



Module 2

Upper Primary Science

Materials in my Environment



THE COMMONWEALTH *of* LEARNING

Science, Technology and Mathematics Modules
for Upper Primary and Junior Secondary School Teachers
of Science, Technology and Mathematics by Distance
in the Southern African Development Community (SADC)

Developed by
The Southern African Development Community (SADC)

Ministries of Education in:

- **Botswana**
- **Malawi**
- **Mozambique**
- **Namibia**
- **South Africa**
- **Tanzania**
- **Zambia**
- **Zimbabwe**

In partnership with The Commonwealth of Learning

COPYRIGHT STATEMENT

© The Commonwealth of Learning, October 2001

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form, or by any means, electronic or mechanical, including photocopying, recording, or otherwise, without the permission in writing of the publishers.

The views expressed in this document do not necessarily reflect the opinions or policies of The Commonwealth of Learning or SADC Ministries of Education.

The module authors have attempted to ensure that all copyright clearances have been obtained. Copyright clearances have been the responsibility of each country using the modules. Any omissions should be brought to their attention.

Published jointly by The Commonwealth of Learning and the SADC Ministries of Education.

Residents of the eight countries listed above may obtain modules from their respective Ministries of Education. The Commonwealth of Learning will consider requests for modules from residents of other countries.

ISBN 1-895369-67-3

SCIENCE, TECHNOLOGY AND MATHEMATICS MODULES

This module is one of a series prepared under the auspices of the participating Southern African Development Community (SADC) and The Commonwealth of Learning as part of the Training of Upper Primary and Junior Secondary Science, Technology and Mathematics Teachers in Africa by Distance. These modules enable teachers to enhance their professional skills through distance and open learning. Many individuals and groups have been involved in writing and producing these modules. We trust that they will benefit not only the teachers who use them, but also, ultimately, their students and the communities and nations in which they live.

The twenty-eight Science, Technology and Mathematics modules are as follows:

Upper Primary Science

- Module 1: *My Built Environment*
- Module 2: *Materials in my Environment*
- Module 3: *My Health*
- Module 4: *My Natural Environment*

Junior Secondary Science

- Module 1: *Energy and Energy Transfer*
- Module 2: *Energy Use in Electronic Communication*
- Module 3: *Living Organisms' Environment and Resources*
- Module 4: *Scientific Processes*

Upper Primary Technology

- Module 1: *Teaching Technology in the Primary School*
- Module 2: *Making Things Move*
- Module 3: *Structures*
- Module 4: *Materials*
- Module 5: *Processing*

Junior Secondary Technology

- Module 1: *Introduction to Teaching Technology*
- Module 2: *Systems and Controls*
- Module 3: *Tools and Materials*
- Module 4: *Structures*

Upper Primary Mathematics

- Module 1: *Number and Numeration*
- Module 2: *Fractions*
- Module 3: *Measures*
- Module 4: *Social Arithmetic*
- Module 5: *Geometry*

Junior Secondary Mathematics

- Module 1: *Number Systems*
- Module 2: *Number Operations*
- Module 3: *Shapes and Sizes*
- Module 4: *Algebraic Processes*
- Module 5: *Solving Equations*
- Module 6: *Data Handling*

A MESSAGE FROM THE COMMONWEALTH OF LEARNING



The Commonwealth of Learning is grateful for the generous contribution of the participating Ministries of Education. The Permanent Secretaries for Education played an important role in facilitating the implementation of the 1998-2000 project work plan by releasing officers to take part in workshops and meetings and by funding some aspects of in-country and regional workshops. The Commonwealth of Learning is also grateful for the support that it received from the British Council (Botswana and Zambia offices), the Open University (UK), Northern College (Scotland), CfBT Education Services (UK), the Commonwealth Secretariat (London), the South Africa College for Teacher Education (South Africa), the Netherlands Government (Zimbabwe office), the British Department for International Development (DFID) (Zimbabwe office) and Grant MacEwan College (Canada).

The Commonwealth of Learning would like to acknowledge the excellent technical advice and management of the project provided by the strategic contact persons, the broad curriculum team leaders, the writing team leaders, the workshop development team leaders and the regional monitoring team members. The materials development would not have been possible without the commitment and dedication of all the course writers, the in-country reviewers and the secretaries who provided the support services for the in-country and regional workshops.

Finally, The Commonwealth of Learning is grateful for the instructional design and review carried out by teams and individual consultants as follows:

- Grant MacEwan College (Alberta, Canada):
General Education Courses
- Open Learning Agency (British Columbia, Canada):
Science, Technology and Mathematics
- Technology for Allcc. (Durban, South Africa):
Upper Primary Technology
- Hands-on Management Services (British Columbia, Canada):
Junior Secondary Technology

Dato' Professor Gajaraj Dhanarajan
President and Chief Executive Officer

ACKNOWLEDGEMENTS

The Science Modules for Upper Primary and Junior Secondary Teachers in the Southern Africa Development Community (SADC) were written and reviewed by teams from the participating SADC Ministries of Education with the assistance of The Commonwealth of Learning.

CONTACTS FOR THE PROGRAMME

The Commonwealth of Learning
1285 West Broadway, Suite 600
Vancouver, BC V6H 3X8
Canada

National Ministry of Education
Private Bag X603
Pretoria 0001
South Africa

Ministry of Education
Private Bag 005
Gaborone
Botswana

Ministry of Education and Culture
P.O. Box 9121
Dar es Salaam
Tanzania

Ministry of Education
Private Bag 328
Capital City
Lilongwe 3
Malawi

Ministry of Education
P.O. Box 50093
Lusaka
Zambia

Ministério da Educação
Avenida 24 de Julho No 167, 8
Caixa Postal 34
Maputo
Mozambique

Ministry of Education, Sport and Culture
P.O. Box CY 121
Causeway
Harare
Zimbabwe

Ministry of Basic Education,
Sports and Culture
Private Bag 13186
Windhoek
Namibia

MODULE WRITERS

Mr. Edward Tindi: *Writing Team Leader*
Senior Inspector of Schools - Science
Teacher Education
Box 50093
Lusaka, Zambia

Ms. L. P. M. Banda: Provincial Resource Centre Co-ordinator
Provincial Education Office
P/Bag RW 21E
Lusaka, Zambia

R. M. Mubanga: Senior Inspector of Schools - Science
Provincial Education Office
Box 80197
Kabwe, Zambia

FACILITATORS/RESOURCE PERSONS

Dr. James Murdoch: Deputy Head of Science
Northern College
Aberdeen, Scotland, UK

PROJECT MANAGEMENT & DESIGN

Mr. Peter Dube: *Content Reviewer*
Education Officer, Secondary Science
Ministry of Education, Sport and Culture
Zimbabwe

Ms. Kgomotso Motlote: Education Specialist, Teacher Training
The Commonwealth of Learning (COL)
Vancouver, BC, Canada

Mr. André Ruhigisha: *Post-production Editor*
Co-ordinator of Instructional Development
Open Learning Agency
Victoria, BC, Canada

Ms. Lee McKenzie McAnally: *Post-production editing*
Open Learning Agency
Victoria, BC, Canada

Ms. Sandy Reber: *Graphics & desktop publishing*
Reber Creative
Victoria, BC, Canada

UPPER PRIMARY SCIENCE PROGRAMME

Introduction

Welcome to the programme in Teaching Upper Primary Science. This series of four modules is designed to help you to strengthen your knowledge of science topics and to acquire more instructional strategies for teaching science in the classroom.

Each of the four modules in the science series provides an opportunity to apply theory to practice. Learning about science entails the development of practical skills as well as theoretical knowledge. Each science topic includes an explanation of the theory behind the science, examples of how the science is used in practice, and suggestions for classroom activities that allow students to explore the science for themselves.

Each module also explores several instructional strategies that can be used in the science classroom and provides you with an opportunity to apply these strategies in practical classroom activities. Each module examines the reasons for using a particular strategy in the classroom and provides a guide for the best use of each strategy, given the topic, context, and goals.

The guiding principles of these modules are to help make the connection between theory and practice, apply instructional theory to practice in the classroom situation, and support you, as you in turn help your students to apply science theory to practical classroom work.

Programme Goals

This programme is designed to help you to:

- strengthen your understanding of science topics
- expand the range of instructional strategies that you can use in the science classroom

Programme Objectives

By the time you have completed this programme, you should be able to:

- develop and present lessons on environmental resources, needs and conservation, materials in the environment, health issues, and natural ecosystems
- guide students as they work in teams on practical projects in science, and help them to work effectively as a member of a group
- use questioning and explanation strategies to help students learn new concepts and to support students in their problem solving activities
- guide students in the use of investigative strategies to learn more about particular scientific concepts, and to find out how tools and materials are used in scientific inquiries
- prepare your own portfolio about your teaching activities
- guide students as they prepare their portfolios about their project activities

The relationship between this programme and the science curriculum

The science content presented in these modules includes some of the topics most commonly covered in the science curricula in southern African countries. However, it is not intended to cover all topics in any one country's science curriculum comprehensively. For this, you will need to consult your national or regional curriculum guide. The curriculum content that is presented in these modules is intended to:

- provide an overview of the content in order to support the development of appropriate teaching strategies
- use selected parts of the curriculum to develop specific teaching strategies
- explain those elements of the curriculum that provide essential background knowledge, or that address particularly complex or specialised concepts
- provide directions to additional resources on the curriculum content

How to Work on this Programme

As is indicated in the programme goals and objectives, this programme allows you to participate actively in each module by applying instructional strategies when exploring science with your students and by reflecting on that experience. There are several different ways to do this.

Working on your own

You may be the only teacher of science in your school, or you may choose to work on your own so you can accommodate this programme within your schedule. If this is the case, these are the recommended strategies for using this module:

1. Establish a schedule for working on the module: choose a date by which you plan to complete the first module, taking into account that each unit will require between six to eight hours of study time and about two hours of classroom time for implementing your lesson plan. For example, if you have two hours a week available for study, then each unit will take between three and four weeks to complete. If you have four hours a week for study, then each unit will take about two weeks to complete.
2. Choose a study space where you can work quietly without interruption, for example, a space in your school where you can work after hours.
3. If possible, identify someone who is interested in science or whose interests are relevant to science (for example, a math or science teacher in your school) with whom you can discuss the module and some of your ideas about teaching science. Even the most independent learner benefits from good dialogue with others. It helps us to formulate our ideas—or as one learner commented, “How do I know what I’m thinking until I hear what I have to say?”

Working with colleagues

If you are in a situation where there are other teachers of science in your school or in your immediate area, then it is possible for you to work together on this module. You may choose to do this informally, perhaps having a discussion group once a week or once every two weeks about a particular topic in one of the units. Or, you may choose to organise more formally, establishing a schedule so that everyone is working on the same units at the same time, and you can work in small groups or pairs on particular projects. If you and several colleagues plan to work together on these modules, these are the recommended steps:

1. Establish and agree on a schedule that allows sufficient time to work on each unit, but also maintains the momentum so that people don't lose interest. If all of you work together in the same location, meeting once a week and allocating two weeks for each unit, this plan should accommodate individual and group study time. If you work in different locations and have to travel some distance to meet, then you may decide to meet once every two weeks, and agree to complete a unit every two weeks.
2. Develop and agree on group goals, so that everyone is clear about the intended achievements for each unit and for each group session.
3. Develop a plan for each session, outlining what topics will be covered and what activities will be undertaken by the group as a whole, in pairs, or in small groups. It may be helpful for each member of the group to take a turn in planning a session.

Your group may also choose to call on the expertise of others, perhaps inviting someone with particular knowledge about teaching or about a specific science topic to speak with the group, as long as this is in keeping with the goals of the module and of the group.

Your group may also have the opportunity to consult with a mentor, or with other groups, by teleconference, audioconference, letter mail, or e-mail. Check with the local coordinator of your programme about these possibilities so that you can arrange your group schedule to be compatible with these provisions.

Colleagues as feedback/resource persons

Even if your colleagues are not participating directly in this programme, they may be interested in hearing about it and about some of your ideas as a result of taking part. Your head teacher or the local area specialist in science may also be willing to take part in discussions with you about the programme.

Working with a mentor

As mentioned above, you may have the opportunity to work with a mentor, someone with expertise in science education who can provide you with feedback about your work. If you are working on your own, your communication with your mentor may be by letter mail, telephone, or e-mail. If you are working as a group, you may have occasional group meetings, teleconferences, or audioconferences with your mentor.

Using a learning journal

Whether you are working on your own or with a group, it is strongly recommended that you use a learning journal. The learning journal serves a number of different purposes, and you can divide your journal into compartments to accommodate these purposes. You can think of your journal as a "place" where you can think out loud by writing down your ideas and thoughts, and this "place" has several "rooms".

Ideas/Reflections/Questions

In one part of your journal, you can keep notes and a running commentary about what you are reading in each unit, write down ideas that occur to you about something in the unit, and note questions about the content or anything with which you disagree. You can use this part to record general ideas about how to use some of the content and strategies in the classroom. If you consistently keep these notes as you work through each unit, then they will serve as a resource when you work on the unit activity, since you will have already put together some ideas about applying the material in the classroom. This is also the section of the journal for your notes from other resources, such as books or articles you read or conversations with colleagues.

Plans

This is the section where you work on your activity for each unit. At the start of each unit, you should start considering what activity you will choose to do, and then develop your ideas as you go along. Each activity will also have specific guidelines.

Observations/Reflections

This is the section where you record your observations about classroom experiences, how students seem to tackle various situations and how each instructional strategy works in practice. This is the place to record your notes after you implement the unit activity about what you feel worked well and what could be improved. If you are part of a group, you can keep your notes about good practice and effective group dynamics, based on the group experience, in this section.

Resources available to you

Although these modules can be completed without referring to additional resource materials, your experience and that of your students can be enriched if you use other resources as well. There is a list of resource materials for each module provided at the end of that module. You can also identify other resources that can enhance the teaching/learning experience, from among materials that may be locally available. These include:

- working examples of materials, tools and techniques that are used and available in your local environment
- magazines that have articles about science topics covered in the module units
- books and other resources (including the internet) about science that may be available in your school or community library

Tips for selecting resources

Working with locally available resources may require selecting those that are most appropriate from among materials that may not be complete or relevant. When reviewing materials to see if they will help you with the module, consider:

- Which module topics does this material address?
- Is it possible the ideas in this material are transferable to the science classroom?
- Is it possible the ideas in this material are transferable to the technologies included in the module?

ICONS

Throughout each module, you will find some or all of the following icons or symbols that alert you to a change in activity within the module.

Read the following explanations to discover what each icon prompts you to do.

	Introduction	Rationale or overview for this part of the course.
	Learning Objectives	What you should be able to do after completing this module or unit.
	Text or Reading Material	Course content for you to study.
	Important—Take Note!	Something to study carefully.
	Self-Marking Exercise	An exercise to demonstrate your own grasp of the content.
	Individual Activity	An exercise or project for you to try by yourself and demonstrate your own grasp of the content.
	Classroom Activity	An exercise or project for you to do with or assign to your pupils.
	Reflection	A question or project for yourself— for deeper understanding of this concept, or of your use of it when teaching.
	Summary	Synthesis of the module or unit
	Unit or Module Assignment	Exercise to assess your understanding of all the unit or module topics.
	Suggested Answers to Activities	Answer keys
	Time	Suggested hours to allow for completing a unit or any learning task.
	Glossary	Definitions of terms used in this module.

CONTENTS

Module 2: Materials in my Environment

Module 2 – Overview	2
Unit 1 – Project/Research Work	3
Unit 2 – Local Technologies in My Environment	9
Unit 3 – Improvisation	19
Unit 4 – Materials and Their Uses	29
Suggested Answers for Activities	44
Glossary	50
References	52

Module 2

Materials in my Environment



Module 2 Overview

We have materials in our environment that we are familiar with. These locally available materials are useful in our daily lives and can be used in the teaching and learning of school science. The aim of this module is to explore ways to use these materials in the most cost-effective way in order to bring about desirable learning outcomes as well as to discuss how some of these common materials are produced.

The module has 4 units:

Unit 1: Project/Research Work

School science should have more to do with getting the pupils to behave like a scientist, i.e., getting the pupils involved in the scientific processes in order to appreciate and understand the products of science. The project/research approach to learning science is the focus of this unit.

Unit 2: Local Technologies in my Environment

High technology is associated with increased productivity and fast selling goods which can become useless after a short time. On the other hand, low technologies are easy to manage and sustain as they are well understood and very relevant to the local needs.

Unit 3: Improvisation

The basic focus in this unit is to find alternative materials that are locally available and low cost.

Unit 4: Materials and Their Uses

We will discuss some materials related to mining that are common within the regions being discussed. The products of these materials are commonly used in our daily lives. While emphasis is on the use of the local environment as a teaching and learning resource, there are other teaching strategies that have been considered within the unit.



Learning Outcomes

After completing this module you should be able to:

- demonstrate knowledge and understanding of the various components of the units
- put in practice the acquired teaching skills
- develop a positive attitude towards the care of the local environment
- demonstrate creativity in exploiting the local environment as a resource for teaching and learning

Unit 1: Project/Research Work



Introduction

Research/project is one of those strategies the teacher can use to bring about meaningful learning. Before applying this method in your classroom, it is important that you know and understand what is involved in these types of activities.

Learning through research/project work offers the pupils an opportunity to interact with the materials. The pupils should be given an opportunity to explore and try out ideas on their own. In investigating a problem and trying out possible solutions, the pupils' thinking capability is stretched to the limit.



Unit Objectives

Using the local environment for teaching and learning, you should be able to:

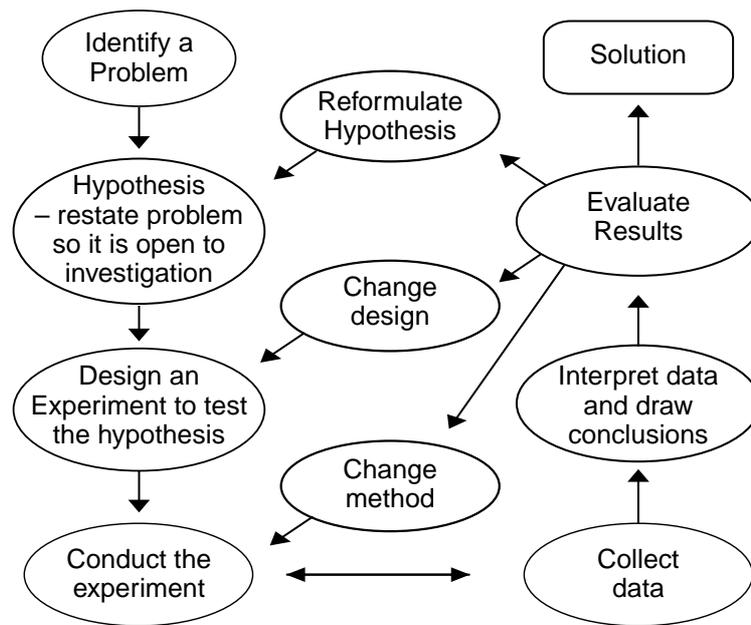
- identify the steps involved in carrying out research work
- follow the steps for carrying out research work
- apply the skills of observation, identification of a problem, formulating a tentative solution, designing a fair test for the tentative solution, data collection, analysis, and drawing a conclusion
- encourage pupils to engage in local researches that are community based on the local technologies that will improve the lifestyles of the local communities



The Scientific Method at Work

Research and project work involves **investigation**. A problem may have several possible solutions and it is the role of the scientist to establish hypotheses for solving the problem and to set up experiments to test the hypotheses.

The **hypothesis** restates the **problem** and makes assumptions and predictions that can be tested. In order to test the hypothesis, an **experiment** or series of experiments need to be designed. Experimentation tests the hypothesis through a series of predetermined steps (methods) that yield **observations** and **data**. Before beginning the experiment, guidelines for generating and recording the data must be established. To be able to make a meaningful interpretation, **data collection** must be carried out in a systematic way. The interpretation or **conclusion** drawn from the data analysis leads to the **solution** of the problem that was being tested. Before the solution is accepted, it has to be **evaluated**. The solution can be accepted, if satisfactory, or the experimental process can be redesigned until a satisfactory solution is achieved.



Stages in research/project work

Figure 1.1: Stages in research/project work adapted from Derek Hodson in School Science Review, March 1992, 73 (264) p. 75.

While individual learning is encouraged, it is equally important that teamwork be encouraged as a means of trying out all the possible suggestions. At the upper primary school level, research/project work should be done as a group work activity in order to have shared experience. Group work allows for discussion before ideas from the group members are tried out.

Conducting research and experiments in a group promotes teamwork and respect for other opinions.

Some of the advantages of this teaching/learning approach are:

- Pupils have an opportunity to interact with the physical environment and have hands-on experience.
- Manipulative skills are developed as materials are handled in carrying out the experiment.
- The pupil relates what has been taught in class to his/her own experience.
- The pupil is given an opportunity to experience what scientists go through.
- The pupil learns to appreciate that ideas that have been found unsuitable can be discarded.

Some disadvantages are:

- It is time consuming.
- The cost of equipment can be expensive.
- It can be difficult for pupils to see the relevance between a practical activity and the classroom learning experience.

The major purpose of hands-on research/project work is to engage students in investigations that use the process of science to explore and develop their conceptual understanding. In the long run, they achieve a deeper understanding of issues and increased expertise in scientific practice.

Teachers should encourage their students to regard this kind of activity as personally worthwhile because it enables them to study phenomena, explore issues, and solve problems. Check your students' progress regularly, and offer direction when they run into problems. Be sure to set a time limit on the activity, otherwise they might become distracted and lose focus. Plan group research/project work so all your students experience success, thereby building self-esteem and engendering the self-confidence to tackle other complex tasks, both in the science classroom and beyond.



Individual Activity 1

This activity may require you to go out into the local environment or think about it.

- (a) Look around your local environment.
- (b) Are you able to identify some pressing problems in your environment?
Here are some of the problems you may have considered that are common in most communities.
 - waste disposal
 - environmental conservation
 - clean drinking water
- (c) State the problems as clearly as you can. For example:
 - How do you dispose of waste in your local community?
 - How can you conserve the environment?
 - How can you make water clean and safe for drinking?
- (d) Suggest possible solutions to the problems that you have identified.
- (e) Try out your suggested solutions by doing experiments as a way of testing the suggested answers. For example:
 - Collect a sample of water from your local community.
 - Pour your sample of water in a clean transparent container.
 - What do you observe?
 - Take a clean white cloth and use it to cover the mouth of the container as shown in the diagram (*Figure 1.2*).
 - Pour your water on the white cloth and examine the white cloth.
 - Describe your observation.
 - What conclusions can you come up with about your sample of drinking water?

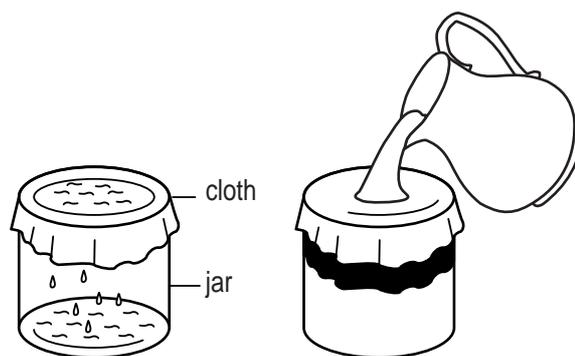


Figure 1.2: Filtration experiment.



Individual Activity 2

Identify some sections of your syllabus for which research/project work is appropriate. You should ask the pupils to come up with problems or investigations that are closely related to the topic being taught.

Ask your pupils to choose a topic from the four areas that have been discussed, or another area related to local technological improvement. The pupils can work individually or in groups of two or three. The pupils must first discuss their topic and do some background reading.

You should not allow pupils to go to the next stage of the research/project work before they discuss with you how they intend to carry out that next stage, i.e., planning for the experiment.

Open a file entitled Research/Project Work and record the research titles and the names of the pupils involved.

Use this file to monitor the pupils' progress and note any observations you make when the pupils are doing their research so that you are able to give advice.

When the research has been completed, the pupils should submit their research report.

How effective has your method been in assisting your pupils to come up with solutions to the problems? Suggest ways of making it more effective.



Self-Marking Exercise

- (a) Should research/project work involve practical work? Explain your answer.
- (b) Suggest how the pupils should write a research report.

Check your answers at the end of the Module.



Summary

You and your students should not view school science as merely doing an experiment that has no direct bearing on life outside the classroom. Science is about finding solutions to problems that affect us every day. What is important is making students aware that scientists engage in research work, and that research is not confined to the laboratory. Your pupils should appreciate that in order to arrive at a solution, they must go through the scientific process by:

- making observations
- identifying problems
- coming up with tentative solutions
- testing the tentative solution by designing an experiment, collecting data, analysing the data, and drawing the conclusions

By engaging pupils in such activities, they will acquire scientific skills through the use of local technologies in the local environment.



Reflection

The question that you have to ask and answer yourself is how the teaching approach that has been discussed can bring about meaningful learning of school science in view of the following constraints:

- research/project work being time consuming
- teaching for examination purposes
- time to be allocated to research work
- research work interfering with a current science topic that might appear to be unrelated



Unit Assignment

1. Write lesson plans using the research/project work teaching strategy on:
 - (a) Methods of fish preservation
 - (b) Vegetable preservation
2. Use the format below to design a worksheet that your pupils can use to conduct research in the community on:
 - (a) Methods of fish preservation
 - (b) Vegetable preservation

Method of Preservation	Fish/Vegetable
Sun Drying	Diagram/picture
Smoking	Diagram/picture
Salting	Diagram/picture

Check your answers at the end of the Module.

Unit 2: Local Technologies in My Environment



Introduction

Urban areas are usually associated with modern technologies characterised by high technology items like computers, cellular phones, microwaves, and canned and frozen foods. On the other hand, rural areas have their own technologies, which can also be termed as indigenous technologies.

The purpose of this unit is to identify some of the indigenous technologies and explore ways to improve them. The school is a natural starting place to increase awareness of indigenous technology and, through school science, make improvements from a scientific point of view.



Unit Objectives

Using the local environment as a resource for teaching and learning you should be able to:

- describe indigenous technologies
- discuss the importance/usefulness of these technologies
- assess and make improvements to the technologies



Uses of Technologies in My Environment

We know that food is responsible for the growth and development of all living things. Food provides the energy needed for the metabolic processes in the body systems. Food also provides the vitamins and minerals that help to prevent conditions such as malnutrition, anaemia, and rickets.

Food can be eaten in two forms, either raw or cooked by various methods. Food production, preservation, storage and preparation methods, and the tools and technologies used will be examined.

Fabric dyeing techniques will also be explored.

Food preservation

We can eat food prepared or straight from the source but more often we preserve it to be used later. We preserve food to ensure that it retains its quality in terms of taste and richness, i.e., proteins, carbohydrates, vitamins, and minerals, etc.

We preserve food to prevent it from going bad. Some vegetables are seasonal and by preserving them we make them available when they are out of season.

Methods of preservation

We shall consider a number of ways of preserving food. You will be familiar with some of the methods while others will be new to you. As stated in the objectives, you must critically assess the present methods of food preservation for the purpose of making improvements.

Sun Drying

Our traditional vegetables like *bondwe*, amaranth, pumpkin leaves, bean leaves, and okra are abundant during the rainy season. We cut the green leaves into small pieces and spread them on a reed mat and put them in the sun to dry. We can boil leafy vegetables before spreading them out to dry.

We dry fresh vegetables to remove water so that microbes cannot decay the food. The process of drying is also referred to as dehydration.

Mushrooms, tomatoes, and wild fruits can also be sun dried.

Refer to Module One—My Built Environment, Unit 1, Human Needs—to find the food value of vegetables.

When sun drying fish and meat we should ensure that house flies do not sit on the fish or meat as this facilitates microbe action resulting in the spoilage and decaying of the meat/fish.

Why is the fish opened up or meat cut in flaps before drying it?

Salting and Sun Drying

Another way to reduce microbe action that could lead to the food (meat or fish) going bad is by salting first and then later sun drying. The degree of salting varies from sprinkling with salt to soaking in a concentrated brine (salt water) for some time and then following by drying.

Smoking

Smoking fish or meat reduces or eliminates microbe action that can result in the meat/fish going bad.

Grain Preservation/Storage

We harvest cereals like maize when it is dry and it has become acceptable that cereals are best used in dry form. Dry cereals are usually attacked by weevils, termites, rats or mice if they are not stored properly. Dry beans, groundnuts, and even vegetables can also be attacked if not properly stored.

Once we sun dry the vegetables, fish, meat, and cereals, they must not be exposed to moisture as they can easily go bad as decomposers will flourish.

The following picture illustrates a traditional storage granary. Can you suggest further improvements to safeguard the foods that are stored?

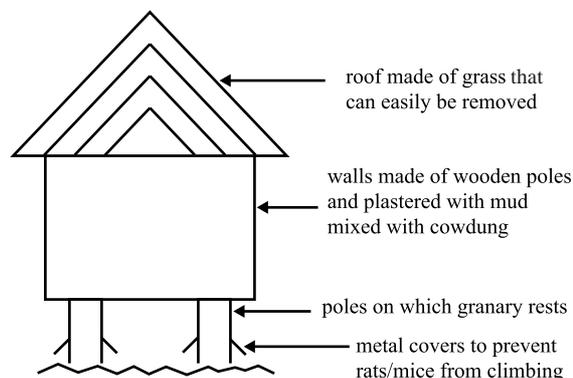


Figure 2.1: Granary.

Other Indigenous Technologies

Making the burner/stove more efficient

What do you understand by the term efficient? We should think of efficiency in terms of using less fuel to create more heat output, reducing heat losses, and obtaining maximum heat transfer. In other words, minimum input and maximum output. In some rural and urban areas, the main source of fuel for cooking purposes is still firewood and charcoal. Charcoal has been more prominent as a source of fuel, leading to indiscriminate cutting of trees and resulting in serious deforestation. The challenge is to reduce deforestation and look at coal resources as a substitute.

In sugar-cane growing regions, the waste fibre called bagasse is used as fuel. In urban areas, the common stove is a brassier made from scrap metal sheets and this type of stove provides heat to the surrounding area. A stove made of clay has to be constructed in such a way that more heat is directed towards the point where cooking is taking place.

Examine the charcoal braziers/stoves below and determine which is most efficient.

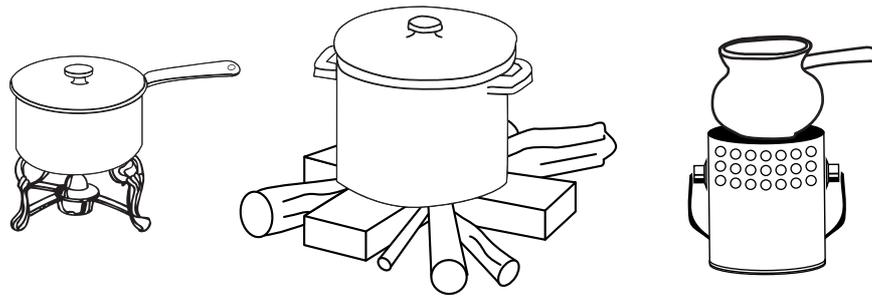


Figure 2.2: Different kinds of sources of fuel for cooking.

From charcoal to coal for domestic fuel

It has been stated that there is an abundance of coal within the region and that we must consider using this as source of fuel because of our concern over the environmental degradation arising from deforestation.

The chemistry of properly treated charcoal is smokeless, odourless, and in plentiful supply. Coal is being suggested in place of charcoal. However there is the need to remind ourselves that while coal is used in industries, specially designed smoke chimneys are used to take care of the gases that may be harmful to the environment.

Cooling of drinking water using the “clay pot”

We are familiar with clay pot that is sometimes used to brew local beers in villages. Unlike a calabash that might affect the water, the clay pot, if properly treated, will not contaminate the water.

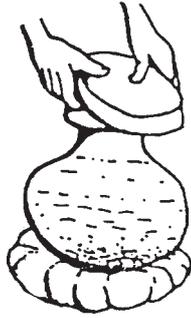


Figure 2.3: The clay pot.

As a research project you must find out how the cooling is achieved and how to make the clay pot more efficient.

Making the hoe an efficient tool

A tool is an implement that we use in our work. A tool that makes our work easier is a machine. In this section we will consider an implement that is widely used in our fields and gardens. This tool is the hoe and is probably the most important farming implement in our traditional setting. You may be aware that there are different shapes of hoes. Some have long handles while others have short handles.

Carry out some research to find out why a community uses a particular type of hoe.

Before you undertake the research, it is important to note that as a machine, the hoe is supposed to make our work easier. When we till the ground, the hoe blade works the soil and the soil is the load. The hoe handle is the lever arm which you hold and to which pressure is applied.

We do work when we apply force. There is work done by the hoe blade on the soil (load) and there is work done by the user on the hoe blade (effort). This relationship is shown below:

Work done on the load = load \times distance through which the load (soil) moves. Work done on the load is the output.

Work done by the effort applied \times distance through which the effort moves is the input. We end up with the relationship:

Work input = work output

Since the idea is to make the machine more efficient we express this mathematically:

$$\text{Efficiency} = \frac{\text{work output}}{\text{work input}} = \frac{\text{work done on load}}{\text{work done by effort}}$$

If our work input is greater than our work output, the machine is more efficient.

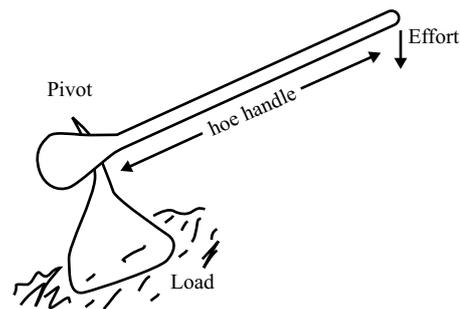


Figure 2.4: The hoe as a simple machine.

- What will be the effect on the work being done if you have a short handled hoe as opposed to a long handle hoe?
- What are the advantages and disadvantages of using a:
 - (a) long handled hoe?
 - (b) short handled hoe?
- What factors do you have to consider in advising the local community on the type of hoe to use?



Individual Activity

Investigating the efficiency of a hoe

The hoe is a machine that is supposed to make work easier. Is the hoe in its present state making work easier?

Review, Plan and Research

What is the background information you have on the use of hoes?

Think about the hoe you use and hoes you have seen other people using. Is there a relationship between the type of hoe used and the crops grown? Is there any relation between the culture of a people and the type of hoe they use? Research the theories on simple machines. How do they work? Why is a hoe a simple machine?

In planning the experiment, what conditions are you going to set? A variety of crops that are grown in Southern Africa include maize, sorghum, beans, groundnuts and sweet potatoes. The hoe is the basic farming implement. What type of hoes do people in Southern Africa generally use? What problems do they experience in using the hoes? What variables have you identified?

To carry out the experiment you should investigate how the length of a hoe affects its efficiency. You will need three hoes (A, B, C) with different lengths of hoe handles but having the same blades and load.

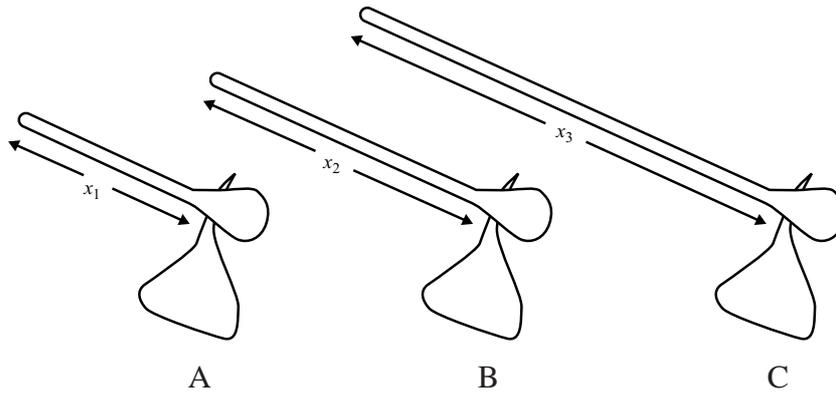


Figure 2.5: Length of hoe vs. its efficiency.



Note—The kind of data you collect may be difficult to measure in terms of actual load and effort. In this case you have to rely on actually performing the work and using each one of the three hoes. Note your observations, feelings, and experiences using a table like the one below.

	Hoe A	Hoe B	Hoe C
How easy is it to use in digging? (Effort applied to the hoe.)			
Is the handle too long or too short?			
In what ways does the length of the handle affect your work?			

Do you think this is a fair activity?

What improvements can you make to this approach?

Do you think this activity will teach the necessary skills?

Evaluation of the results and methods

It may have proved difficult for you to take measurements of effort against the load with varying effort distances. At this stage you should re-examine the method of conducting the experiment and either change the experiment or make decisions on what you should measure. Consider other variables that will lead to the improved performance of the implement.

Has the activity been worthwhile?

Do you think the local community will benefit from the results of your research?

In what ways do you think the local community will benefit from the activity?

When you finish the activity, check the Suggested Answer section to see if you included/followed all required elements in your investigation report.

Dyeing

Natural Dyes

For centuries, we have practiced dyeing at the household level and it has become a tradition of a particular community. The human desire for specific design and colour has developed the dyeing industry to the point where natural dyes are replaced by synthetic dyes.

We make natural dyes from bark, roots, leaves, berries, flowers, insects, and other animals. We boil, squeeze, soak, or pound these materials to obtain the liquid colour. Then the fabric is soaked in the dye.

The following account gives you a brief history of dyes. Some of the earliest natural dyes included red madder dye made by the Egyptians from plant roots, and indigo blue made in India. Saffron yellow was extracted from a fall-flowering crocus by the Greeks and Romans. Cochineal was a red dye made by the Aztecs from insects, and Tyrian purple was made by the Phoenicians from snails. Orange-red henna came from a shrub in North Africa and the Middle East.

Because early dyes washed out very easily, it was necessary to use minerals, called **mordants**, to set the colour. Some of the materials needed to produce the dyes were very scarce and very expensive.

Commercial Dyes

Commercial dyes are mainly synthetic. With the introduction of synthetic dyes in 1856, a new industry developed. It was found that coal tar could be used to produce the whole spectrum of colours. Synthetic dyes had greater colourfastness and were much less expensive. Today, synthetic dyes have almost entirely replaced natural dyes for commercial dyeing.

If you are going to use commercial dyes such as Dylon at home or at school, read the instructions carefully. There are two types of dye: hot water dyes and cold water dyes. Both types come in a wide variety of colours.

In this unit we will look at making the dye and using the dye to produce desirable effects.

There are a few points you should think about before dyeing fabric.

- What is the fabric made from? If the fabric is made from natural fibres, it should dye well. If the fabric is made of rayon or viscose fibres, it can be dyed but they don't dye as well as natural fibres because they don't absorb the dye as easily.
- What is the original colour of the fabric? Check the colours that are produced by combining different colours. It may not come out as you expected!
- How much time and what sort of equipment do you need?

We will consider three types of dyeing:

- dyeing a fabric to change colour
- batik dyeing
- tie dyeing

When you dye a fabric, you change its colour. You use white fabric and soak it in a dye solution for a period of time. To change a fabric from one colour to another you should know that colour mixing is important. Can you suggest ways to make the dye permanent so it does not easily fade?

The process of batik dyeing prevents the dye from getting to certain parts of the fabric. Depending on your skill, you can get some interesting effects. The Indonesian art of batik is a process of drawing on a fabric with hot melted wax and then dyeing it. The waxed area resists the dye. Melted candle sticks with the wicks removed can be used. The wax is removed by ironing between several changes of newspaper.

You will have to conduct some research on the types of batik designs. Here are some worth researching:

- free batik design
- embroidered batik
- dipped batik
- coloured waxes
- nigerian starch resist

In the tie-dyeing method the cloth is pleated and then tied tightly with string. This should be done on different areas of fabric. Small stones with elastic bands tied around them can be used. The fabric is then soaked in the dye solution and then rinsed and washed. The strings and elastic bands are cut. The dye will not reach the tied parts. You should explore a number of ways of tie-dyeing.



Individual Activities

Activity 1

In this activity you will be doing research. You may need to refer to Unit 1 so you can familiarise yourself once more with the stages of research.

Examine the three different sources for cooking in *Figure 2.2* and identify those features you think make one stove more efficient than the other.

Think of the variables that are likely to affect the efficiency in terms of fuel use and heat transfer.

Activity 2

You will need some enamel containers, stirring rods, dye sources such as spinach or cassava leaves that are a good source for green colour, onion skin for yellow, beetroot for violet, carrot peelings for orange/yellow, and tea leaves for brown, a mordant such as alum (to brighten colour) or iron (to darken colour) and small pieces of white fabric.

- **Preparing the dye solution**

Put the source of your dye in the water. Cut up the plant in the water so you don't lose any of the colour. Boil the mixture for one-half hour to one hour until you get a nice colour. Take the mixture off the heat and strain the liquid into another pan.



- **Preparing the fabric**

Wet the fabric so it will take the dye better and absorb the coloured water more evenly. This will also remove any finish which can stop the dye from being taken up and from being fast.

- **Dyeing**

Put the wet fabric in the dye and stir well until the fabric is warm.

Dissolve the mordant in a little water and add this to the dye. Stir well. If you can, leave the fabric in the dye for at least 10-12 hours. It can be left for up to 48 hours. Rinse the fabric thoroughly several times. Dry the fabric.

What can you do to ensure that the dye is permanent?

Dyeing can be a messy activity so you will have to identify a suitable working surface. Put on gloves and aprons to prevent the dye staining your hands or clothes.

Activity 3

Identify different sections of the syllabus which relate to local technologies.

Ask your pupils to come up with problems for investigation in relation to the topic identified.

For the purpose of encouraging communication among the pupils, they should work in groups of twos or threes.

How effective has your method been in assisting the pupils to come up with solutions to the problems? Was it more effective than in Unit 1?



Self-Marking Exercise

1. Did your pupils enjoy going through the exercises? Suggest possible explanations for why they did or did not enjoy it.
2. How did you find this teaching approach?



Summary

The emphasis in this unit has been on using your local environment as a resource for teaching and learning. The activities can be applied to your local communities, especially the rural community. The technologies you have studied have become part of a way of our life. However, often no improvements have been made to enhance their potential and efficiency.



Reflection

The examples we have identified are but a few local technologies. Expand on this list and give some background of what the identified local technology is all about. The question you have to ask yourself, and answer, is how will the identified local technology fit into your day to day school science teaching in view of the following constraints:

- failure by pupils to come up with local technologies
- syllabus restrictions
- failure by pupils to identify local problems and to come up with tentative solutions



Unit Assignment

1. How do you define the following expressions?
 - Local technology
 - Appropriate technology
 - Indigenous technology
 - Relevant technology
2. List other local technologies, other than those discussed, that you feel should be improved upon.

Unit 3: Improvisation



Introduction

In this unit we will discuss the skill of improvisation, an activity that every science teacher should be engaged in. This is because most of the materials that are used in practical science activities are commercially made and are expensive. Teachers often use lack of equipment as an excuse for not teaching science effectively. We also know that some teachers lack the skill to improvise. However, we cannot over-emphasize the importance of improvisation because this skill, once acquired, will enable the pupils to have hands-on learning experiences.

Improvisation enables you to “unpack” scientific concepts in the most cost effective and user friendly way.



Unit Objectives

By using the local environment as a resource for teaching and learning, you should be able to:

- identify teaching aids that can be improvised using locally available materials
- determine the extent to which you can use the improvised material
- make and use the improvised teaching aids effectively in the classroom situation
- transfer the skills of improvisation to the pupils
- demonstrate the skills of improvising
- demonstrate knowledge and understanding of an improvised item



What is Improvisation in Science?

Improvisation is a term that you, as a science teacher, are familiar with because it has become part of your vocabulary. We associate improvisation with a locally made item that is a substitute for a commercially made product that is not available because of the high cost associated with it.

An improvised item can give the same results as a commercially made one. An improvised item may include the following:

- the use of a polystyrene drinking cup as a beaker calorimeter
- a discarded 750 ml plastic bottle can provide a funnel, dish, tubes, and beakers as illustrated in *Figure 3.1*

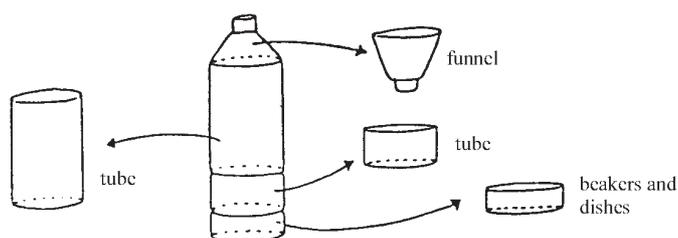


Figure 3.1: Improvising with a discarded plastic bottle.

We can use eggshells or coral as a substitute for marble/limestone (calcium carbonate). The eggshells can be crushed into various sizes to show the effect of size particle (surface area) on the rate of the reaction.

You can buy kitchen foil or drinking cans from a shop as a substitute for commercially made aluminium for use in the laboratory.

You can use discarded telephone wires as connecting wires in simple circuits.

Cotton reels can be used as pulleys. A pulley is another type of machine you can use for lifting or lowering a heavy object, as illustrated in the fourth diagram of *Figure 3.2*.

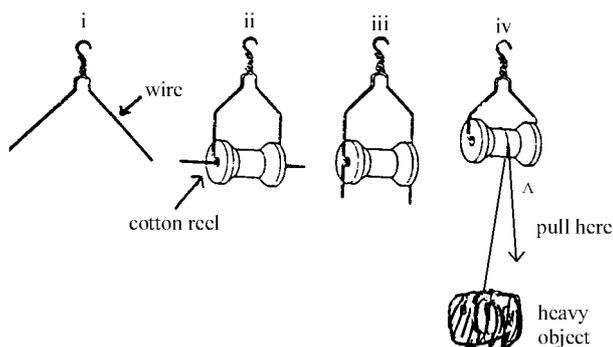


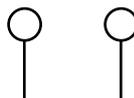
Figure 3.2: Pulleys.

You can make a simple motor from locally available materials and keep the cost low. It will work like a commercially made item.

To make a simple motor follow the steps listed below.

Materials

- 2 bar magnets
- 20 cm insulated copper wire
- 2 x 1.5 V dry cells
- 2 rigid shot wires with loops
- connecting wires

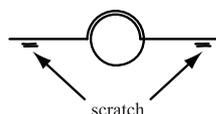


Construction

1. Take the 20 cm insulated wire and bend it into a loop.



2. Scratch as indicated.



3. Fix the two rigid supports onto the wooden block.
4. Mount the loop onto the supports as shown in *Figure 3.3*.
5. Connect the supports to the cells.
6. Position the magnets one on either side of the loop. What happens?

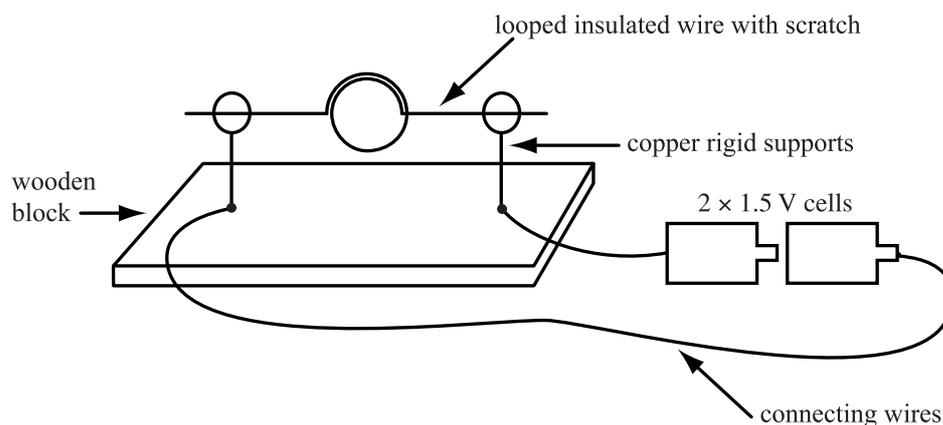


Figure 3.3: Simple motor.

Some issues to consider about improvisation

An improvised item may be considered inferior because of the low cost component despite the fact that it will provide the same results as a commercially made item. One way to overcome this is to have the users make the item and demonstrate that it works.

It is a good idea if both you and your pupils are involved in making an improvised item. This project can contribute to developing your skills and a sense of ownership, and better understanding what can lead to the improvement of the item. Depending on the availability of local materials, you can produce these improvised items in large quantities while maintaining the quality and reliability at low cost.

There is the danger that you and your pupils may spend too much time producing the item at the expense of teaching/learning time.

When designing an item it is important that you maintain a balance between sophistication and simplicity. Increased sophistication means greater cost and excessive simplicity leads to inaccuracy or unreliability.

Having discussed what improvisation is, we should now discuss how you can acquire the skills of improvisation. Imagine that in your school there is no science laboratory, let alone any science equipment to help you teach school science through hands-on activities. Sometimes you are unable to illustrate a scientific concept because you have no teaching aids to help you. You lack the materials to teach school science the way you have been trained to teach the subject.

In the absence of commercially made teaching aids such as models, charts, and apparatus you are left with little choice but to make do with what is locally available. You must ensure that the improvised item gives the same results and has the same effect as a commercially made product.



Individual Activities

Activity 1: Separation Techniques

Do the experiment and then describe with the help of diagrams how you would separate two substances, one soluble and the other insoluble, e.g., salt and sand. You could do this in a number of ways, either by decantation or filtration.

To use the decantation method you will need:

- mixture of salt and sand
- 2 jam jars or tins
- heat source
- filtering apparatus (cloth, tissue paper, filter funnel, filter materials)

Add water to the salt/sand mixture and stir. The salt will dissolve and the mixture will appear muddy. Allow the sand to settle and gently pour out the dissolved salt solution into a container. The process used to separate the sand from the salt solution is the **decantation**. You should heat the decanted liquid so that the liquid evaporates and the salt will remain. What is the colour of the salt that has remained? How can you ensure that you get white salt?

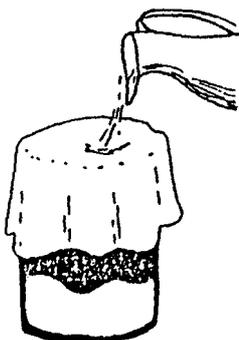


Figure 3.4: Filtering apparatus.

To use the filtration method you will need

- mixture of salt and sand
- 2 containers (jam jars/tins)
- heat source
- filtering apparatus (cloth, tissue paper, filter funnel, filter materials)

Figures 3.4 and 3.5 illustrate **filtration**.

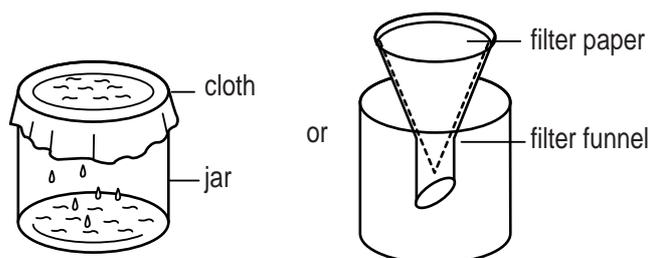


Figure 3.5: Filtering apparatus.

You then heat the filtrate until all the water evaporates leaving the white salt. You must investigate the type of cloth or tissue paper that will give you the best results.

You can also make the jar and funnel for filtration from a discarded 750 ml plastic bottle. Cut the bottle into the parts indicated in *Figure 3.6* and to come up with the parts you can use for the filtering process.

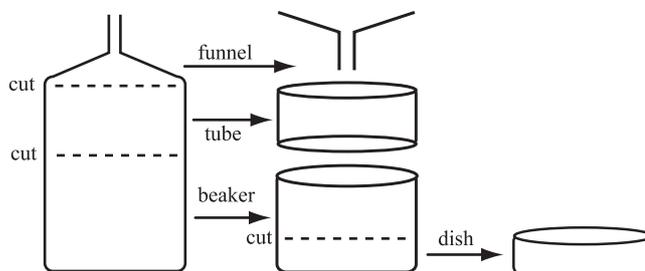


Figure 3.6: Improvised parts from a plastic bottle.

Activity 2: Making a magnifier

Glass hand lenses may not be available to you although nowadays we have relatively cheap ones made of plastic. The idea behind a magnifier is simply that the transparent material is thin at the edges and thick in the middle. Look at *Figure 3.7* for these features.

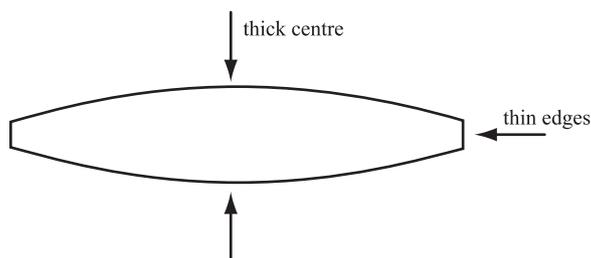


Figure 3.7: Magnifier.

How to make things appear bigger.

First place a pencil behind a clean, clear bottle and state the appearance of the pencil. Does the pencil appear bigger, smaller or the same size? Pour some water in the bottle and look at the pencil through the water. How does the pencil appear this time?

Activity 3: Light bulbs as multipurpose containers

Opening and emptying a light bulb

You can use spent electric bulbs as containers. They should never be heated as they may explode. Always wrap the bulb in a thick cloth for safety when working on it. Rub the base over a rough surface (cement or stone) to weaken the seal. Alternatively, use a pair of pincers to remove the seal. A nail can be used to open and clean out remains of the seal. The filament and rest of contents come out easily. File the opening smooth if needed.

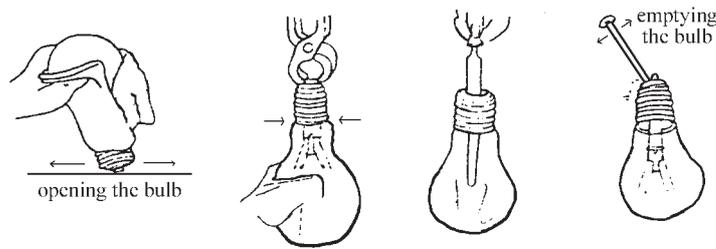


Figure 3.8: Multi-purpose bulb.

In what other ways can you use a bulb?

Try to make a magnifier using a discarded bulb. What happens to the size of the object when you vary the amount of water? What are the advantages of using the discarded bulb over the bottle?

Activity 4: Making a Rain Gauge

What materials would you need to make a rain gauge? Does your list of items compare with the one below?

Materials

- transparent plastic bottle
- scissors or sharp knife
- ruler marked in millimetres
- white paper
- cellotape

Instructions

1. Cut off the top part of the bottle so that you have a funnel and a cylinder. The funnel must have the same rain catching area as the surface area of the container.
2. Measure the height of the collecting container and make a scale in millimetres on a strip of white paper.
3. Cut out the strip of white paper and secure it to the side of the container with cellotape.
4. Place the rain gauge away from buildings and plants at about 1 metre above ground level. Why away from buildings and plants? Why not on the ground? What purpose does the funnel serve?

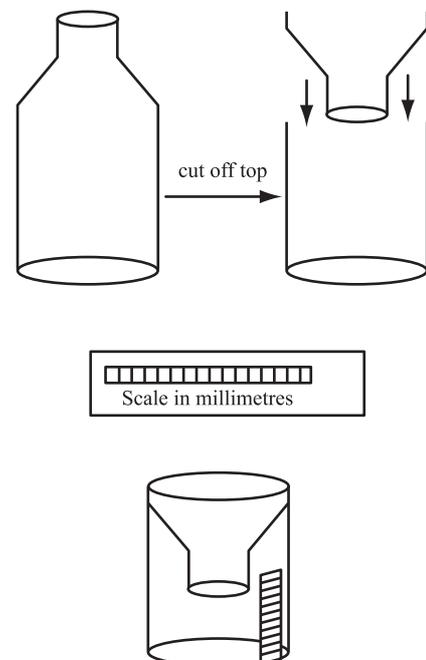


Figure 3.9 Rain gauge

Activity 5: Making a Pin Wheel

Materials

- sheet of paper (20 cm x 20 cm)
- drinking straw
- nail
- stick

Instructions

1. Draw lines on the paper as shown here. Cut the paper along the lines to about 1 cm before the centre point.
2. Fold the paper along the cuts.
3. Make a hole at the centre of the foldings. Enlarge the hole with a nail so that it is big enough for a small section of the drinking straw to fit through.
4. Nail the propeller to a stick through the straw.

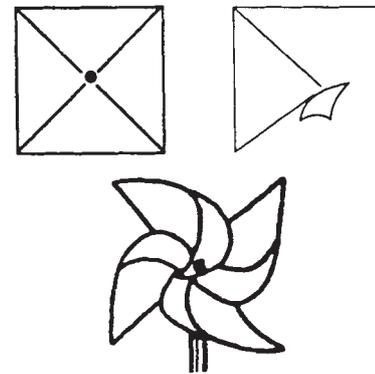


Figure 3.10 Pin Wheel

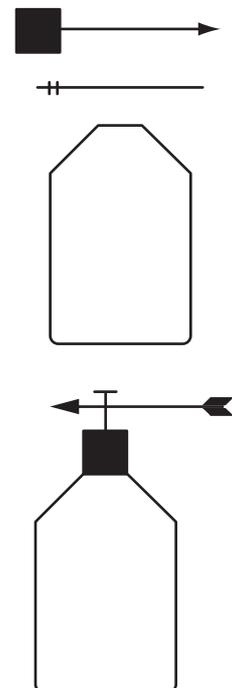
Activity 6: Making a Bottle Wind Vane

Materials

- bottle and cork
- maize stalk
- cardboard
- drinking straw
- nails

Instructions

1. Cut a piece of cardboard to make the tail and a piece to make the pointer. The tail should be bigger than the pointer, but the pointer must be heavier. Fix them at the two ends of the maize stalk.
2. Find the balancing point of the vane. Make a hole through it so that the drinking straw will just fit through it.
3. Write on the sides of the bottle the letters of the cardinal points. Fill the bottle with sand.
4. Fix the vane onto the cork with a nail passing through the drinking straw.



Activity 7: Making a balance

List the materials you would require in making a balance.

After the construction you must test if it works to give the desired results.

Think of other materials you would use to make a balance.



Individual Activity

Refer to your scheme of work.

Identify those topics that will require some teaching aids.

Identify the materials that would be required to make the items and ask your pupils to bring the materials to class.

Make sure all your pupils participate in making some items, with your guidance if necessary. While some pupils may be very good at making items using locally available materials, you may depend on those pupils and deny others the opportunity to make teaching aids from improvised materials.

1. For the grade level you are teaching, write a lesson plan on one of the items that was made in the unit activity. Indicate how the improvised materials will be used, i.e., as a demonstration to the class or by the pupils in a hands-on activity.
2. Show your pupils a diagram of a simple motor and ask them to bring the materials needed for the construction of it. You should have them work in pairs. Design a simple instruction sheet for them to follow. The pupils should test their simple motors to see which ones work and which ones do not.

The pupils should discuss among themselves why some of the motors worked while others did not, and suggest ways to make improvements.



Self-Marking Exercise

Reflect on the improvisation activities that you have done and on your understanding of what is involved in improvisation. Answer the following:

1. Why is it important that precautions be given to the users of improvised materials?
2. State the disadvantages of the teacher/pupil getting over-involved in the making of teaching aids.



Summary

You should view improvisation as a teaching strategy to employ in the classroom. The idea is to put the pupils in a situation where they should think of alternatives when a particular item is not available. The replacement item should be locally available but carefully selected so it gives the same results as an original item.

As an improviser you should learn to appreciate the potential of any discarded materials in the local environment.

With the help of a syllabus you should be able to identify teaching aids and the variety of materials that can be used to make the improvised apparatus. If you live in the Kalahari Desert your improvised items will be different from those who live in a place where there is plenty of bamboo grass.

Making and knowing how to use improvised apparatus is very important for you as a teacher. After you have made the item, you will be able to demonstrate and explain it to your pupils.

Please note that improvised materials have their limitations and, if ignored, can have disastrous effects. Pupils could then shun improvised materials and look on them as inferior and unworkable. You should first experience improvisation yourself and store suitable items for future use.



Reflection

The unit has not covered everything on improvisation. The ideas presented are something for you to think about and to reflect on when making improvements to an item you need to improvise. By trying out different materials, you will eventually find the most suitable material to use.

Through professional teachers' group meetings, you can volunteer to make an improvised item and can demonstrate it to your peer group before it is tried out in the real classroom situation.



Unit Assignment

1. Write a lesson plan on how to use a simple electric circuit. The lesson should be activity based in the sense that the pupils will do the activity. List the items you will require in the construction of simple circuit boards.
2. Take a walk round the school grounds and identify as many of the discarded materials as possible. For each item, list as many uses as possible and complete the table below.

Item	Diagram	Uses (how and on what topic)

Unit 4: Materials and Their Uses



Introduction

In this unit, we will focus on two materials that have proven to be useful in our daily life. These materials are copper and iron. We will discuss how these materials are extracted from ores. We will then examine the properties of these materials and how the properties relate to their uses—with specific reference to copper as an electrical conductor and to iron as a magnet.

Even though we still use copper in the area of communications, the copper telephone cables are being replaced by fibre optics, products of glass which are more efficient and less expensive.

NOTE: The level of content in this unit may not be appropriate for pupils and is intended only for you, the teacher.



Objectives

Using the local environment as a resource for teaching and learning, you should be able to:

- describe how copper and iron are extracted from their ores
- describe the properties of these materials
- discuss the uses of these materials with reference to:
 - (i) Electricity
 - (ii) Magnetism
- demonstrate how practical work can be used as a teaching strategy on any topic
- demonstrate an investigative approach involving predictions and testing the predictions



Materials and their Uses: Copper and Iron

Mining is a major contributor to the economies of our countries. There are a variety of minerals in the sub-region but for the purpose of this unit we will focus on copper and iron because of the common usage of these materials in our daily lives.

Copper Production

Two methods are commonly used to mine the copper ores azurite and malachite. These are shaft (deep or sub-surface) mining and open cast mining.

Shaft or Deep mining

Read the following account to familiarise yourself with the mining of copper ore.

Shaft mining involves sinking a shaft deep in the ground with tunnels opening out at the levels where the mineral-bearing rocks are found. The rock

containing the copper ore is blasted by using explosives and taken to the surface where the copper is extracted from the ore. *Figure 4.1* shows the features of a mine shaft and tunnels.

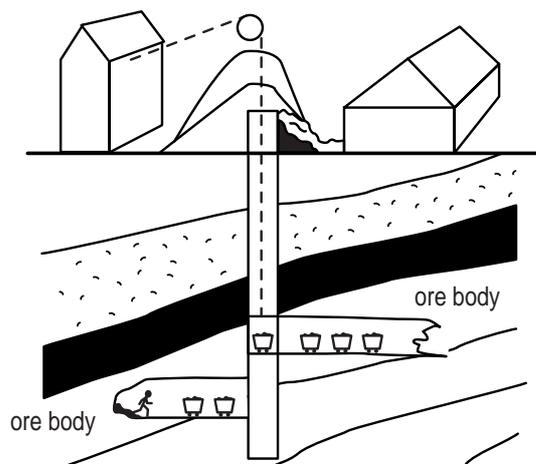


Figure 4.1: Mine shaft showing the tunnels.

Open cast mining

How do you think this method operates? We sometimes refer to this type of mining as open pit mining because the copper ore is usually on the earth's surface. The ground in the area where the ore is located is blasted and then the blasted material is excavated and taken to a refinery where the metal is extracted.

Extraction process

There are a number of stages involved in the extraction process. Let us discuss these stages.

Crushing

At this stage, the ore is crushed between metal steel balls into a fine powder.

Flotation

Here the powder mineral is mixed with oily water and air is blown into the mixture with continuous stirring. In this way the copper sticks to the bubbles and floats onto the surface while the other unwanted materials sink to the bottom. We call the floating copper a **concentrate**.

Smelting

The sulfur in the concentrate is burned off with oxygen, leaving relatively impure anode copper.

Electrolysis

The anode copper is placed in an acid vat, and electricity is passed through it, resulting in pure copper being deposited on the cathode plate.

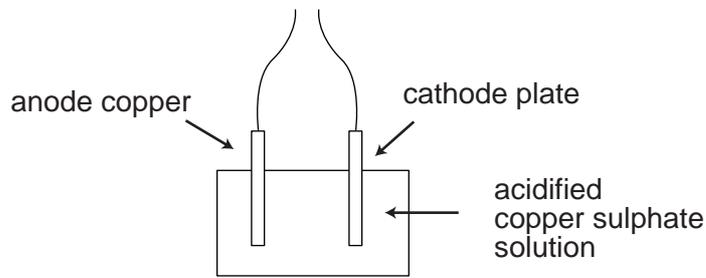
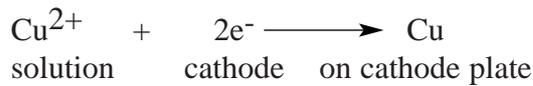


Figure 4.2: An electrolytic cell.

In solution we have copper ions and hydrogen as positive ions. On the cathode plate we have the electrons. So the copper ions get to the cathode plate to get electrons and in the process the copper is deposited.



Sometimes the copper plates, also known as copper sheets, can be exported at this stage.

Smelter

The cathode plates on which the copper has been deposited are taken into the smelter where they are smelted and made into copper bars that are ready for export. Copper is exported to industries that specialise in copper products such as electrical wires.

The processes described above are illustrated in *Figure 4.3*.

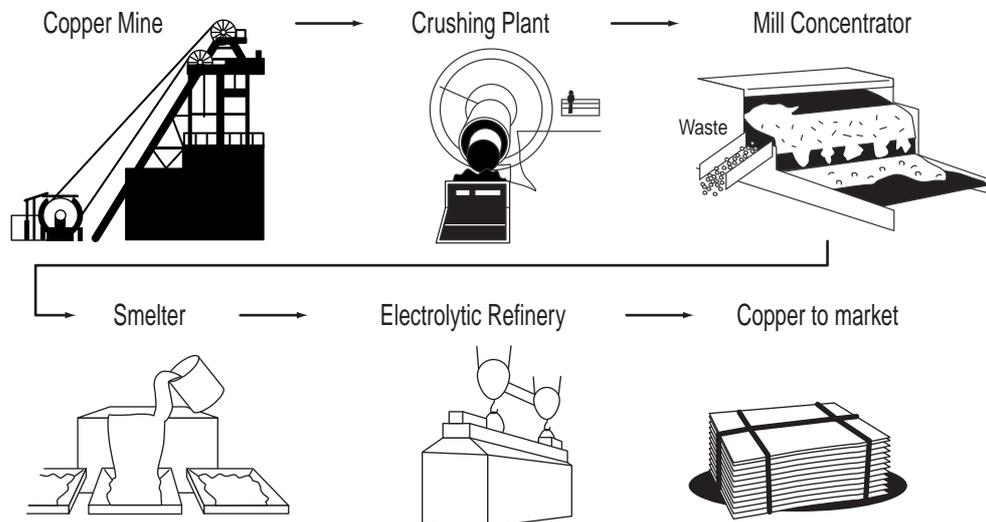


Figure 4.3: Production of copper ore to metal.

Properties of Copper

Copper metal has a number of properties that make it useful to us. You will now investigate some of these properties.

Collect the following items:

- piece of copper
- plasticine
- glass
- clay pot
- wood
- plastic

Using a hammer hit each of the objects.



Precaution—Be careful how you hammer, especially when hitting the glass or clay, because it may shatter and you might hurt yourself. Observe and describe what happens when you hit each material. Record your results in a table similar to the one below.

Material	Action Taken	Observation
Copper	Hammering	
Plasticine	Hammering	
Glass	Hammering	
Clay pot	Hammering	
Wood	Hammering	
Plastic	Hammering	

Subject the same materials to:

- fire
- hitting
- scratching

Can you think of other properties of copper? Copper is non-magnetic and has a high melting point.

Uses

Can you identify some of the uses of copper from its properties? Since copper does not wear away easily, we use it widely in the manufacture of parts for equipment and machines, e.g., automobiles, aircraft, ships, computers, boilers, radiators, refrigerators, electromagnets, and electrical conducting wires. We also use it to make decorative ornaments. Copper is well known as a good conductor of electricity and hence its wide use in electrical appliances.

Copper is a good conductor of heat and we use it to make saucepans. It is perhaps the best low cost conductor of electricity and we can draw it out into wires for electrical cables. Since copper resists corrosion, so we use it to make pipes for domestic water supply. One of the most important properties of copper is that it blends with other metals such as zinc, tin, nickel, aluminium, lead, and manganese to form a wide range of useful alloys that are stronger

than pure copper. Can you list some of these alloys? Some examples you may have thought of are presented in the table below.

Alloy	Mixture	Use
Brass	Copper & Zinc	Machine parts
Bronze	Copper & Tin	Statues and bells, instrument casings for ships
Nickel	Copper & Nickel	Cutlery, silver coloured coins

Copper chemicals

Copper can be combined with other elements to form a number of useful chemicals. One of the most familiar of these is copper (II) sulphate, which has bright blue crystals and is used to make pigments, electrolytes in batteries, and wood preservatives. Its most important role, however, is in agriculture where it acts as a pesticide and fungicide. We also add it to the soil and to animal feeds in order to provide grazing animals with the tiny amounts of copper they need for good health.

Other agriculture chemicals include copper (I) oxide (which is used as a fungicide) and a copper-arsenic compound known as Paris green (which acts as an insecticide and wood preservative).

We use a number of copper compounds as pigments. Copper (I) oxide is a red pigment used in the manufacture of antifouling paint, coloured glass, glazes on porcelain and ceramic materials. We can use both copper (II) oxide and copper (II) carbonate to make blue and green pigments. In addition, yellow and brown pigments can be made with copper (II) chloride. You can make a deep blue pigment by adding ammonia to a solution of copper (II) sulphate. This contains a complex cuprammonium compound which dissolves the cellulose in cotton and can be used to make rayon. Copper compounds have a range of important industrial applications.

For example, we use copper chloride as a catalyst in the production of both acrylonitrile (synthetic fibre) and chloroprene (a synthetic rubber) from acetylene. Copper (I) sulphide is a vital component in luminous paints, solar cells and solid lubricating materials, while copper (II) oxide serves to remove sulphur from petroleum.

Iron

The main sources of iron ore are:

- haematite
- magnetite
- pyrite

Extraction process

Remember—the information we are discussing is meant for you and not your pupils.

The metal ore is crushed and smelted in a blast furnace. In the blast furnace, the metal ore is mixed with coke and limestone. Hot air is blasted into the mixture.

The hot air reacts with the coke resulting in the formation of carbon monoxide. The carbon monoxide reduces the iron ore which is an oxide (haematite is iron (III) oxide) to iron metal.

There are a number of stages involved before one gets pure iron. The iron ore will give rise to the impure pig iron which on further processing gives iron.

During the smelting, the limestone is converted to calcium oxide which reacts with silicon dioxide impurities to give rise to calcium silicate. The slag, which is made up of calcium silicates and other impurities, floats on the surface and in this way can be separated from the iron. See the diagram of the blast furnace below.

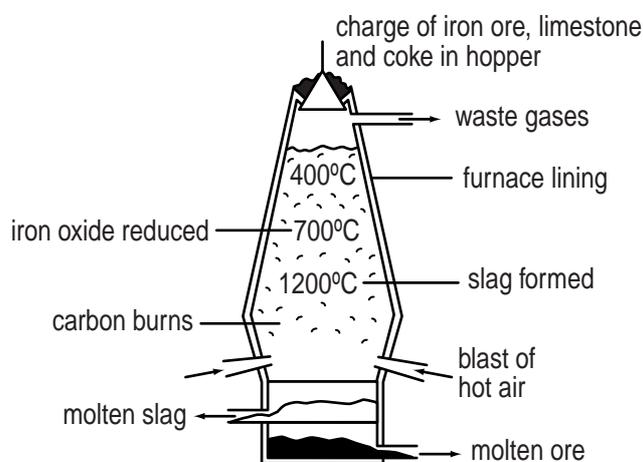


Figure 4.4: The blast furnace.

Properties of Iron

Properties of iron are quite basic and you should remember them easily. Iron is a metal with a high melting point. It is malleable, ductile, lustrous, conducts heat and is magnetic. To make iron stronger and more durable, we make it into steel. Can you identify other components of steel other than iron?

Uses of iron

Like copper we use iron widely in the manufacture of parts of equipment and machines, e.g., automobile parts, aircraft parts, ships, roofing materials, and water pipes. We also use it to make magnets.

Application of Copper—Electricity

As we know, copper is widely used as a conductor in the electrical circuits of appliances. An electrical circuit comprises a power source such as dry cells, connecting wires made of copper, and a load in which there are energy changes.

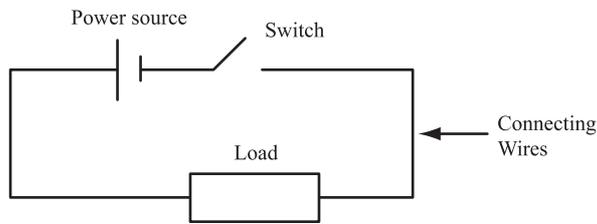


Figure 4.5: Simple circuit diagram.

When you complete a circuit, you create a pathway for the electrons to flow along, and in the process they dissipate their energy. When you break or open the circuit, it will be incomplete and the flow of electrons will stop.

Diagrams 4.6 (a) and (b) both represent a circuit.

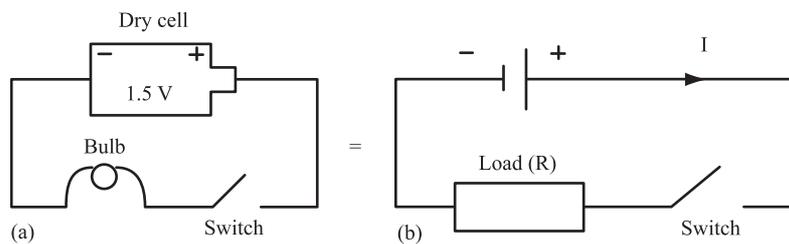


Figure 4.6: Circuit diagram presentations.

Having stated the components of an electric circuit, it is important that we explain the idea of electricity and how the components function.

Electricity is a form of energy associated with flow of charge in a conductor, in this case electron flow. The electron flow in a conductor would constitute current (I).

We call the bulb a load of high resistance. Resistance facilitates energy changes in a particular component which we call the load in a circuit. The load may be of high resistance or low resistance. By high resistance we mean there is no easy passage for the electrons and low resistance means there is an easy passage for the electrons.

In all circuits, the load is a component where the electrons dissipate their energy, resulting in energy transformations. The bulb lights because the electric energy is converted to heat energy and then finally to light energy, that is, electric energy produces first a heating effect and then a lighting effect. Our power source is the dry cell that has stored electric energy. The electrons in a conductor derive their energy from a driving force called the electromotive force of the cell (V).

Application of Iron—Magnetism

A special type of rock known as lodestone exhibits magnetic properties. The lodestone attracts magnetic materials but not non-magnetic materials. Examples of non-magnetic materials include copper, rubber, glass, and wood. Magnetic materials contain iron.

Making a magnet

You can make a steel bar magnet by using these methods:

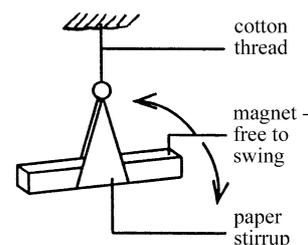
- stroking method
- induction method
- electromagnetic method

If we use steel, we will produce a permanent magnet but if we use iron (soft iron) we will produce a temporary magnet.

Investigating properties of a magnet

You will need string and a bar magnet.

1. Suspend a magnet on a string as shown in the diagram.
2. Let the magnet swing until it comes to a stop.



In what direction, North, South, East, West, do the ends point?

Note—ensure that there are no magnetic materials nearby when performing this experiment.

Bring another bar magnet close to one end of the suspended magnet. What happens?

Now bring the other end of the magnet to the suspended magnet. What happens?

In both cases describe what takes place.

To examine further properties of a magnet, you must do these following activities yourself. You will need:

- 2 bar magnets
 - cardboard
 - white paper A4
 - iron filings
1. Place a bar magnet on a flat surface, cover it with cardboard and place a white sheet of paper on top. Sprinkle the iron filings while tapping the cardboard lightly. Observe and draw what you see with the iron filings.
 2. Place the two magnets end to end. Repeat as in 1. Observe and draw.
 3. Place the two magnets end to end with one bar magnet turned around. Repeat as in 1. Observe and draw.

Science Investigations

We conduct scientific investigations in order to make predictions and test them. Testing predictions is possible through carefully designed experiments. Doing experiments and making observations to test the predictions is a practical activity that gives your pupils a hands-on experience. A practical activity is an activity in which the pupils take an active part as they interact

through manipulation with the materials. To make the practical work more meaningful, you should use materials that are locally available.

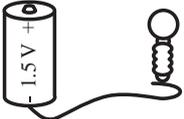
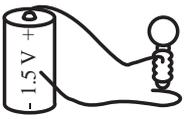
Testing the predictions

You are presented with a worksheet. The advantage of individualised activity is that the pupil actually interacts with the materials while group work allows for a discussion among the peer group members as various views are later tested.

Worksheet 1 - Which bulb will light?

Carefully study each of the following diagrams. In each case, do you think the bulb will light up? Enter your answer in the prediction column. This may involve a discussion if you are working in a group.

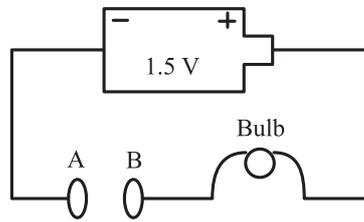
To test your predictions, make the connections as shown in each diagram.

Type of Connection	Prediction	Testing the Prediction
		
		
		
		

Worksheet 2 - Conductors and non conductors

Which material will light the bulb? Collect as many materials as possible, such as bottle tops, glass, iron nails, plastic, wood splints.

For the following circuit diagram, use the worksheet below.



Study the circuit diagram and predict what will happen to the bulb if you place one of the objects you have collected from your local area between A and B. Make and discuss the prediction before testing.

Type of Item	Prediction – Will the bulb light?	Testing the Prediction – Did the bulb light?

Note—Lighting the bulb is an indication that the object/item conducts electricity.

Materials that conduct electricity (those that will light the bulb) are conductors while those that do not conduct (those that will not light the bulb) are non-conductors or insulators.

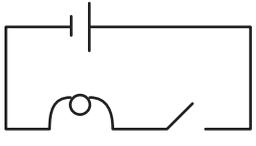
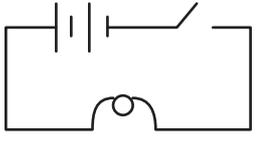
Worksheet 3

You will need:

- 2 dry cells (2 x 1.5 volts)
- connecting wires
- 2 torch bulbs

Connect only one cell and note the brightness of the bulb. Connect both cells and note the brightness of the bulb.

Before you do this activity you must think about what will happen to the brightness of the bulb when you connect only one cell and when you connect two cells. Compare the predictions with the actual results of the activity as a way of testing the predictions.

Diagram	Prediction (Brightness)	Test the prediction (Brightness)
a) 		
b) 		



Individual Activity

- Read the information on iron extraction and its uses and prepare a worksheet for your pupils. They must use it to predict which materials will be attracted to a magnet and to test their predictions.
- Study the topics in the syllabus and identify the topics that will require hands-on experience through group work or individualised activity by first making a prediction and then testing the prediction.



Self-Marking Exercise

1. In the extraction of copper, why is acid added to the concentrate in the electrolytic tank during the electrolysis process?
2. Why does an iron bar at room temperature feel cooler when touched by hand?
3. State the energy changes that take place from the time the switch is closed and to when the bulb lights.
4. Both copper and iron have the same properties of malleability and ductility. What do you understand by the terms malleable and ductile?
5. State an advantage and a disadvantage of pupils predicting and testing.
6. What are the advantages of group work as opposed to individualised work?
7. Why would you need to predict before testing?

Check your answers at the end of the Module.



Summary

In this unit an attempt has been made to give you some information on the materials that we consider important as they contribute significantly to the economy of a country.

It is important that you know the processes involved in the extraction of copper and iron and appreciate their sources and other raw materials used in their extraction. As users of the products of these materials we need to know how they are produced.

We should know the chemistry and physics of these materials so we can appreciate why they are used for specific purposes. The applications are for specific purposes and are derived from the properties of the materials.

Since experience is the best teacher, an activity-based experience enables you to acquire the skills as well. That is why we discussed and asked you to apply practical work to your teaching by applying what you have learned from investigations through predictions.

Now that you have acquired knowledge and teaching skills using practical work based on group work or individualised learning, the final stage is to put this into practice in the real classroom situation. The emphasis here is on the use of the local environment. That is the reason you must teach about those substances that the children are familiar with. Even if the two metals are not mined in your country, you should be familiar with products commonly made from copper and iron.



Reflection

The target is you, the upper primary school teacher, whether you are trained or not. We have made some assumptions regarding your knowledge of the subject matter. What is being presented is information that will be useful, especially at the grade level you are teaching.

It would be a good idea if your school formed a teacher's group where professional issues related to classroom practice can be discussed. In such a teachers' group, you would discuss lesson presentations through peer teaching before putting into practice what you would teach in the real classroom situation. We call this the Experience Reflection Observation Trial and Integration (EROTI) model of learning.



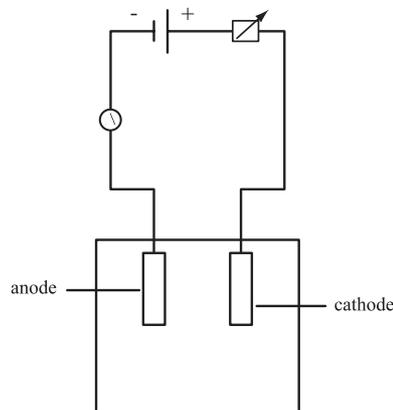
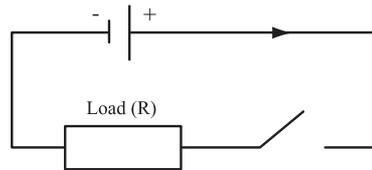
Unit Assignment

1. Which property of copper is responsible for the metal being made into wires?
2. Describe the reaction that takes place at the cathode plate in the copper electrolytic tank and write the chemical equation for the reaction at the cathode plate.
3. Write down word equations for the reactions that take place in the blast furnace.
4. Briefly describe the function of each of the following components in an electric circuit.
 - battery
 - switch
 - load
 - connecting wires
5. Draw diagrams to illustrate the following ways to make a magnet:
 - a) stroking
 - b) electromagnetism



Module Test

1. Write word equations for the following reactions that take place in a blast furnace:
 - coke combining with hot air
 - iron ore being acted on by coke
 - limestone being decomposed
 - formation of slag
2. Study the circuits below. Which one is used in the electrolytic refining of copper?



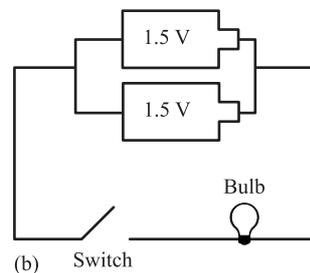
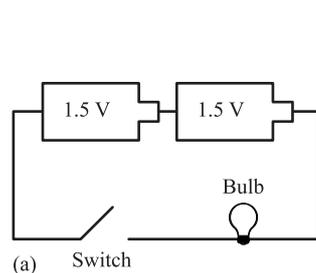
What is a cathode?

Name the material it is made of.

Name the electrolyte.

Describe the reactions at the anode, cathode.

3. Study the two circuit arrangements and answer the questions below.



In which of (a) or (b) will the bulb light brighter? And why?

Which of (a) or (b) will light the longest and why?

What is the advantage of one over the other in terms of electrical energy consumption?

State the energy changes that take place in the bulb when the circuit is switched on.

4. A worker uses a 1.5 m log as a crowbar to move a rock weighing 500 newtons. If the pivot is 0.25 m from the end of the log touching the rock, how much effort must the worker apply? Draw a diagram to represent the above.
5. Draw diagrams showing the magnetic fields around:
 - a single bar magnet
 - two magnets with their unlike poles close together
 - two magnets with their S-poles close together

Suggested Answers to Activities



Unit 1

Possible Answers to Self-Marking Exercise

- (a) Most often, research/project work involves practical work that leads to the scientific processes of observation, problem identification, and coming up with a tentative solution that would lead to designing an experiment where data would be collected, analysed, and conclusions made.
- (b) The report should contain:
- name of the researcher(s)
 - research/project title
 - difficulties and acknowledgements
 - aim
 - list of apparatus used
 - method
 - data presentation
 - discussion and conclusion

Possible Answers to Unit Assignment

1. Lesson Plan

Lesson: Methods of fish preservation/vegetable preservation.

Lesson objectives: The pupils should be able to:

- (a) state the different methods they know
- (b) describe the methods stated
- (c) research the most common methods used

Teaching aids that could be used are the local environment, books, magazines.

Lesson development

Provide clear instructions of what you want the pupils to do:

- (a) conduct research
- (b) state the things to be done in research
- (c) methodology
- (d) observations
- (e) data collection and analysis

Lesson Evaluation

- (a) my performance
- (b) pupils learning

2.

Worksheet: Fish/Vegetable Preservation	
You must work in pairs.	
Write your names: 1. _____ 2. _____	
Give a short description of the method and draw diagrams or cut out pictures of the preserved food from old magazines.	
Method	Diagram/Picture
Sun Drying	
Smoking	
Salting	



Unit 2

Possible Answer to Individual Activity: Investigating the efficiency of a hoe

In arriving at a possible solution you should consider the following steps:

- problem – what it is you are investigating
- background information or literature review, i.e., how much you know about the local technology and/or item.
- planning the experiment

How you intend to go about doing the research.

- experiment
- method
- apparatus
- measurements and observations made

How you will present the data.

- tables
- graphs

Discussion of results from data and conclusions.

- What problems were encountered?
- Has the problem been solved? If not, what needs to be done?

This is the procedure scientists follow when looking for solutions to problems. If you found this activity valuable, you should be thinking of how you can impart these skills to your pupils, i.e., getting pupils to perform their science activities like scientists. You can ask them to carry out the same investigation as you just did or choose any other example of simple machines in your environment.

Possible Answers to Self-Marking Exercise

1. They enjoyed them because:
 - They were successful.
 - They completed the exercise.
 - They were interested and actively involved.
 - They were able to work at their own pace.

They did not enjoy them because:

- They failed to design a solution.
- They did not complete the activities.
- The tasks were too difficult.

2. You enjoyed them because:
 - Pupils were able to find information for themselves.
 - You had more time to assist pupils.
 - The activities were successful.
 - Pupils enjoyed them.

You did not enjoy them because:

- They were time consuming.
- There was too much preparation.
- The activities were unsuccessful.
- You found it difficult to control the class.

Possible Answers to Unit Assignment

1. **Local technology** is the technology that exists within a certain local community.

Appropriate technology is a suitable technology, either local or adapted from elsewhere, that achieves the desired results.

Indigenous technology is local technology that has been used for a long period of time.

Relevant technology adapts to our way of life. For example, a computer might be considered relevant technology in an urban setting, but it is not practical in a community that does not have a reliable power supply.

2. The list is endless depending on the community you identify yourself with.



Unit 3

Possible Answers to Self-Marking Exercise

1. If the procedure is not followed and precautions ignored, the teaching aid might not serve the purpose for which it is made. Precautions must also be observed for the safety of the pupils.
2. The teacher might spend too much time making improvised teaching aids, which might affect other aspects of teaching, such as lesson planning, marking of homework, etc. The pupil, likewise, may spend too much time on improvised aids and ignore other lessons, homework, etc.

Possible Answers to Unit Assignment

1. Lesson: Simple electric circuit

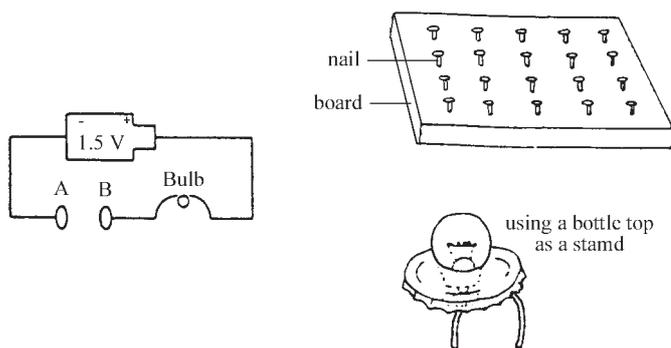
Lesson objectives. The pupils should be able to:

- a) use the given materials to construct a simple circuit
- b) identify the components of a simple circuit
- c) use the circuit to test conductivity of some materials

Materials needed:

- 1/2 inch nails
- Iron nail
- Board
- Plastic pen
- Switch
- Paper
- Bottle top as bulb holder
- Glass
- Telephone wires
- Copper wire
- Torch light bulb
- Piece of dry wood
- 1.5 V dry cell

Using the circuit board, connect the wires as shown below:



Lesson introduction:

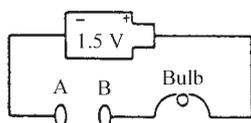
Ask the pupils to identify the parts and what they are used for.

Lesson development:

Use a work card

Pupils to work in groups

Work Card: Simple Circuit



Which of the following given materials will light/not light the bulb?

Draw the table and complete it.

Item	Will light the bulb (put a tick (✓) for lighting and an (✗) for not lighting).



Unit 4

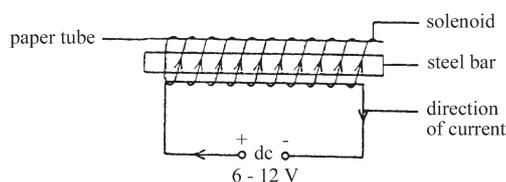
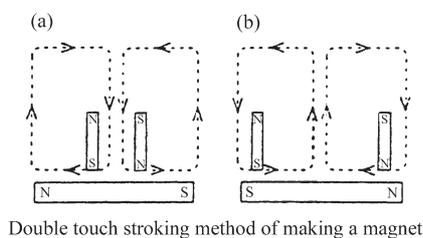
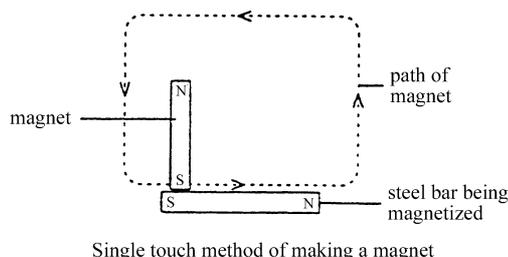
Possible Answers to Self-Marking Exercise

1. The acid is added to the concentrate so as to enable the electricity to pass through to decompose the substances in the electrolytic tank. What is actually happening is that in the electrolytic tank the acid helps to ionise the substances in the concentrate. Cu^{2+} , H^+ , OH^- are present in solution. Copper ions move along the cathode plate to receive electrons and Cu^{2+} and $2\text{e}^- \rightarrow \text{Cu}$ is deposited.
2. Because the iron bar quickly conducts heat away from the hand.
3. Electrical, Heat, Light
4. Malleable—able to be spread into sheets. Ductile—able to be stretched into wires.
5. Advantages—relate activity to their previous knowledge.
Disadvantages—may influence their observations.

6. Advantages of group work:
 - Discussion and mutual respect for each other's opinions.
 - The limited resources are well distributed.
 - Pupils learn from fellow pupils.
7. Predicting gives the teacher an insight into the pupils' thinking—whether they are “tracking” the teacher's line of thought.

Possible Answers to Unit Assignment

1. Ductility.
2. At the copper cathode there are electrons.
Copper ions ($\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$)
Solution Cathode plate deposit
3. Hot air passed over coke
 - i. Oxygen + Coke Carbon dioxide + heat
 - ii. Carbon dioxide + Coke Carbon monoxide
 - iii. Iron (III) oxide + Carbon monoxide Iron + Carbon dioxide haematite (quicklime).
 - iv. Limestone Calcium oxide + Carbon dioxide
 - v. quicklime + silica calcium silicate
4. Battery—power source
Switch—an electric component that will allow/not allow electricity to flow.
Load—a component that converts electricity to some other forms of energy in a circuit.
5. Diagrams to answer question 5



Glossary



Anode:	positive pole (electrode) of an electrolytic system.
Cathode:	negative pole (electrode) of an electrolytic system.
Conductivity:	the property of a substance to conduct (carry) heat or electricity.
Corrosive:	destructive effect due to chemical action.
Decant:	pour out gently without disturbing the sediment.
Ductile:	capable of being drawn out into wires without fracturing.
Electromotive force (emf):	the voltage of a power source.
Fabric:	cloth
Filtrate:	liquid/solution that passes through a filter.
Indigenous:	native
Induction:	production of an electric or magnetic state in an object by bring an electrified or magnetic object close to but not touching it.
Ions:	charged particles usually in solution/molten form.
Lustre:	to glow or to shine.
Malleable:	capable of being extended or shaped by beating with a hammer, or by the pressure of rollers.
Metal ore:	rock that contains metal.
Preserve:	keep from decay/to treat the food so that it can be kept for future use.
Research:	a study or an investigation that leads to new facts or information.
Residue:	a substance which is left over or does not pass through a filter.
Resistance:	a measure of a component's opposition to the flow of an electric charge, usually expressed as a ratio of the potential difference across an electric component to the current passing through it.

Slag:	liquid material which is an impurity produced during the smelting or refining of metals.
Sonorous:	material(s) which can produce sound.
Teaching aid:	an aid to teaching/learning.
Technology:	study of applied sciences.

References

- Archenhold, W. et.al., *School Science Laboratories*, 1978, John Murray London.
- Byers, Andy et.al., *The Science Teachers' Handbook*, 1994, Heinemann Educational Publishers Oxford.
- Harris, O.F. et.al., *Chemistry*, Longman, 1991, London.
- Hodson, D., *Redefining and reorienting practical work in School Science Review* 1992 Vol. 73 No. 264.
- Ministry of Education, *AIEMS Module 6 Draft*, 1994, Lusaka.
- Naidoo M.R. et.al., 3rd Edition, *A Secondary Geography of Zambia*, 1996, Longman, Zambia.
- Sheffield City Polytechnic, *Active Teaching and Learning Approaches in Science*, 1992.
- Sherrington, R. *ASE Science Teacher's Handbook*.
- Solomon, J., *Exploring the Nature of Science: Key Stage 3*, 1991, Blackie, London.
- UNESCO, *New UNESCO Source Book for Science Teaching*, 1973, United Nations, Paris.
- Ward (1993). *Magnets and Electricity: A practical introduction with cheaply produced kit of materials* in *School Science Review*, Vol. 74 (268) March 1993.
- Yandila, CDR., *Science Teaching in Botswana*.