box and observe and explain properties of light • observe and define different objects and the way light rays behave when falling on transparent, opaque, and translucent objects.
Experimenting with reflection and refraction of light and distinguishing incident and reflected/refracted rays.	Students: • perform simple experiments about reflection and refraction of light to identify the relationship between the incident and the refracted light rays • discuss the laws of reflection and refraction link to their different uses of light rays in different situations.
Experimenting with images produced by variety of mirrors and lenses.	Students: • carry out simple experiments using mirrors and lenses to explain images formation, identify and explain the types of images, virtual/real mages • discuss the uses of mirrors and lenses relating to real life situations.

The human eye verses the camera.	Students: • construct a model or use an eye model and identify structures and functions of each structure • compare and contrast human eye against a camera highlighting their structures and functions • discuss and list the many deformities associated with the human eyes and the corrective measured in place • discuss and explain the importance of an eye test particularly of colour blindness and the consequences involved • identify other optical devises and their appropriate applications.
Dispersion of light and colours	Students: • use a prism to split white light into its different colours and relate to the formation of natural phenomena–rainbow formation.

Resources

The amount of equipment required for this unit will depend very much on the total number of groups in a class. Ensure that there is a set of equipment/materials for each group in a class.

Light kits including ray box and accessories;

Variety of objects which are transparent, translucent, opaque;

Eye model;

Old camera; photo papers;

Mirrors (plane and curved) and lenses (convex/concave, bi-concave/bi-convex); lens holders;

Candles etc.

Assessment

There are two summative assessment tasks prescribed for this unit that all students are required to complete with the marks recorded towards internal assessment:

Task 1: Practical skills – Perform experiments using light rays (25 marks)

Task 2: Objective test – Multiple choice and short answers (25 marks)

Instruction for task 1

The teacher

i) inform students about this task in advance
ii) ensure all the required materials are available and on hand
iii) plan for a round robin where at least 5 different simple experiment stations are set up for students
iv) ensure safety procedures are followed
v) use the checklist below to mark students
vi) check all materials and instructions are in order for the next class
vii) ensure all students complete the task on the same day
viii) give feedback to students as soon as you can

The students

This task requires students to:

i) follow all instructions carefully and correctly
ii) do a number of experiments with light rays as determined by laws of reflection and refraction
iii) identify types of images formed by different shaped mirrors and lenses
iv) use safety procedures when working with fragile instruments
v) leave all materials/equipment and stations clean and set for another class.

Assess task 1 on the extent to which students can meet the assessment criteria below:

- demonstrate linear propagation of light rays
- draw ray diagrams to illustrate experiments
- manipulate optical devices to produce required type of image
- measure angles of incidence, reflection and refraction
- measure the focal length of curved mirrors and lenses.
-

This unit has a checklist for assessing task 1. Teachers can follow this checklist to award marks for task 1. The criteria number is given in (first column) of the checklist.

Criteria No.	Students have demonstrated that they can:	Marks 25
2	1. Draw a ray diagram showing simple reflection	1
2	2. Draw a ray diagram indicating angle of reflection	2
1	3. Set up a simple experiment that shows light travelling in a straight line.	1
1	4. Set up a simple experiment that shows the convergence of light though a convex lens	1
1	5. Set up a simple experiment that shows refraction of light through a prism	2
1	6. Set up a simple experiment that shows the divergence of light through a convex lens	2
4	7. Measure the angle of incidence and reflection for a plane mirror	1
2	8. Draw a ray diagram showing refraction through a prism	2
4	9. Measure the angle of refraction through a prism	2
2	10. Show using a diagram how lenses work	3
3	11. Set up a lens system to illustrate how light moves through glass	3
2	12. Draw a ray diagram – show the focus of a convex lens	1
5	13. Measure the focal length of a lens	2
5	14. Measure the focal length of a curved mirror	2

Instruction for task 2

The teacher

i) inform students about task 2 early as suggested in the sample unit program
ii) use the sample test specification plan on page 55 of this teacher guide and write a test specification plan for this task
iii) ensure all students do the test at the same time
iv) mark, record marks, and give student feedback as soon as you can.

Assess task 2 on the extent to which students can meet the assessment criteria below:

- explain particle and wave models of light based on (simple investigations/observations)
- show understanding of reflection, refraction and dispersion
- describe how the eye works, its defects and corrective methods
- describe the role of light in sustaining the environment
- link optical inventions to major scientific discoveries.
-

Very high achievement	21 – 25 marks
High achievement	15 – 20 marks
Satisfactory achievement	10 – 14 marks
Low achievement	0 – 9 marks

The total assessment for this unit is 50 marks

10.5 Communication

This is a core unit and should take between six and seven weeks. It focuses mostly on physics concepts of sound waves and electromagnetic waves application. However, it begins with simple traditional ways of communication and looks at the more complex telecommunication commonly used today. Before you start teaching, it is important that you read the context, content and process described in the Science syllabus to start your thinking about what to focus your teaching on. It is recommended that it be taught as the second last unit to be followed by unit 10.1.

The unit outcomes

Outcome 10.5.1: Students can demonstrate an understanding of wave motion and wave nature of sound

To help students achieve this outcome they are provided with opportunities to contextualise the wave notions by focusing on:

a) wave and wave motion
b) transmission of waves
c) nature of sound
d) sound production.

Outcome 10.5.2: Students can investigate the effect of wave characteristics on volume and pitch

To help students achieve this outcome, they are provided with opportunities to:

a) use different musical instruments to produce sound
b) examine factors affecting sound particularly volume and pitch.

Outcome 10.5.3: Students can present an investigative report on development of communication means over the ages.

To help students achieve this outcome, they are provided with opportunities to:

a) investigate how methods of communication have evolved through time
b) investigate current and efficient ways of communication locally, nationally, globally.

Outcome 10.5.4: Students can analyse the importance of science in communication technology for improved socio-economic development.

To help students achieve this outcome, they are provided with opportunities to:

a) explain what an electromagnetic wave is
b) identify the use of electromagnetic waves in contemporary society
d) describe functions of different communication systems for social and economic development

e) discuss and reflect on how the science of communication has evolved through centuries.

Programming a learning sequence

This sample unit program provides a brief overview of the essential topics, approximate time required in weeks, samples activities and the suggestions for completing the assessment tasks.

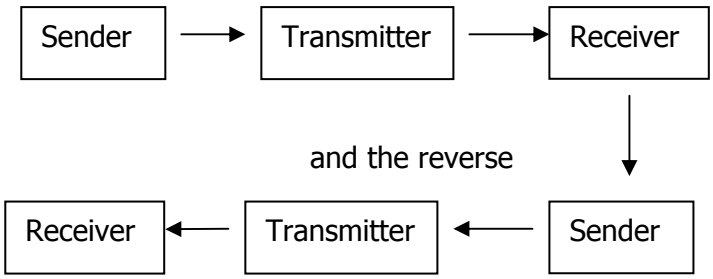
Weeks 5 (Minimum)	Key Content Topics	Sample Activities	Assessment
1	Method of communication	Students reflect on and discuss the traditional (past) means of communication; list these ways and explain the way a message was sent (source), transmitted (medium) and received. Students discuss and list modern (present) means of communication and listing the three components of communication, the source, medium of transmission and the way it is received. Students in small groups, tie about 80 cm of cotton thread to a tea spoon. Swing the tea spoon slowly so it gently strikes the side of a bench wall or a cupboard and listen to the sound it makes. Place the free end of the cotton thread carefully against your ear and again gently strike the tea spoon against the same surface and listen to the sound made and identify if cotton thread makes any difference to sound heard when the spoon strikes a surface. Students discuss speeds of sounds through air and solids and the properties of the solids that make the difference. Students research and find out about the ways communication evolved through the ages for example, from sound as an old method to various forms of telecommunication. Students construct a table and list speed of sound (metres per second) in some common substances such as dry air, water, sea water, wood, glass, steel, aluminium, granite etc.	
2	Sound waves	Students produce sound with rulers, blowing into empty containers, plucking guitar strings, tuning forks etc. and explain the way high or low sounds are produced and the way loud and soft notes are produced. Students investigate the way sound travels through different mediums such as placing a ticking clock against the ear and listen to the tick while a partner moves the clock away where the tick can no longer be heard. The partners then measures the distance from the ear to the point where tick sound can no longer be heard. Define the concept of echo and relate its application in real life situation. Students examine different sources of sound and explain the relationship between sound and vibration; sound and energy.	Complete Task 1 (end of week 2)
3–4	Making waves	Students create water waves, observe, discuss and define waves/frequency/amplitudes etc. Students research the electromagnetic wave and its application in today's world of efficient means of communication.	
5	Telecommunication	Students research the application in telecommunication such as microwaves, AM, FM radio broadcasting, repeater stations, and satellite communication. Students discuss the importance of the role of communication in development and in the global society.	Complete Task 2 (end of week 5)

Elaboration of content and activities

Activities

A range of activities can be used to ensure students learn the expected content knowledge of this unit. Some are identified and elaborated below.

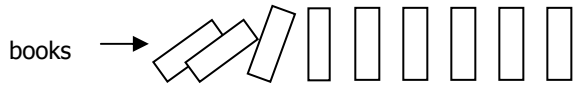
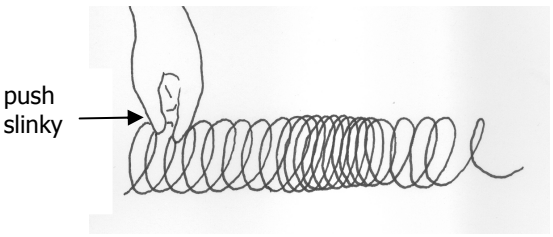
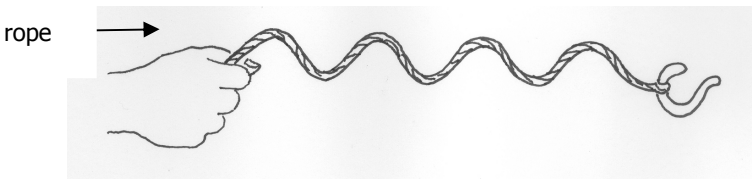
- Define communication.
- Discuss and list traditional and contemporary ways of communication, comparing and contrasting the sender, transmission and receiver of messages.
- Identify the three processes involved in all forms of communication:
- sender (source)
- transmission (how message travels)
- receiver.



- Give examples of sounds as an old method of communication.
- Identify and discuss traditional and cotemporary musical instruments explore how sounds are made by these instruments.
- Construct a rope and can phone and describe/explain how sound travels in different mediums.
- Examine different sources of sounds, how they vibrate to produce sound.
- Examine sound and energy transmission.
- Make items vibrate to produce sound-tuning forks, rulers etc.
- Investigate the speed of sounds through the three different mediums (solid, liquid and gas).
- Research the application of echo in a technological aspect.
- Give examples of sound as an old method of communication.
- Discuss why sound is most familiar and most used method of communication.
- Discuss the examples given previously in which sound is prominent (most).
- Read about the ear, draw and label parts and functions of the ear.
- Research and present the ear's role as a sensory organ in receiving and giving meaning to sound.
- Give examples of sound as an old method of communication.

- Discuss why sound is most familiar and most used method of communication.
- Define and demonstrate an echo.
- Discuss what an echo is
- Use clapper boards and walls to produce an echo.
- Measure speed of sound using echoes (optional).
- Research and report on useful applications using echo e.g. sonar, radar, and others presentations of reports.
- Demonstrated using clapper boards, observe and explain echo and discuss its application in a technological aspects such as sonar and radars etc.
- Produce written descriptions or what a sea/water wave is or what a sea/water wave can do e.g. move objects (cause them to float).
- Show that longitudinal waves move away from the source of disturbance by using a row of books.
- Describe wave type/direction of movement when a slinky is disturbed at one end.
- Make and observe water waves
- Explain waves as a form of energy and the way waves transmit that energy using appropriate library books.
- Calculate speed of waves.
- Brainstorm and list the advantages and disadvantages of using mobile phones and the many ways that humans have communicated with each other since the beginning of history.
- Research any discoveries that lead to the advancement of communication technologies over time.
- Make a concept map that shows how t the following ideas are connected: loudness, pitch, echoes, amplitude, compression, hertz, wavelength, decibels, rarefaction, frequency, waves, sonar.
- Differentiate sound waves and electromagnetic waves in a table.
- The following table gives elaboration of some selected activities from the above list.

Activity	Expanded elaboration
Traditional and contemporary methods of communication	Students: • individually brainstorm what the term communication means to them and teacher lists students' answers on the board for further discussions and reach a common meaning • in small groups discuss by reflecting on the simple means of communication used traditionally to the modern ways of communication and list the two ways of communication on a chart and present to the rest of the groups • discuss using concrete examples the three important processes of communication; (i) sender (source), (ii) means–how it travels and (iii) receiver • describe different ways of communication and identify the three processes.

Making sounds with musical instruments	Students: • sit silently, listen and record any sounds from outside taking note of the different sources sounds are coming from • discuss and explain causes of sound and define vibration • bring to class any musical instruments they may have both traditional ones such as kundu drum, bamboo flute, small garamut etc. and contemporary ones such guitar, ukulele, keyboard etc. for lessons • make sounds with musical instruments and other objects such as rulers, observe and explain the concept of sound; how sounds are made, what affects sounds to be high/low sounds, loud/soft notes etc. • identify and discuss the kind of materials used for making instruments and the quality of sounds made • in small groups construct a rope can phone and describe how sounds travel in different mediums.
Investigation of sounds and how it travels.	Students: • investigate echo by how sounds travel with it • investigate the speed of sounds through the three different mediums (solid, liquid and gas) and determine the speed of sounds through these mediums • demonstrate using clapper boards, observe and explain echoes and discuss their application in technological aspects such as sonar and radars etc.
Discuss concepts of sounds and vibrations.	Students: • individually research and define the term vibration • discuss the concept of sound and vibration and explain compression and rarefaction • use musical instruments to produce sound and observe vibrating parts of instruments and explain how sounds are produced and transmitted through the air to the ears • observe and discuss sound through a vacuum to show that sounds require a medium to travel through.
Making types of waves.	Students: • define wave by reflecting on their prior knowledge of sea/water waves • demonstrate, observe, describe and explain longitudinal and transverse waves giving examples • discuss the behaviour of waves on the water and sea etc. to determine the way they move objects • use a rope or a slinky to demonstrate the direction of waves and energy and present a written report • differentiate between longitudinal waves and transverse waves by using models to show how objects (medium) move with reference to the direction of the wave e.g. using slinky and row of books line up as shown below.    • explain waves as a form of energy and the way waves transmit that energy using appropriate library books as reference.

Making water waves	Students: • classify the different types of waves and compare and contrast using diagram of waves progression and label amplitude, wavelength and frequency • conduct experiments to demonstrate the production of water waves • conduct experiments, observe and explain the production of water waves showing direction of the wave movement and energy flow. Draw a diagram of the waves created and the direction wave travels • label diagram of wave given of wave progression, amplitude, wave length and frequency ensuring they define these terms • contextualise waves and their importance to life calculating speed of wave using mathematical formulae Speed of sound = wavelength x frequency.
Investigate telecommunication as an improved way of communication	Students: • discuss and list examples of modern communication evolved through the ages, e.g. birds; letters, dots and dashes-the Morse code; electrical telegraph; ring, ring the telephone; radio; television and mobile • in groups select a mode of telecommunication, research, organise information and communicate to others in the class about ways different modes of telecommunications work • discuss as a class some of the dangers involved with the use of different telecommunications such as use of mobiles in heavy rain and thunder storms in case of electrocutions etc. from lightning • carry out a case study on telephone, radio and telephone networks • discuss the importance of the role of modern communication in development and in the global world • research and define the term electromagnetic wave and further discuss its application in telecommunication and AM and FM broadcasting • discuss issues related to vandalism of telecommunication networks and the implications on development and general lives of people. Students can make a concept map.

Resources

The amount of equipment required for this unit will depend very much on the total number of groups in a class. Ensure that there is a set of equipment/materials for each group in a class.

Large bowls, rulers, musical instruments (both traditional and contemporary), slinky spring, tuning fork, two metre rope, clatter boards, stop watch/timer.

Assessment

There are two summative assessment tasks prescribed for this unit that all students are required to complete with the marks recorded towards internal assessment:

Task 1:	Practical skills – Production and measurement of waves test (25 marks)
Task 2:	Objective test – Multiple choice and short answers (25 marks)

Instruction for task 1

The teacher

e. inform students early about this task as suggested in the sample unit program
f. ensure all the required materials and equipment are available and on hand
g. break the tasks into two manageable ones for two different times or organise for several tasks to be done at one time only
h. use the assessment performance criteria below to assess.

The students

This task requires students to:

i) follow all instruction carefully and correctly
ii) use some traditional music instruments, a two-metre rope, a slinky spring and a basin of water to make different waves
iii) make waves with water and observe
iv) measure and calculate the speed of waves in the water
v) leave all materials and equipment clean and set for the next class.

10.5 Performance standards for assessment task 1: Production and measurement of waves test 25 marks				
Performance Criteria	**Very High Achievement (21–25)**	**High Achievement (15–20)**	**Satisfactory Achievement (10–14)**	**Low Achievement (0 – 9)**
Identify the sender, the medium and the receiver of communication process (3 marks)	Identify all three components of communication process and their relationship	Identify one to two components of process and their relationship communication processes correctly		Not able to identify any components of the communication process
Demonstrate traditional and modern methods of communication (3 marks)	Show four distinct examples each of traditional and modern methods of communication	Show two to three distinct examples of traditional and modern methods of communication.		Show only one or no traditional or modern methods of communication
Show factors that affect the pitch and volume of sound (6 marks)	Demonstrate clearly how pitch and volume of sound can be varied in three contexts	Demonstrate clearly how pitch and volume of sound can be varied in two contexts		Demonstrate only how pitch and volume of sound can be varied in 1 or context.
Measure amplitude, wavelength and frequency and calculate the speed of water waves (8 marks)	Measure correctly measure amplitude, wavelength, and frequency correctly calculate the speed of water waves with no assistance.	Measure correctly amplitude, wavelength, and frequency calculate the speed of water waves little assistance.	Measure correctly amplitude, wavelength, and frequency calculate the speed of water waves with limited assistance.	Measure amplitude, wavelength, and frequency calculate the speed of water waves but with a lot of assistance.
Show how different notes are achieved on traditional musical instruments (5 marks)	Demonstrate clearly and correctly high and low notes are Achieved on three to four traditional musical instruments	Demonstrate clearly and correctly high and low notes are Achieved on two to three traditional musical instruments.	Demonstrate clearly and correctly high and low notes are achieved on two traditional musical instruments.	Demonstrate high and low notes are Achieved on one of the traditional musical instruments.

Instructions for task 2

Objective Test: Multiple choice and short answer (25 marks)

The teacher

i) inform students about this task beforehand as suggested in the unit overview of plan
ii) discuss with students the assessment criteria
iii) use the test specification plan on page 55 of this teacher guide and write a test specification plan for this task
iv) ensure all students sit for the test at the same time
v) mark, record and give feedback to students as soon as you can.

Assess task 2 on the extent to which students can meet the specified assessment criteria below:

- recognise energy conversions involved in a communication process
- show understanding of wave characteristics and properties
- show understanding of factors that affect the pitch and volume of sound
- identify and explain amplitude, wavelength and frequency from wave diagrams.

Very high achievement	21 – 25 marks
High achievement	15 – 20 marks
Satisfactory achievement	10 – 14 marks
Low achievement	0 – 9 marks

The total assessment for this unit is 50 marks

Recording and reporting

All schools must meet the requirements for maintaining and submitting student records as specified in the *Grade 10 Assessment, Examination and Certification Handbook.*

Recording and reporting student achievement

When recording and reporting student achievement you must record the achievement of the students in each unit and then, at the end of the year make a final judgment about the overall achievement, or progress towards achievement, of the broad learning outcomes. To help you do this, descriptions of the levels of achievement of the broad learning outcomes are provided in the Broad Learning Outcome Performance Standards.

When reporting to parents, the school will determine the method of recording and reporting. In an outcomes based system, student results should be reported as levels of achievement rather than marks.

Remember that the final school-based mark will be statistically moderated using the external exam results. The students overall level of achievement may change.

Levels of achievement

The level of achievement of the broad learning outcomes is determined by the students' performance in the assessment tasks. Marks are given for each assessment task with a total of 100 marks for each 10 week unit, or 50 marks for each five week unit. The marks show the student's level of achievement in the unit, and therefore progress towards achievement of the broad learning outcomes.

There are five levels of achievement:

1. Very high achievement
2. High achievement
3. Satisfactory achievement
4. Low achievement
5. Below minimum standard

A very high achievement means overall, that the student has an extensive knowledge and understanding of the content and can readily apply this knowledge. In addition, the student has achieved a very high level of competence in the processes and skills and can apply these skills to new situations.

A high achievement means overall that the student has a thorough knowledge and understanding of the content and a high level of competence in the processes and skills. In addition, the student is able to apply this knowledge and these skills to most situations.

A satisfactory achievement means overall that the student has a sound knowledge and understanding of the main areas of content and has achieved an adequate level of competence in the processes and skills.

A low achievement means overall that the student has a basic knowledge and some understanding of the content and has achieved a limited or very limited level of competence in the processes and skills.

Below the minimum standard means that the student has provided insufficient evidence to demonstrate achievement of the broad learning outcomes.

Total Marks	Achievement Levels				
	Very High Achievement (90%)	High Achievement (70%)	Satisfactory Achievement (50–70%)	Low Achievement (below 50%)	Below minimum standard (20%)
700	630 – 700	490 – 629	350 – 489	200 – 349	0 –199
600	540 – 600	420 – 539	150 – 209	129 – 149	0 – 119
500	450 – 400	350 – 449	250 – 349	100 – 249	0 – 99
400	360 – 400	280 – 359	200 – 270	80 – 199	0 – 79
300	270 – 300	210 – 269	150 – 209	60 – 149	0 – 59
200	180 –200	140 – 199	100 – 139	40 – 99	0 – 39
100	90 – 100	70 – 89	50 – 69	20 – 49	0 – 19
60	54 – 60	42 – 53	32 – 41	13 – 31	0 –12
50	45 – 50	35 – 44	25 – 34	10 – 24	0 – 9
30	27 – 30	20 – 26	15 – 20	6 –14	0 – 5
20	18 – 20	14 – 17	10 – 13	5 – 9	0 – 4

Sample format for recording Science assessment task results over two years

Remember that recording of assessment task marks are strictly following the unit implementation sequence. Therefore record 9.2 assessment tasks marks first and 9.1 assessment tasks marks last.

Grade 9			
Unit	**Assessment task**	**Marks**	**Student marks**
9.2	1. Practical skills – performance	30	
	2. Report on guided investigations	30	
9.3	3. Human impact on an ecosystem	30	
	4. Objective test	20	
9.4	5. Make a working model	30	
	6. Objective test	30	
9.5	7. History of atomic model and the periodic table	30	
	8. Objective test	30	
9.6	9. Practical skills – performance	30	
	10. Objective test	30	
9.7	11. Project	30	
	12. Objective test	30	
9.1	13. Oral presentation of traditional knowledge and or process	25	
	14. Essay	25	
GRADE 9 TOTAL		**400**	

Grade 10			
Unit	**Assessment tasks**	**Marks**	**Student marks**
10.2	Practical skill performance	20	
	Objective test	30	
10.3	Chemical reaction tests	20	
	Objective test	30	
10.4	Practical skills performance	25	
	Objective test	25	
10.5	Making and measuring waves	25	
	Basic skills performance	25	
10.1	Project	50	
Practical test	Practical skills performance	30	
	Investigation	20	
Grade 10 Total		**300**	

Resources

Learning becomes more interesting and meaningful when you use a variety of resources and materials in your teaching. There are local people in the community – parents, village leaders, people with special skills and knowledge, local workers, business people, government officers and many more experts who can be invited to talk to students. Visiting places with students also makes learning more interesting.

You should be always trying to adapt, improvise, make or write material that will be useful for lessons in any subject. Collections of newspapers, magazines, pamphlets, brochures, old gazettes, posters can be very useful. There are many resources in schools which can be useful for more than one subject. One of the biggest resources are other teachers, especially teachers with local area knowledge.

Selecting and using resources

Selecting and using appropriate resources to communicate information is a very important part of your task. For example, instructional resources can help students learn more effectively by:

- helping to gain and maintain interest in a lesson
- encouraging mental involvement and the use of different senses while learning
- making learning more meaningful by linking it with previous knowledge and/or providing organising structures which give abstract ideas a concrete form or representation
- catering for students who learn best through different senses – for example, some students learn best through listening, while others learn best through seeing, touching, tasting, or a combination of these four ways
- reinforcing, integrating and extending classroom instruction
- helping in the recall of information
- making explanations of difficult concepts and skills clearer
- providing immediate feedback and knowledge of results
- encouraging independent learning.

Types of resources

Print materials	**People**
text books, reference books, magazines	people in specific occupations
project kits	people now retired, elderly people
simulation games	groups, associations, organisations
diagrams, maps, charts, graphs	experts
posters	skilled persons, artisans
worksheets, information sheets	sportspersons
pamphlets, brochures	village experts

Audio visual material	**Materials and artefacts**
. television and radio broadcasts, video, film, film strips . audio recordings slides, sound slide sets . computer software, interactive video . overhead transparencies	. pictures, photographs . chalk/whiteboard, felt boards, magnetic boards . models, globes . newspapers documents/reports/ . personal items e.g. watches . made or found objects . junk or local throw aways e.g. empty can, tins, plastics . museums . equipment e.g. laboratory chemicals/physical tools/

General guidelines for selecting and using resources

The effectiveness of the resources very much depends on whether it is suitable for the knowledge or skill to be learned and the attitude of the students. The students' attitude may be influenced by such factors as prior knowledge, the way they construct knowledge, their feeling toward the resource and/or the difficulty level of the material provided.

Resources should be selected on the basis of whether they are suitable for the learning task you have in mind. There is no single resource suitable for all purposes. Being clear on what resource best suits your purpose is important.

- Make sure that your resources are appropriate for the age, abilities, knowledge and interests of the students. If you are selecting print materials then the reading level should be matched to the ability of the students.
- Check the amount of time you have for the lesson and determine whether the resource you have in mind will be appropriate. For example, you may wish to show a 20 minute video in a 30 minute lesson. In such a case you would not have time to introduce and discuss the video so an alternative decision would need to be made.
- Check the class size. The resources you use in a whole class setting may be different from the kind of resources used in a small group setting.
- Prepare thoroughly. Make sure that you are familiar with the resource so that you use it with confidence and assurance. If equipment is involved, check that it is in working order, make sure that you know how to operate it and that it is available when required.
- Be very selective about the number of resources that you use in a lesson. The use of too many resources can overwhelm and confuse students.
- Use the resource at the right place and time in the lesson. The resource should fit in with the flow and sequence of the lesson. It should serve a definite teaching purpose and be but one part of the lesson.

Glossary

Syllabus outcomes, objectives, performance standards and examination questions have key words that state what students are expected to be able to do. A glossary of key words has been developed to help provide a common language and consistent meaning in the syllabus and teacher guide documents.

The glossary will help teachers and students understand what is expected in responses to examinations and assessment tasks.

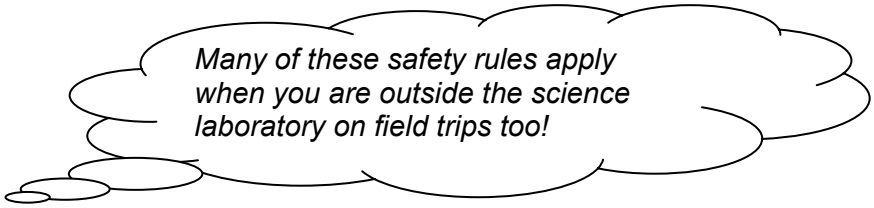
Account	Account for: state reasons for, report on. Give an account of: narrate a series of events or transactions
Analyse	Identify components and the relationship between them; draw out and relate implications
Apply	Use, utilise, employ in a particular situation
Appreciate	Make a judgment about the value of
Assess	Make a judgment of value, quality, outcomes, results or size
Calculate	Ascertain/determine from given facts, figures or information
Clarify	Make clear or plain
Classify	Arrange or include in classes/categories
Compare	Show how things are similar or different
Construct	Make; build; put together items or arguments
Contrast	Show how things are different or opposite
Critically (analysis/evaluate)	Add a degree or level of accuracy depth, knowledge and understanding, logic, questioning, reflection and quality to (analyse/evaluation)
Deduce	Draw conclusions
Define	State meaning and identify essential qualities
Demonstrate	Show by example
Describe	Provide characteristics and features
Discuss	Identify issues and provide points for and/or against
Distinguish	Recognise or note/indicate as being distinct or different from; to note differences between
Evaluate	Make a judgment based on criteria; determine the value of
Examine	Inquire into
Explain	Relate cause and effect; make the relationships between things evident; provide why and/or how
Extract	Choose relevant and/or appropriate details
Extrapolate	Infer from what is known

Identify	Recognise and name
Interpret	Draw meaning from
Investigate	Plan, inquire into and draw conclusions about
Justify	Support an argument or conclusion
Outline	Sketch in general terms; indicate the main features of
Predict	Suggest what may happen based on available information
Propose	Put forward (for example a point of view, idea, argument, suggestion) for consideration or action
Recall	Present remembered ideas, facts or experiences
Recommend	Provide reasons in favour
Recount	Retell a series of events
Summarise	Express, concisely, the relevant details
Synthesise	Putting together various elements to make a whole.

Appendices

Appendix 1 – Safety rules

1. Students are not allowed into to the laboratory unless a teacher is present. Running, eating and drinking is not allowed.
2. Never touch any equipment until you are told to do so.
3. Pour waste liquids into sinks, unless you are told to use special containers. Place solids in the rubbish bins.
4. Keep books, paper and clothing away from naked flame. Tie back long hair.
5. Never conduct experiments which you have not been told to do.
6. Never taste chemicals or allow them to get onto your skin. If chemicals get onto your skin wash them off IMMEDIATELY with plenty of water. Then tell the teacher.
7. Report any breakages or damage.
8. Clean and put away all equipment after use. Clean the bench tops and sinks.
9. After heating equipment, let it cool before picking it up or passing it on to someone else.
10. Do not point the open end of test tubes towards anyone when heating.
11. Do not work with broken or cracked glass equipment.
12. Never play practical jokes.
13. If anything is spilt, clean it up immediately. Liquids on the floor are very dangerous.
14. Take care to avoid fires. Use spark lighters or matches carefully. Don't put burning things into the bins
15. Wear a protective footwear at all times
16. When you are asked to wear safety gloves, keep them on.
17. Always put your burner to the yellow flame when you are not using it.



Appendix 2 – Student-cantered learning strategies

Different students learn in different ways. Some students learn best by reading and writing, others by talking and discussing, others by listening. Most students learn by using a combination of these strategies. Many learn skills through practising and repetition. Teachers of Science need to use a variety of teaching strategies to cater for the different ways students can learn.

Fieldwork

Fieldwork is an essential part of the study of Science. It is a means of understanding natural and cultural environments and the nature of inquiry. Fieldwork can enhance learning opportunities for a wide range of students because it caters for a variety of teaching and learning styles but requires advance planning and preparation. Fieldwork enables students to:

- acquire knowledge about environments by observing, mapping and recording phenomena in the real world in a variety of places, including the school environments
- use different types of tools to assist in interpretation of and decision-making about phenomena
- understand the spatial and ecological dimensions of the environment
- explore processes that form and transform environments.

Group work

Group work is a teaching and learning strategy that encourages students to participate in achieving a shared goal. A range of grouping strategies is possible, the appropriateness of each will depend on the nature of the shared goal and the needs of the students. Successful group work increases the opportunities for students to interact with each other and to value each member's contribution. Group work encourages cooperative learning.

Cooperative Learning

Cooperative learning encourages social construction of knowledge. Children learn from each other. It means collaborative interaction for students and expands individual student's capacity to learn. Through cooperative learning, students will:

- learn more and learn to think more deeply
- share labour through cooperation and contribute to discussions
- help each other and seek guidance from peers when they need it
- be content with sharing marks
- be prepared to work with children with different characteristics.

Guest speaker or visitor

A guest speaker or visitor is a person who is invited to share his/her knowledge and skills with the students. This may be a teacher from another class, a parent, a member of the local community or a representative from a group, organisation or institution.

Interviews

An interview involves asking someone questions in order to find out more information about a subject. There are usually many experts with special knowledge about a topic. Students can invite them to the classroom or meet them during fieldwork. To conduct an interview successfully students need to:

- prepare questions beforehand
- make sure questions are simple and to the point requiring more than a single word answer
- listen carefully to answers
- take notes if possible
- thank them at the end

Consequence charts

A consequence chart is used to record what students believe to be the likely consequences of a decision or action. Charts can take different forms and enable students to explore cause and effect relationships, alternative consequences or the likely consequences of alternative actions or decisions.

Classroom displays

A classroom display provides a way of focusing on the current unit. It stimulates learning, provides a record of learning as well as encouraging students to interact and to respond to learning.

Tinkering table

A tinkering table can be created in the classroom where old and broken down equipment such as old clocks, radios, TV, watches etc. can be left for students to handle and see for themselves how they are designed. It will create curiosity and interest in students.

Charts

Helping students to learn to chart, that is, to organise information in various groupings under different headings, is valuable. It not only helps students to make sense out of a previously unrelated mass of data, but it is a crucial step in the process of developing a store of concepts to use in making sense of own experiences. Charts (for example, major processes in open cut

mining, endangered or endemic species of plants and animals, weather maps of El Nino and LA Nina, space travel and spaceships, Safety instructions/rules) are a powerful organising tool and of considerable help in getting students to think about information in general.

Cultural activities

Through participation in cultural activities, students are exposed to a variety of activities that give them insight into their own culture or that of others. Programming should take into account local cultural events as well as national events. Through cultural activities students identify what is provided from the environment and therefore understand the value of caring and sustaining the biodiversity of life. It provides opportunities for students to observe and record traditional practices and procedures unknown to them. For example, they explore materials used for head dresses and grass skirts and identify the characteristics of these materials leading to investigations and research of the nature, availability/sustainability of these materials in the environment.

Jigsaw groups

Jigsaw groups are a method of organising students so that the whole class can conduct an in-depth study of a topic or issue within a relatively short period of time. Topics are analysed and broken down into discrete research tasks or activities. These tasks form the pieces of an information ‘jigsaw’. A group of students is allocated one of the jigsaw tasks to investigate. Each expert jigsaw group then reports the results of its findings back to the other groups, thus gradually building up a detailed and complete ‘picture’ of the topic.

Learning games

Learning games are devices that involve students in simulated experiences to develop concepts and understandings, record information or demonstrate knowledge and understandings. Learning games can be created by teachers or students.

Mind maps/concept maps

A mind or concept map is a way of recording information. It allows students to organise their ideas either as a class, small group or individually. A mind map is often associated with brainstorming and is useful for drawing connections between ideas and concepts, assisting in the further research of a topic.

Models

Models provide demonstration of concepts in concrete forms. Models can include items made from anything at all from locally available materials such as plastics, cartons, clay, wood, bamboo etc,

Reflective learning

Reflection is the act of thinking about what has been learnt. It often involves putting learning into a new context, looking at the experiences in a new light, interpreting what has been said or done for different applications or a new situation. Teachers need to provide time both during and at the end of any learning experience for students to contemplate the content and processes in which they have engaged. The time provided needs to allow for individual, small group and whole class reflection. As a result of reflective learning students may develop flexibility and creativity.

Role-play

Role-play involves taking on and acting out roles of real or imaginary individuals in varied, non-threatening simulated situations in order to clarify values and develop empathy with other people. Role-play is possible with most topics in the study of issues or current affairs. Points to consider are:

- Explain the role-play to the whole class so that they begin from a common understanding of the situation
- Cast beginning students with learners who are competent and relaxed. Acceptance of the role-play by some will give others more confidence.
- Avoid placing students in their usual life role as this can be self-defeating and will limit possible experiences for the students
- Be prepared to intervene where necessary
- Stop the drama after main behaviours and points have been observed
- Debrief role-play participants. This is an essential step as it helps players out of their roles. They must be disassociated from the role, both in their own eyes and the eyes of other students.

Task Cards

Task cards are teacher-defined activities or pieces of research work, presented in a written form and assigned to individual students or groups. They are a method of directing student learning. Teachers can devise task cards to direct activities on an aspect of a topic.

Appendix 3 – Assessment of experiments and science projects using a generic rubric

Teacher information

Assessing and grading science experiments and projects usually requires great deal of time. However, the end result is that you have a better picture of what students truly know, understand, and are able to do.

A complete assessment of experiments and/or science projects is something that needs to be carried out no more than once a year or once in a benchmark year. Please remember that students should still be conducting scientific investigations in between these assessments tasks to enhance their understanding and use of the scientific method, and the process skills. *Note:* There are no student sheets to this assessment because of its design.

Assessment options

Because of the time factor, when grading experiments and science projects teachers should consider breaking the assessment tasks into sections. This will allow for multiple local grades to be given and also allow the teacher to spread the evaluation of student work over a broader expanse of time. Suggestions for the split:

Section 1	Background research and stated hypothesis
Section 2	Identified variables and experiment procedure
Section 3	Tables of collected data and graph results
Section 4	Student observations, conclusions, inferences
Recommendations and teacher observations	

Other Advantages to Consider:

- A generic scoring rubric of this type gives you the option of allowing students to pick their experiment, or
- opens the door for teachers of different science courses to assess students in their particular field. This evaluation measures the methodology and the processes which could be the same for all science fields.

Other Options

This generic rubric can easily be expanded to measure other science skills such as

- use of scientific equipment
- model formulation
- proper safety procedures, etc

Sample 1:

Note: This is only an example of how a science experiment rubric could look. Teachers can adapt it to fit their particular needs.

Performance Assessment Scoring Rubric for Experiments Using the Scientific Method				
Method	**Very high Achievement**	**High Achievement**	**Satisfactory/Average**	**Low Achievement**
Research	Conclusive (answer contains an exceptional amount of prior knowledge)	Partially conclusive (answer contains a reasonable amount of prior knowledge):		Inconclusive: (answer indicates lack of prior knowledge: (0–1 mark)
Hypothesis	Correctly stated with both variables identified: (3 marks			No hypothesis (0–1 mark)
Variables	All variables are stated correctly (3 marks)	All variables are stated correctly, but not all controlled variables are listed (2 marks)		One of the three types of variables is missing or incorrectly stated (1 mark)
Procedure	Easily followed containing all procedural steps in their correct order. Metric units are used where necessary: (3 marks)	Written, but some steps are vague or unclear. Metric units are used: (2 marks)		Procedure missing two or more critical steps; metric units not used: (1 mark)
Chart of Data	Complete and correctly labelled: (3 marks)	Complete, but lacking a clearly explanatory title and/or labelling: (2 marks)		Incomplete, lacking any of the following: a title, dependent or independent variable, or collected data: (1 mark)
Graph of Results	Complete and correctly labelled: (3 marks)	Complete, but lacking a clearly explanatory title and/or labelling: (2 marks)		Incomplete; lacking any of the following: a title, dependent or independent variable, or collected data: (1 mark)

Observations	Observations Very descriptive using a variety new vocabulary terms: (3 marks)	Partially conclusive using some new vocabulary terms: (2 marks)	Inconclusive demonstrating limited vocabulary terms: (1 mark)
Conclusions, Inferences, and Recommendations	Tells whether hypothesis was proven correct or incorrect by providing sufficient information for all of the following – conclusion (a statement of the results), inferences (assumptions that can be drawn from the conclusion) and recommendations for the design of a new experiment (3 marks)	Provides sufficient information for any two of the following – conclusion, inferences, recommendations. (2 marks)	Provides insufficient information for two or all of the following – conclusion, inferences, recommendations (1 mark)
Teacher Observation	Student performed experiment honestly, accurately, and independently (3 marks)	Student performed experiment honestly and accurately, but needed teacher assistance (2 marks)	Student did not perform the experiment honestly and/or accurately:. (1 mark)
Overall Rating	25 – 27 marks	19 – 24 marks	Below 18 marks

Sample 2: Scientific Report Rubric

The scientific report rubric can be written in several, slightly different ways. The sample below can be used when the focus of the marking is on the scientific investigation processes.

Title of Report: …….

Student name: ……Date:

General use – for any units if preferred Total: 50 marks					
Check list	**Very high achievement**	**High achievement**	**Satisfactory Achievement**	**Low Achievement**	**Score**
Introduction (5 marks)	Students are able to present a concise lead-in to the report. (5 marks)	Students are able to give too much information– more like a summary. (4 marks)	Students are able to give very little information. (3 marks)	Students are able to give no information about what to expect in the report. (0–2 marks)	

Research (10 marks)	Students are able to answer most questions and include many other interesting facts. (9–10 marks)	Students are able to answer some questions and include a few other interesting facts. (7–8 marks)	Students are able to answer some questions. (5–6 marks)	Students are unable to give any answer to any questions suggested in the template. (0–4 marks)	
Purpose or problem (5 marks)	Students are able to address a real issue directly related to topics research (literature reviewed) (5 marks)	Students are able to address an issue clearly related to topic researched (literature review) (4 marks)	Students are able to address an issue which is related to the topic researched (literature reviewed). (3 marks)	Students are able to address an issue which is unrelated to the topic researched (literature reviewed). (0–2 marks)	
Procedure (5 marks)	Students are able to present easy to follow steps which are logical and explicitly detailed (5 marks)	Students are able to present steps that are clearly understandable; logical and adequately detailed (4 marks)	Students are able to present steps that are understandable, logical and with some detail (3 marks).	Students are able to present steps that are not logical or properly sequenced and details are confusing (0–2 marks)	
Data and Results (10 marks)	Students are able to provide data table and graph completed and totally accurate. (9–10 marks)	Students are able to provide data table and graph neatly completed, following conventions with a high level of accuracy. (7–8 marks)	Students are able to provide data table and graph completed with required accuracy. (5–6 marks)	Students are able to provide table and/or graph missing, some information is inaccurate. (0–4 marks)	
Conclusion (10 marks)	Students are able to present a logical, lucid explanation of findings that fully addresses the issue. (9–10 marks)	Students are able to present a logical explanation of findings that addresses the issue. (7–8 marks)	Students are able to present an explanation of findings and related it to the issue. (5–6 marks)	Students are able to present an explanation of findings that is mostly unrelated to the issue. (0–4 marks)	
Grammar and spelling (5 marks)	Students are able to make sure all spelling and grammar are correct. (5 marks)	Students are able to make only one or two minor errors. (4 marks)	Students are able to make more than two errors. (3 marks)	Students are able to make very frequent grammar and/or spelling errors. (0–2 marks)	
Total					50

Sample 3 – Performance standard rubric for a specified task; for example: Oil Spill task.

Teachers can also consider the second assessment rubric when assessing specific projects. Sample two is given below

10.1: Performance standard for a project				**50 marks**	
Criteria	**Very High Achievement (45–50 marks)**	**High Achievement (30–44 marks**	**Satisfactory Achievement (20–39 marks)**	**Low Achievement (0–19 marks)**	**Score**
• Identification of an issue **(10 marks)**	Students are able to accurately and clearly identify examples of scientific (physical, biological and chemical), technological, environmental, economic and social issue in media article. (8–10 marks)	Students are able to identify and put into categories examples of scientific (physical, biological and chemical), technological environmental, economical and social issue in the media article. **(5–7 marks)**		Students are able to identify a few examples without identifying whether they are scientific (physical, biological and chemical), technological, environmental, economic and social issue in media article. (0–4 marks)	
• Science knowledge and understanding (10 marks)	Students are able to show a very good understanding of concepts associated with all of the issues. (8–10 marks)	Students are able to show knowledge and understanding of concepts associated with most of the issues. (5–7 marks)		Students are able to show knowledge and understanding of a few of concepts associated with the different issues. (0–4 marks)	
• Application of understandings (10 marks)	Students are able to clearly and accurately explain the issues identified in the article. (8–10 marks)	Students are able to explain issues accurately and clearly in most categories, but there are some gaps in the explanation. (5—7)		Students are able to I found it difficult to explain the issues in the media. (0–4)	
• Communication of information and understandings. (10 marks)	Students are able to draw extensively on the information they had gained from the article and the activities to present a clear and logical explanation. (8–10 marks)	Students are able to draw on some of the information they had gained from the article and the activities to present a clear explanation. (5–7 marks)		Students are able to use a small amount of information to make their explanation. (0–4 marks)	
• Use of Scientific terminology (10 marks)	Students are able to use appropriate scientific terminology throughout. (8–10 marks)	Students are able to mostly use the appropriate terminology. (5–7 marks)		Students are able to use the appropriate terminology to a small extent. (0–4 marks)	
Total marks					

Appendix 4 – Resource books

Some recommended resource books where teachers and students can research for new ideas and information are listed below.

Teachers are encouraged to explore and make available variety of resources to ensure learning is done well.

Anderton J & Papua New Guinea Department of Education, (1993) *Fundamental Science for Melanesia Books 3 and 4*, Longman Cheshire Pty. Ltd. Melbourne, Australia.

Andrews C et. al. (2002) 2nd edition, *Active Science Skills and Experiments-Student Work Book,* Oxford university press, Victoria, Australia.

Appleton K, (1997) T*eaching Science: Exploring the Issues*, Central Queensland University Press. Australia.

Aung T, Kaluwin C, Lennon G. W. (1998) *Climate Change and Sea Level Part One: Physical Science,* Flinders University, Adelaide, Australia.

Beckett B & Callagher R. M, (1996 second edition) *New Co-ordinated Science Biology,* Oxford University Press, Melbourne, Australia.

Byres A, Childs A, Laine C, (1994) *The Science Teachers Hand Book,* Heinemann, Volentary Service Overseas, London, United Kingdom.

C.Andrews C, Naid S & Laidler C (2002) *Active Science-skills and experiments – students' workbook* 1. Oxford University Press. South Melbourne, Australia.

Dawson C (1997 reprinted). *Science Teaching in the Secondary Schools*, Longmann, South Melbourne, Australia.

Department of Education, (1998) *Grade 9 Project Work Handbook*, Curriculum Development Division, Waigani, Papua New Guinea.

Laidler G & Bridge T, (1997) *Introductory Science Skills for Junior Secondary Students,* Longmann, Melbourne, Australia.

Lesley R et al. (2000 second Edition) *Nature of Biology Activity Manual*, Jacaranda, Milton, Queensland, Australia.

Liklik Book (2003) *A Source Book for Development by Workers of Papua New Guinea Information Centre*, Unitech, Papua New Guinea.

Mackness B et al., (1994) *Practical Science Teachers Book*, Dellasta, Mt. Waverley, Australia.

Nardelli D, Richards M & Paton R, (2003) *Science Worksheets for Multiple Intelligences*, Jacaranda, Milton, Queensland, Australia.

Perrin B, (1987) *Science Technology and Society Books 1 & 2*, Jacaranda Press, Milton, Queensland, Australia.

Science Now Books 1, 2, 3 and 4, Macmillan Education Australia Pty. Ltd. South Yara, Australia.

Stannard P & Williamson K (1997 reprinted). *Science Now Books 1-4*, Macmillan. South Melbourne, Australia.

Stannard P & Williamson K (2001 2nd Edition) *Science World,* Macmillan, South Yara, Australia.

Stannard, R. & Williamson, K. (2001 second edition) *Science World 10*, Macmillan, South Yara, Australia.

Watson G, (1998) *Science Works Book 1, 2, 3 and 4*, Oxford University Press, Melbourne, Australia.