Module 1

Junior Secondary Science

Energy and Energy Transfer

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**
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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*
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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

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Introduction

Welcome to the programme in Teaching Junior Secondary 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 energy and energy transfer; the use of energy in electronic communication; the needs of living organisms and their environmental resources; and the study of scientific processes. The topics on energy and the environment will focus on learning, through the scientific inquiry method, ways to achieve a sustainable environment
- 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 related to energy and to support students in their problem solving activities
- guide students in the use of investigative strategies to learn more about particular technologies, and to find out how tools and materials are used in science
- 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 as examples for application of 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 provides for 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 of doing 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 2 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 3 and 4 weeks to complete. If you have four hours a week for study, then each unit will take about 2 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 of 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 some of the 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:

- exploring and investigating sources and types of energy used in your local environment
- investigting local efforts to diversify energy sources and efficient uses of energy
- magazines that have articles about sciences and the topic of energy
- books and other resources about science (energy) that are in your school or community library
- use of the Internet as a source of information (if applicable)

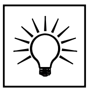
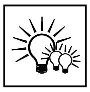
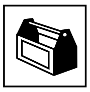
Tips for selecting resources
Working with locally available resources may require selecting those that are most appropriate from among materials that may not be complete or relevant. When reviewing materials to see if they will help you with the module, consider:

- 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 students.
	**Reflection**	A question or project for yourself— for deeper understanding of this concept, or of your use of it when teaching.
	**Summary**	
	**Unit or Module Assignment**	Exercise to assess your understanding of all the unit or module topics.
	**Suggested Answers to Activities**	List or description of tools or apparatus required for this activity.
	**Equipment**	Suggested hours to allow for completing a unit or any learning task.
	**Glossary**	Definitions of terms used in this module.

CONTENTS

Module 1: Energy and Energy Transfer

Module 1
Energy and Energy Transfer

Module 1 Overview

This module contains support material and is not intended to cover the entire range of information on energy and energy transfer.

This module is designed to help you improve your questioning skills, and you are encouraged to take what you learn from this module and apply it to new situations. This will increase your confidence in the use of questioning. However, we are not suggesting this is the only way to teach energy.

The module has four units:

Unit 1: Energy Sources

Unit 2: Energy Transfer and Uses

Unit 3: Using Energy from the Environment

Unit 4: Energy Conservation

Module Objectives

The module aims to equip you with skills in using the questioning technique, research questionnaires, field trips, and the ability to assess your pupils as they carry out practical assignments. It is hoped that in the process of acquiring these skills you will also increase your knowledge in uses and conservation of energy and learn to design and use learning activities based on practical work and meaningful dialogue among the pupils.

Learning Outcomes

- Demonstrate skills in the use of the questioning technique, designing simple research, and the use of field trips to teach pupils about energy.
- Identify the different ways we use energy from the environment and how energy can be conserved.
- Explain to pupils the energy conversions that occur as energy is used and changed from one form to another.

Unit 1: Energy Sources

Introduction

The activities in this unit demonstrate how the skill of questioning can be successfully used to direct pupils to carry out simple investigations, obtain information, and to analyse the information they gather.

The activities in this unit have been designed to be carried out in schools with limited resources. Directions are given for simple activities that pupils at the junior secondary level can carry out with little assistance. Group work is strongly recommended as it promotes pupil-pupil interaction.

During the activities, pupils should be urged to record their findings and to draw conclusions based on their observations. By doing this, pupils will acquire an understanding of the topics being studied.

Objectives

It is hoped that the activities in this unit will equip you, the teacher, with the skills of questioning and investigating, so you can teach your pupils to:

- identify sources of energy
- classify ideas about energy
- study the properties of a given type of energy

Once you have mastered these skills, you should be able to apply them to teaching new subject matter.

Content

This unit involves an investigation of the sources and forms of energy, but its main focus is on the use of questioning skills. The skills you learn in this section can be applied to all the units of this module.

Introduction to the Use of Questioning

"A timely, well-phrased question can capture students' attention, arouse their curiosity, focus upon important points, or even occupy a student's thoughts after class has ended."

– Goodwin and Dalgaard (see Appendix)

Learning science begins when one starts to ask quality questions. A good question is one that reveals new information and teaches the pupil to ask searching questions in order to understand the new material they are learning.

People in different occupations use questions for a variety of reasons. A detective asks searching questions to solve a mystery. Lawyers use questions to help them prove their point and win a case in court. A judge asks questions that will help weigh the evidence and make a sound judgement. There is, however, no other profession where one asks as many questions as the teacher does.

Teachers use thousands of questions in their professional careers, and it is important for them learn to ask quality questions that will direct pupils to learn new information. Questioning is a useful and complex skill. One way to understand the skill of questioning is to categorise the questions used by teachers.

Types of Questions

The next time you teach a lesson to your junior secondary science class, consciously note the types of questions you use. After the class, analyse the lesson you planned. Did you ask questions that encouraged your pupils to:

- analyse, synthesise, and evaluate new information?
- understand and recall the information?
- use the information to solve a new problem?

These categories of questions can be classified as lower order and higher order questions. Lower order questions include recall and understanding while higher order questions pertain to application, analysis, synthesis, and evaluation.

Examples of lower order questions

- What is the colour of litmus paper in an acid?
- What is the unit for measuring current?

Example of higher order questions

- Explain why a cyclist is able to balance on a moving bicycle.
- Why are you a woman and not a man? (or vice versa depending on gender)

Questions may also be classified as **open-ended** or **closed** questions. Usually closed questions have only one correct answer while open-ended questions have a number of possible answers. An assessment of responses to open-ended questions reveals the nature of reasoning and the logical development of the answer rather than whether the responses are right or wrong.

- Give two examples of open-ended questions.
- What are other characteristics of open-ended questions?
- Why do teachers ask questions?

The Use of Questioning

Following are a few of the reasons teachers ask questions:

- to encourage pupils to think about and understand ideas, phenomena, procedures, and values
- to examine a pupil’s knowledge, skills, and level of understanding
- to review, recall, or reinforce recently learned information

- as a reminder of earlier procedures
- for classroom management, to stop calling-out by pupils, to direct pupils' attention to teacher or text, to warn of precautions
- to reach the whole class with pupil answers
- to give everyone a chance to answer
- to prompt bright pupils to encourage others
- to draw shy pupils into the discussion
- to encourage pupils to express their feelings and ideas, and to be empathetic

How do these reasons for asking questions compare with the ones you produced?

This array of reasons for asking questions demonstrates that some basic skills are required in order to ask and use questions effectively.

First, a teacher needs to master the skill of asking quality questions. Quality questions are clear and appropriately designed to meet the intended function. Teachers often complain about pupils being unable to answer questions intelligently. It would be interesting to find out if the teacher was capable of giving correct responses to some of the questions he/she will have asked.

When marking pupils' responses, teachers might be startled to discover the question they asked was not as easy as they thought. In this case, it is only honourable to change the marking scheme accordingly. The situation can be worse in the classroom because there is no time to reflect on the type of questions being asked. For this reason, you are advised to write your questions down and reflect on them before using them in the classroom.

Targeting is another skill you have to master before using the questioning technique effectively. Targeting refers to the way you select the pupil who will answer your question. It is concerned with how you distribute questions in your class, and how you match the questions to a target group or individual.

Another skill you have to master is that of asking questions to enhance teacher-pupil dialogue. These types of questions will help you interact with an individual carrying out an investigation or with a group of pupils working together on a task.

Write two questions that will bring about a dialogue between you and your pupils.

Interacting involves asking questions and encouraging pupils to answer. It also involves, among other things:

- making eye contact and cueing students' responses
- using body language and encouraging participation by your proximity
- the manner and tone of voice
- use of prompting

- use of follow-up questions intended to help pupils elaborate and improve the quality of their answers (e.g., Why? Can you elaborate? Do you agree? Can you give an example? Could you summarize Paul's point? etc.)

Interaction is brought about by mastering the skill of asking one question at a time and pausing to give pupils time to reflect on the question before responding. If you are relatively new to the profession, you might need to practice how and when to pause. One way of doing this is to pose a question and slowly count to three. That gives your pupils three seconds to organise their thoughts.

Do you think three seconds is a reasonable time? Try it. Experiment until you find what you think is a suitable time. Remember—the waiting time will depend on many variables. Some of these variables are the pupil's age, ability, the degree of difficulty of the question, and the rapport between teacher and pupil. One recommended way to ask a question in a classroom situation is to remember the **four Ps** in questioning:

- pose a question
- pause for a moment
- pounce on a target pupil
- praise the pupil for making an effort to respond, whether or not they give a plausible response

Pausing can be modified into a *pregnant pause* when trying to encourage a pupil to elaborate on what you feel they know. To persuade pupils to say more without actually telling them to do so, look at them with a face that is not disapproving of what they said, but a face that is not quite accepting of their response. Your expression should show the pupil that you need more, that what they have said is not quite enough. There is a need to practice this skill before using it. Excessive use of this method can be devastating to the pupil and should be used only when appropriate. When this skill is combined with the use of probing questions, it encourages pupils to speak their minds.

Providing feedback is another important skill that is closely associated with effective questioning. The questions you ask have an effect on your pupils. An over-emphasis of the use of correct language can discourage some pupils from responding because they are afraid of using the wrong terminology. To protect a pupil's self-esteem, you must ask questions in an encouraging and supportive way, and respect all attempts to answer questions.

You will not master the skill of questioning by simply reading about it. You will learn more by applying these principles as you deliver the following lessons on energy resources.

If you want to learn more about the use of questioning in the classroom, go to the appendix (at the end of this module) and read the article *"Effective Classroom Questioning"*.

Syllabus

From the list below, indicate which types of energy you are required to teach.

- sound
- heat
- electric
- chemical
- mechanical
- potential
- kinetic
- nuclear

Design a set of activities, similar to those in the previous section, that will guide your pupils to investigate the properties of one of these energy types. Make up a set of questions to accompany the activities.

- Have your pupils carry out the activities and answer the questions. Answering these questions should lead pupils to conclusions which cover requirements in your syllabus.
- Specify the amount of time they should spend on each activity.
- Analyse your pupils' answers. Did your questions bring about the intended conclusions?

Energy Sources and Forms

Before asking your pupils to carry out an investigation about energy, it is important to find out what they already know about this topic. It may be necessary to expand on their knowledge before carrying out the investigations recommended in the activities in this Unit. There are various ways of establishing the starting point for this situation. One way is to ask the following questions:

- What do you know about energy?
- How can you tell energy exists?
- What are the effects of energy?
- In what ways do you experience energy in your life?

If you choose to begin teaching this section in this way, think of more questions to ask your pupils. Your pupils' knowledge provides the foundation on which to build your lessons, and you can use the pupils' answers to guide you in developing a suitable lesson plan.

Another way to determine the starting point of a lesson is to use a mind map, as illustrated in *Figure 1.1*. This activity should involve the whole class and encourage discussion among the pupils. A lot of information can be obtained from a mind map, which can then help you to plan lessons.

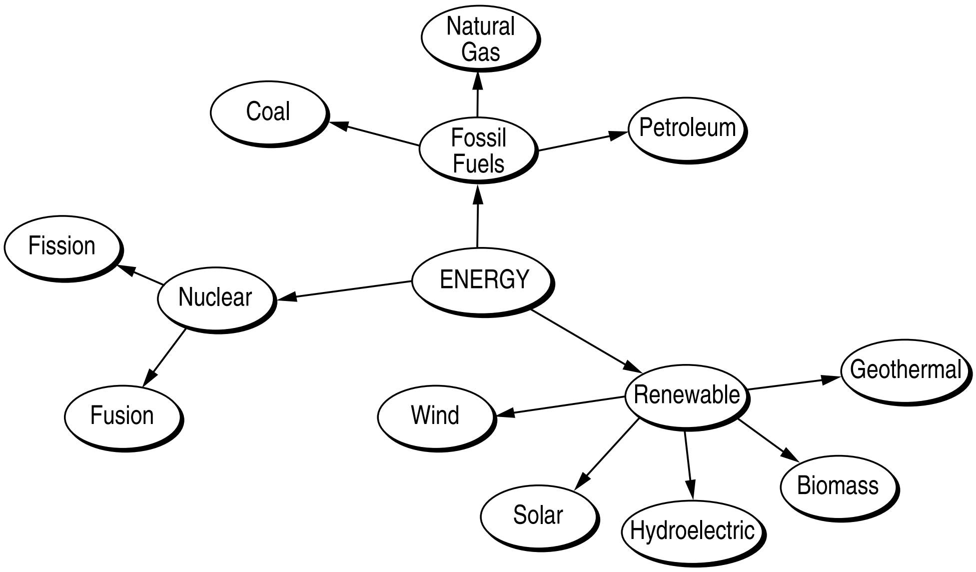
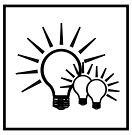


Figure 1.1: A mind map showing various sources of energy.



Classroom Activities

To find out more about energy and its sources, organise your pupils into groups and have them make a chart about energy. Have them start by writing the word energy at the centre of the chart and then write their ideas about **energy** around this. Encourage your pupils to use their textbooks to find more terms and ideas about energy.

Activity One

From the ideas the pupils produce, ask them the following questions:

1. What is energy?
2. Which of their ideas would they classify as
   - forms/types of energy?
   - sources of energy?
   - uses of energy?
3. For each of the sources above, indicate the type of energy produced.
4. In their environment, which sources are they mainly dependent on?
5. Of the sources available, which are renewable and which are non-renewable?

After this activity, bring the groups together to share their findings.

Make sure each pupil has written this work in their exercise book at the end of the discussion.

Activity Two

Give each group of pupils the materials they need to carry out the following activities. From each activity they should be able to identify the type of energy each source produces.

Select several energy sources from the mind map classification and carry out simple activities to demonstrate that they produce energy. Following are a few examples. Encourage your pupils to think of others.

Example 1

Place a few grains of rice or cereal seeds on a small drum. Tap the drum gently to observe what happens. (Remember—to observe is to get information by using our senses.)

1. What did you observe?
2. Which forms of energy does hitting the drum produce?
3. What other activity can produce these forms of energy?

Example 2

Connect a torch bulb to a small battery as shown in *Figure 1.2* below.

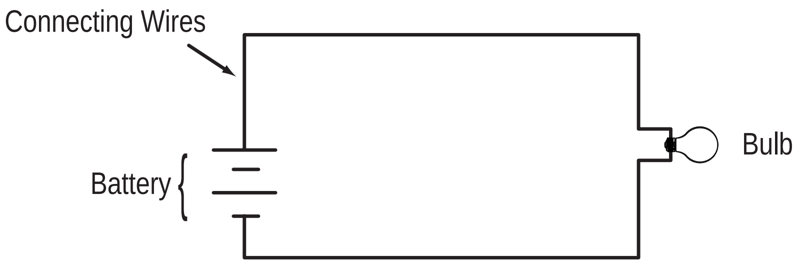


Figure 1.2: Sample circuit (a torch bulb connected to a battery)

1. What do you observe about the bulb?
2. What is the source of this change?
3. How does the bulb feel?
4. What conclusion can you make from this observation?
5. What types of energy are produced in this activity?
6. Indicate the source of each type of energy.

Example 3

Place two spoonfuls of mealie-meal in a metal lid from a wide-mouthed bottle. Heat the lid over a Bunsen burner flame until the mealie-meal lights up. Place a small beaker with enough water to cover the thermometer bulb over the flame of the mealie-meal.

1. Record the initial and final temperatures of the thermometer.
2. What is the temperature difference?
3. What conclusion can you make about mealie-meal from this activity?
4. What types of energy were produced in this activity?

Design other simple demonstrations to help your pupils investigate sources of energy. Formulate questions that will direct your pupils' attention and observations so they gather all the essential information. For example:

- Suggest that the pupils classify energy sources into renewable (i.e., those that can be used over and over) and non-renewable (i.e., those that will run out some day).
- Which energy sources are used the most in your country?
- Is your country likely to run out of energy one day? Refer to the sources you indicated your country used most.

Classroom Activities

The following activities can be done with your pupils to study the properties of light. Each activity contains questions you can ask your pupils to help them reach the intended conclusions. You should be able to use the knowledge gained from this activity to plan and design exercises to investigate other forms of energy.

Materials: three post cards (all the same size), candle, matches, pin, torch, plastic beaker, tin, glass beaker, wooden board, cardboard, can, magnifying glass, plain sheet of paper, mirror, long bottle, pencil.

Activity One

Take two post cards, label them card A and card B, mark their centre points, and use a pin to make same-sized holes at the centre of each card. Stand the cards on a table with their centre points lined up. Use some sand or two small rocks to keep the cards in place.

1. Put a source of light in front of card A and look through the hole in card B. Can you see any light from behind card B?
2. Take a third card C (which is the same size as A and B) with no holes and place it between cards A and B and look through the hole in card B. Can you see any light from behind card B this time?
3. Remove card C and make two holes that are not at the centre of the card (mark them with an X). Again place card C between card A and B. Look through the hole in card B. Can you see any light from behind card B this time?
4. From these activities, what conclusions can you make about the way light travels?

Activity Two

Shine light onto a post card with no holes in it. Hold a small object which does not completely block the light (e.g., a coin) between the light source and the card.

1. What do you observe on the post card? Describe each region seen.
2. What is this called?

3. Make a diagram of this investigation.
4. Have you made similar observations in your day-to-day life? Describe them.
5. What conclusions can you make about light from these observations?

Activity Three

Pass light through different materials, e.g., plastic, glass, tin, hard cardboard, paper, wood, etc. If possible try to have all your materials about the same thickness. Record your observations.

1. What conclusions can you make from your observations?

Activity Four

On a sunny day hold a piece of paper underneath a magnifying glass so the sunlight shines through the magnifying glass onto the paper. Wait for a few minutes or until a change is noted on the paper.

1. What did you observe?
2. Compare the size of the spot of light falling on the paper with the size of the glass used. (Note that the light falls on the whole surface of the glass.)
3. Make a diagram of the magnifying glass and the paper. Show the rays of light from above the glass as well as between the glass and the paper.
4. What conclusions can you make about light from this activity?

Activity Five

Hold a mirror at an angle to a light source so it will reflect and make a spot of light on a wall or other surface.

1. Draw a diagram to represent what you did. Indicate where the light spot forms.
2. Draw rays of light from the light source to the mirror and from the mirror to the light spot on the wall.
3. What conclusion can you make about the behaviour of shiny materials when light is thrown onto them?

Activity Six

Fill a glass container about three-quarters full. Put a pencil in the water but make sure that part of it is above the water. Look at the pencil through the container of water.

1. Draw what you see.
2. What seems to have happened to the pencil?

Summary

- A mind map can be used in the teaching of science to determine the following:
  - the starting point in teaching a given topic
  - obtaining general information on a given concept/idea topic
  - how much is known to pupils about a given concept
- Information obtained from mind maps can be used in various ways, e.g., determining a lesson to be taught for a given topic.
- To show pupils that a given material is an energy source, you must perform an activity which shows the production of energy.
- During an investigation, pupils can acquire valuable information by carrying out simple activities.
- Good questions direct pupils to obtain information about the topic being studied.

Reflection/Self Assessment

It is likely that some of the questions you used in the practice activity led pupils to the desired conclusions while others did not.

- What led to either success or failure?
- Did the activities you assigned to your pupils fit well with the properties of energy they were investigating?
- Did your questions guide pupils successfully in their investigations?
- Did your pupils get the expected answers during their investigations?
- Did your pupils complete their work in the specified time?

Unit 1 Assignment

1. What should you consider when designing an investigation on the properties of a given form of energy?
2. What do you need to consider when designing questions for an investigation?

Unit 2: Energy Transfer and Uses

Introduction

This unit will help you develop and strengthen your research and questioning skills in an effort to improve your classroom and field work practices. The suggested strategies in this unit are not the only techniques available and you are encouraged to use other teaching methods. In this unit, we have integrated selected content with methodology and, as much as possible, the activities presented here are interactive. By the end of this unit you should be able to use the questioning technique to bring about:

- analysis, synthesis, and evaluation of given data
- understanding of concepts
- recall of information
- application of learned concepts
- guidance of the learning process

Objectives

This unit is by no means exhaustive. It is not a textbook and is not intended to be a teacher's guide. You are still required to read and use other textbooks and this unit should compliment the textbooks you are currently using. By the end of the unit you should be able to:

- get pupils working in groups and engaging in meaningful educational dialogue
- ask questions at different levels of cognitive difficulty
- design and carry out experiments on energy transfer
- make work cards that engage pupils in meaningful and challenging practical investigations

Content

In this unit, you will continue to use the questioning technique at different levels as you cover the topics listed below. For a review of the questioning technique, please refer to Unit One of this module.

While you teach your class about energy transfer and uses, you will practice introducing the topic to your students in an interesting manner. You will also look at ways to combine teaching strategies in your classroom, including structured discovery, directed inquiry, and the use of workstations.

Energy Transfers and Uses

You need to read as widely as possible on the topic of energy transfers and uses before teaching it. In your reading, you will see that energy is like money. It is of no value or use until it changes hands. Energy can only be detected when it changes from one form to another. This transfer of energy is described as transduction. A transducer is a device that transfers energy from one form to another. It is also known as an energy converter. Transducers can be either mechanical or biological converters of energy.

- Give two examples of a biological transducer.
- Give two examples of a mechanical transducer.
- Explain how the energy is converted in each case.

An example of a biological transducer would be the leaves of plants or muscles of the body. In plant leaves, energy from the sun is converted to carbohydrates and stored in the plant as chemical energy. In the human muscle, carbohydrates are oxidised. When you flex a muscle, energy is released and the muscle moves or twitches. When a cricketer throws a ball, he uses the energy in his muscles. This energy is produced from the food he eats (energy input). The cricketer throws the ball at a certain speed (energy output), and with a kinetic energy.

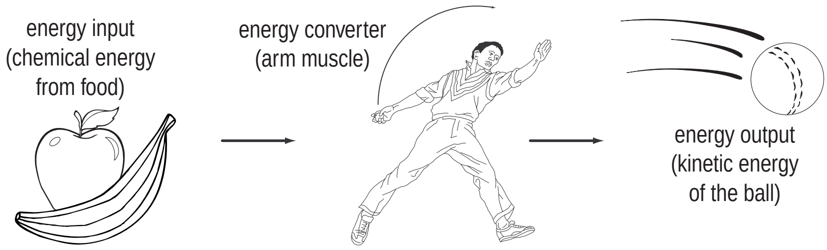


Figure 1.3: Energy transfer - biological transducer

Here is a diagram of energy transfer in an electric heater:

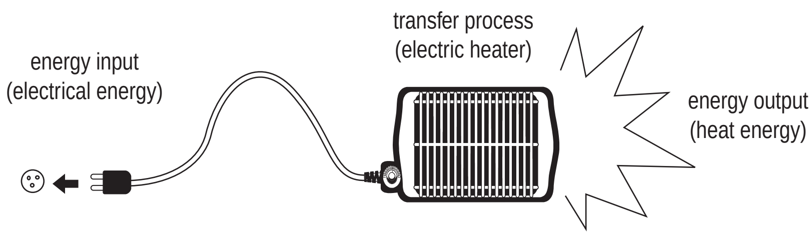


Figure 1.4: Energy transfer - mechanical transducer

An electric motor is an example of a mechanical transducer.

The activities in this unit will help you to:

1. State uses of energy in the environment.
2. Identify a wide variety of mechanical and biological converters (transducers) of energy.
3. Explain that energy can only be detected when it is transformed from one form to another.

Individual Activity

After you read everything you can about energy, outline the key concepts you want your pupils to learn. Find out if these concepts are in the syllabus document that indicates what pupils are expected to know.

Decide on the amount of extension work to give your pupils. Make a definite distinction between what is necessary for pupils at the junior secondary level to know about energy transfer and what is extra material.

You should also decide which skills you intend to impart to your pupils and which key concepts of energy you want your pupils to learn. Following are a few concepts which you may want to consider:

- energy can only be detected when being transformed from one form to another
- there are mechanical and biological energy converters
- there is evidence of energy use in the environment
- energy that is transformed from one form to another can be measured
- work is a result of energy transfer

Following is a list of skills to be imparted:

- designing experiments
- making predictions
- observations
- taking measurements
- data collection
- drawing conclusions

How do these concepts and skills compare with the ones you thought of? After you decide which concepts and skills you are going teach, decide how much time to spend on each one. You also need to decide on the methodology you will use. In this example, pupils will take part in guided discovery and conduct basic research.

Classroom Activity

Think of an engaging introduction to the topic of energy transfer. This could be a series of questions, short drama, surprise demonstration, or anything that is short, succinct, and will attract and sustain the pupils' attention.

You will need to have a flat wooden or plastic board, a metal pan, a Bunsen burner, and some groundnuts or dry maize grains. Set up the demonstration as shown in *Figure 1.5*.

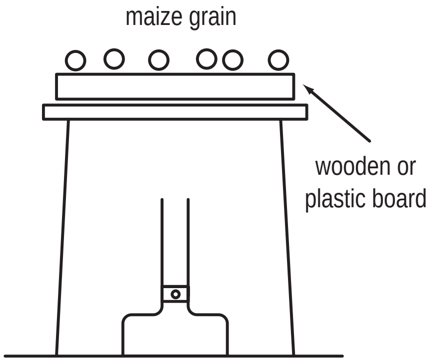


Figure 1.5: Example of energy transfer experiment (not good!)

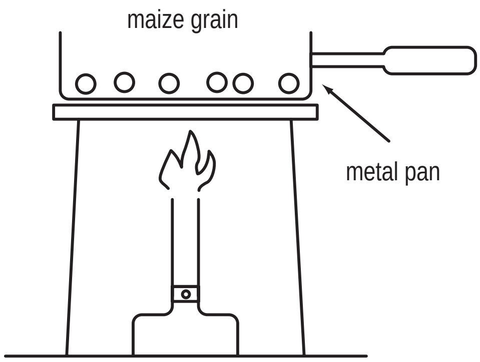


Figure 1.6: Example of energy transfer experiment (good!)

If your pupils are paying attention, one of them should stop you from lighting the burner as shown in *Figure 1.5* and you should ask them why.

You can then produce your metal pan and start roasting your popcorn or maize grain as shown in *Figure 1.6*. As you roast the popcorn/maize, begin asking your pupils questions, such as:

1. How do you know that the popcorn/maize grain is roasting?
2. What is causing the roasting?
3. How does this happen?
4. Describe the energy conversion taking place in this experiment.
5. Why can you roast on the metal pan but not on the wooden board?

The following are possible answers to the above questions:

1. (i) Maize changes colour (chemical change).
   (ii) You can smell the maize roasting.
   (iii) Diffusion of gases from roasting maize.
2. Heat is being transferred to the maize.
3. Chemical energy in gas is converted to heat, and heat is converted to kinetic energy (vibration of particles in the metal).
4. The metal particles in the pan vibrate and heat is passed on.
5. The wood particles vibrate but quickly burn.

You can present the questions to your pupils orally or written on a work card. However, an oral introduction would be better than a written one as you will be able to direct and control the pupils learning by establishing goals and objectives.

Keep the following points in mind when you plan questions:

- include at least one open-ended question in the instructions
- identify which questions are low order questions
- identify which questions are high order questions
- determine if the questions are suitable for the introduction of this topic

Before presenting the introduction to your pupils, evaluate it by asking yourself the following questions:

- What type of introduction have I decided on? A series of questions, a drama, a demonstration?
- Is it interesting? Why?
- How does my introduction compare with the one above?
- Which introduction is more interesting? Why?

Look for ways to improve your introduction and the questions you ask, so your pupils will get as much as possible from the lesson.

Developing the Lesson

This stage requires you to make a decision on what method to use. Some methods are:

- structured discovery
- directed inquiry
- workstation circuit

Try using a mixture of techniques in the workstation circuit. For this method, you will have to set up a number of workstations, each with its own task or experiment. This method works especially well if classes are large and there is limited apparatus for the pupils to work with.

You should make work cards containing instructions for each workstation, and have the pupils move from one workstation to another, either independently or in small groups. Assign a different task at every workstation. One workstation might have written work where the pupils answer questions about energy. At other workstations, set up a game or a simple experiment.

Following are some suggested activities that you could assign, depending upon the ability of your pupils.

Workstation One

For this activity, you will give your pupils instructions/questions that will lead to an action.

- Design an experiment to demonstrate energy transfer.
- Did it work?
- If it did not work, identify the weaknesses and correct them.

Workstation Two

- Turn a bicycle upside down.
- Attach a generator to the wheel.
- Turn the pedals until the wheel turns fast on its own.
- Release the dynamo so it rubs against the bicycle tire.

- What happens to the turning wheel?
- What has happened to the energy of movement of the wheel (kinetic energy)?
- How can you convert the kinetic energy of the wheel into light energy?
- Write down the energy chain involved in transferring the kinetic energy of the wheel to light energy.
- What kind of energy converter is used in this workstation?

Review the types of questions used at this workstation.

- Are there any closed questions? Identify them.
- Are there any open-ended questions? Identify them.
- Are there any low order questions? Identify them.
- Are there any high order questions? Identify them.

One of the purposes of this task is to teach pupils how to design and carry out an experiment. Pupils are expected to learn communication skills by discussing with their colleagues the work they have done and the results they have found. At some stage of this activity, you should ask probing questions. When explaining how to transfer kinetic energy into light energy, you might try the pregnant pause as a way to encourage your pupils to express all of their ideas.

Workstation Three

Include an activity in the workstation circuit that will encourage your pupils to ask questions. You will have to suggest some activities/problems for which the pupils have to come up with questions. Your other role in this activity is to answer the pupils' questions.

The following activity will train your pupils to ask questions:

- Show the pupils a bimetallic strip at room temperature.
- Instruct the pupils to draw the strip as it appears.
- Dip the strip in ice cold water and leave it there for a few minutes.
- Have the pupils draw the strip showing the new shape.
- Allow the strip to return to room temperature and observe the shape again.
- Heat the strip over a smokeless flame, observe the new shape, and draw what you observe.
- Invite your pupils to ask questions that will help them explain the different observations.
- What types of questions did they ask?
- How did you respond to the questions?

Following are some possible questions and answers:

Questions	***Answers***
Can I get the same result if I use a bread knife?	No
Does the strip contain special chemicals?	No
Was this the first time the strip was heated?	No, it has been heated many times.
Would it ever break from this continual bending?	No
Did the ice water have anything to do with its bending the first time?	No
If you leave the strip in a refrigerator will it have the same effect?	Yes
What is the strip made of?	Find out.
Where can I find this information?	Suggest possible sources.

Pound two nails into a wooden board so that a metal strip fits between them, as shown in *Figure 1.7* below. Remove the metal strip and heat it. Try to fit it between the nails again. What happens? Why?

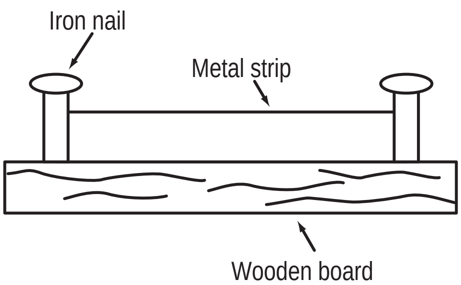


Figure 1.7: Experiment (a) - energy transfer and its effects

Try the same investigation with a coin, a nail, and a wire loop as shown in *Figures 1.8* and *Figure 1.9*. What happens?

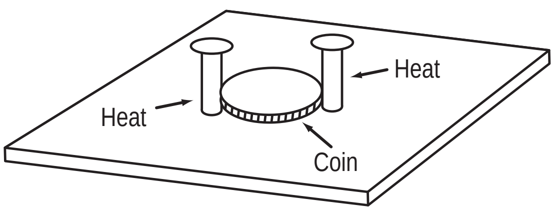


Figure 1.8: Experiment (b) - energy transfer and its effects

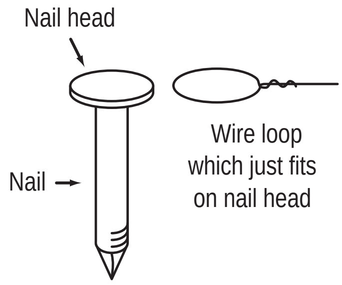


Figure 1.9: Experiment (c) - energy transfer and its effects

Try these demonstrations with your pupils and take note of the types of questions they ask. Compare their questions with those provided in the previous table. Review your pupils' questions in the same way you reviewed the questions for Workstation B.

Decide how to conclude your lesson. Following are a few suggestions:

- Summarise the main points of the lesson.
- Give a few questions as a written exercise.
- Design a game on energy transfer and give it to the pupils.
- Design a quiz on energy transfer.

Summary

- The questioning technique is a powerful tool when handled well.
- A variety of questions can be used to teach science.
- Pupils should be encouraged to ask questions.
- Pupils should be encouraged to enter into dialogue with each other.
- Introductions to science lessons should be interesting.
- As much as possible, pupils should learn about science through practical work.

Reflection/Self Assessment

- Did you encourage your pupils to ask questions?
- Did they have enough time to formulate and write down their questions?
- Were pupils encouraged to answer their colleagues' questions?
- Did you respect the pupils' questions?
- How did you lead pupils to search for answers?

Unit 2 Assignment

Design an activity that can be used to teach energy transfer and its uses. This activity should engage pupils in meaningful educational dialogue.

Prepare a work card that will enable pupils to learn about energy connectors in a practical way.

Unit 3: Using Energy from the Environment

Introduction

Energy consumption reflects the lifestyle of a particular community or country. It is equally true that the lifestyle of the people in a community reflects energy consumption.

> Energy affects lifestyle.
> Lifestyle affects energy consumption.

This unit is about the uses of energy from the environment, which includes both biotic and abiotic (i.e., the living and the non-living) components of the environment. The energy uses suggested in this unit are in no way exhaustive. You may have to do further research into how energy is used in your community.

By the end of this unit you should be able to use the **questioning technique** and **field work/trips** to help pupils study how energy from the environment is used.

Objectives

- Use a variety of questions to encourage pupils to find out more about the uses of energy from their environment.
- Develop questions that will direct pupils to identify and research manageable problems in the uses of energy from the environment.
- Assess pupils' proposals for mini-research projects on the uses of energy from the environment.
- Design and construct models on the uses of energy from the environment.
- Plan and go on field trips where pupils will be directly involved in learning about the uses of energy from the environment.

Content

Topics

The topics listed below are to be used with the suggested teaching strategies.

- solar energy
- photosynthesis
- solar panels
- photocells
- weather
- evaporation
- direct heating
- geothermal energy
- water supply

- general electricity
- sound energy
  - uses in the environment
  - noise pollution
- wind powered machines
- high tide and wave power
- fossil fuels and vehicles
- light energy

Teaching Strategies

This unit focuses on research, referencing, and field work to help pupils discover and understand the uses of different forms of energy from the environment.

The Purpose of Using Field Trips

Field trips involve visiting places or sites of interest or educational value. These could be industrial plants, mines, or even ecosystems. A field trip can be a powerful tool for a teacher who has planned it well, and it can be used in conjunction with other teaching methods, such as questioning, project work, group and individual work, and discussions.

Most pupils never have an opportunity to collect their own data and are solely dependent on textbook information. Field trips promote independent learning and help the pupil realise that the teacher and textbook are not the only sources of information. Textbooks may contain errors, but if errors are found by studying the environment, it will be a human error made by someone who has failed to observe, collect, or interpret the data correctly.

The purpose of all field trips is to provide pupils with an opportunity to:

- gain first hand experience and knowledge
- have contact with scientists and see them at work
- grapple with real life problems in science
- stimulate interest and curiosity—the scientists will become role models and seeing them at work will inspire your pupils
- learn to observe, collect, record, and analyse data—valuable tools in teaching and learning science
- promote learning by observing the natural environment

Research

The main reason for going on a field trip is to conduct research. What do you think about when you hear the word research?

Research is required if you are looking for information about issues or solutions to problems. The fact that you are looking for information or a solution implies that research begins when there is a question or problem that needs to be answered. Your first task in getting pupils to carry out research is to help them identify problems by asking them questions. Once again, you make use of your questioning skills.

Identify a problem in your community environment that you can have your pupils research. Be sure to state the problem as clearly as possible. Before giving the problem to your pupils, answer the following questions as honestly as you can.

- Do you think the problem is at the appropriate level for your pupils?
- Why do you think so?
- Is it possible for your pupils to work on the problem?
- What difficulties are they likely to encounter?
- What contingency plans do you have for assisting pupils who get stuck?

Do not present the problem to your pupils until you are certain they can work with it. Ask them to come up with hypotheses or tentative solutions to the problem. Have them discuss the consequences of each hypothesis. This process will eliminate some of the possible solutions. The remaining hypotheses can be tested through investigation or experimentation. Collect and analyse data to reach a conclusion.

It is important to remind your pupils that research will not always lead them to the answer they want or expect when doing research. Their conclusions must be based on the evidence, and sometimes the evidence may force them to accept a conclusion that is against their values and expectations.

Once a problem has been identified, the following steps will be necessary to solve it:

- investigation
- research
- observation
- interpretation of data
- model construction

When teaching about the use of energy from the environment, apply these steps to the field trips and research activities in which your pupils will be involved.

Organising a Field Trip

What comes to mind when the term field trip is mentioned?

A field trip does not necessarily involve going on a bus or some other form of transportation. A field trip can be taken on foot, and you can even go on a field trip within the confines of your school. The crucial aspect is that the trip must be well-planned, monitored, and evaluated.

For a field trip to be effective, pupils must know what you expect of them. After you decide where to go and how to get there, make a checklist of things that must be done before going on your field trip, including what you want the pupils to do on the field trip. Brief your pupils thoroughly before departing on the field trip. Compare your checklist with the one on the following page.

Possible Checklist

- ✓ Before going on the field trip, make sure you have permission from your head of school and parents.
- ✓ If you are going far away from your school, plan meals and sleeping arrangements. Make prior arrangements with the education authorities in the area you will visit.
- ✓ Advise your pupils to take suitable clothing for the occasion and what provisions to carry. Remember to take anti-malaria tablets.
- ✓ Prepare handouts for your pupils. Each pupil should have a guide which spells out the major tasks you expect them to do. Remind them they are not limited to what is on the handout but are free to explore other areas that are not included in the guide.
- ✓ Emphasise the need to record observations and ask questions. If necessary, spend some time before the trip preparing tables where the data will be recorded.
- ✓ While on the tour, ensure that your pupils are collecting data. Move around and discuss their findings with them. Offer guidance where necessary, but do not be over-bearing.
- ✓ Give pupils the freedom to collect data that interests them, however make sure they collect relevant information. Remember to be tolerant and accept new ideas and problems that will inevitably surface while you are on the fieldtrip.
- ✓ When you return to your school, evaluate the trip. Design an evaluation form to check on the following:

Preparations for the Field Trip

- transportation
- meals
- sleeping arrangements
- handouts/guidelines
- permission to visit certain places
- permission from parents
- authorisation from school officials

On the Trip

- Are the guidelines relevant?
- Is the available information useful?
- Collect all relevant information.

After the Trip

- Was the discussion worthwhile?
- Did you learn anything?
- What did you learn?
- What could be done to improve the field trip?

Energy

There are a few things you should introduce to your students before teaching this topic. Your main thrust should be to give your pupils a chance to find out information for themselves, and your task is to show them where they are likely to find this information. Before starting the actual lesson, think of the main concepts you want to cover under the heading *Uses of Energy from the Environment*.

Make a list of the types of energy you would like to cover in your lessons. One way to organize your ideas is to produce a mind map like the one shown in *Figure 1.10* below.

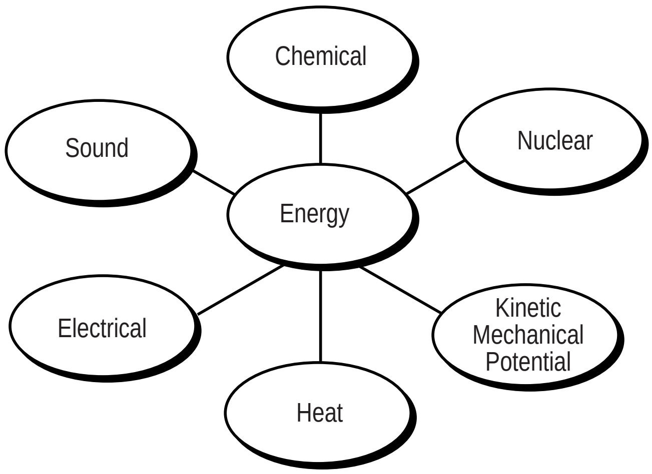


Figure 1.10: Types of energy, a mind map.

How does your list compare with this mind map?

Once again, you should read as widely as possible to learn how these different types of energy are used. When you feel confident about this, think about the scientific skills you want to impart to your pupils while learning about the different uses of energy from the environment.

Write down the skills you want your pupils to learn. After listing the skills, think about the teaching methods you will use. It is through your instruction that your pupils will acquire the intended skills.

In this unit, we will look at using field trips and research, however, you should not eliminate other teaching methods.

Think of an interesting way to introduce the topic of uses of energy from the environment.

- What type of introduction have you decided on?
- Do you think it is interesting?
- Why do you think it is interesting?
- What elements of your introduction are interesting?

Following is a suggestion on how to introduce the lesson by using a prepared piece of apparatus as shown in *Figure 1.11* below.

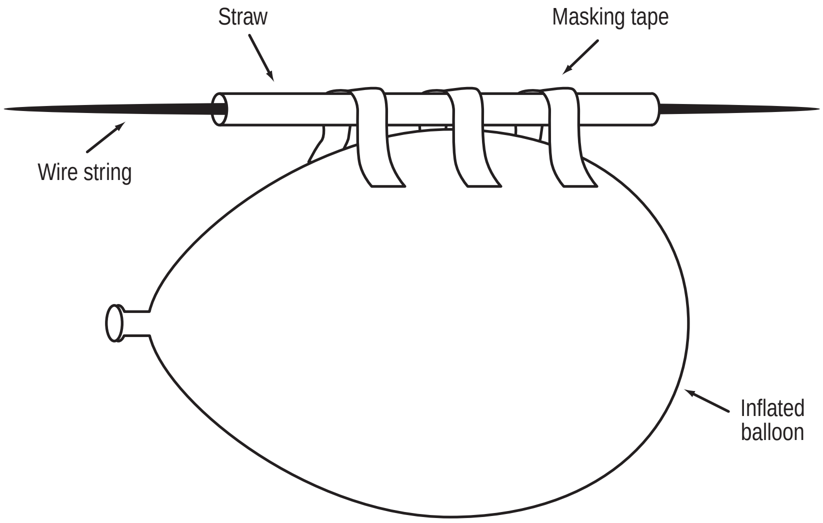


Figure 1.11: Apparatus for an introductory demonstration on the use of energy from the environment.

Set the materials where everyone can see them. Ask one pupil to inflate the balloon, then tie the opening of the balloon with a knot that is easy to undo. Ask another pupil to untie the knot and let go. Ask the class the following questions:

1. What happens when the knot is undone?
2. What causes this action?
3. Where in life do we have this type of action?
4. What are the energy conversions taking place?

Following are possible answers to these questions:

1. The air comes out of the balloon and moves it in the opposite direction.
2. Kinetic energy of air moving in one direction creates an equal and opposite force, causing the balloon to move in the other direction.
3. Jet propulsion, launching a space craft.
4. Potential energy is converted to kinetic energy.

Compare this introduction with yours. Which is more interesting? Why? Classify the questions into lower and higher order questions. Try the two introductions with your pupils. Which was more appropriate and captivating?

Solar Energy

A wide variety of technologies rely on solar energy and you should instruct your pupils to do research on the various technologies used in their community or country. Where possible, pupils should make models of the technologies observed as this will help them understand how the technologies work.

Research projects about the various technologies available in your community may be undertaken through field trips. You should visit these sites before taking your pupils to them. Make a list of what is available and get permission to visit these places. Remember—you need to plan your field trip or educational tour well in advance.

- Prepare a plan for taking your pupils to the various sites.
- Design a handout or questionnaire that your pupils could use on the trips.
- Discuss your handout with a colleague or other members in your department.
- Brainstorm the handout and produce a final document.

After producing the handout, you need to analyse it. Look for areas where you need to take safety measures and, if necessary, devise a set of rules which your pupils must follow.

How does your handout compare with the one prepared for a solar water heater and solar cells?

Solar Water Heater

When the pupils visit the site, they should try to answer the following questions:

- What are the main parts of the solar water heater?
- Why is the dark-coloured surface facing the sun?
- What is the function of the glass cover?
- What metal are the tubes made of?
- Why was the substance used?
- If you did not have that particular substance, what substitute could you use?
- How does the water get heated and used?
- What are the scientific principles on which the design is based?
- What materials would you need to construct a working model of a solar water heater?

Model Solar Heater

- Design a model solar heater which actually heats water.
- Explain how the different parts of your model work.
- Design a way of finding out whether your model is as efficient as the commercial product.
- Point out the strengths and weaknesses in your model.
- Is there a way to improve your heater?

Direct radiation from the sun can be focused with a lens or curved reflector. Design a device that can concentrate the radiation from the sun. How can you show that heat energy is really concentrated by your device? Suggest ways of making the concentrator more efficient.

Solar Cell Panel

- In what ways is this panel different from the solar water heater?
- What is the principle on which this panel works?
- What is the maximum voltage from this panel?
- Design an experiment to investigate conditions that give a maximum current and those that give a minimum current.
- Try the experiment if you can.
- What problems did you face in carrying out the experiment?
- How do you prepare to overcome the problems?
- Explain how the solar cell produced electricity.

Armed with this worksheet or handout, go through the formalities of getting permission and arrange to take your pupils on a field trip.

Compare this worksheet with yours. Find out if there is anything that needs to be improved. Try out the worksheet or handout and see how it works.

Solar Cells/Photocell

Connect the solar cells so that they give:

- maximum current
- maximum voltage

Draw a diagram in each case. What is the energy conversion in a solar cell?

In the last task, you prepared a work card or handout for your pupils to use. Give it to your class and assess the results.

- Was the handout useful?
- Does it need improvement?

You cannot study everything on a field trip, neither can you take your pupils out every day. In the classroom, however, you can teach other uses of solar energy. Perhaps from your wide reading, you now realise the sun is the source of virtually all our energy.

Converting Solar Energy to Wind Energy

Begin this activity by giving pupils a diagram of an indirect solar drier, as shown in *Figure 1.12* below.

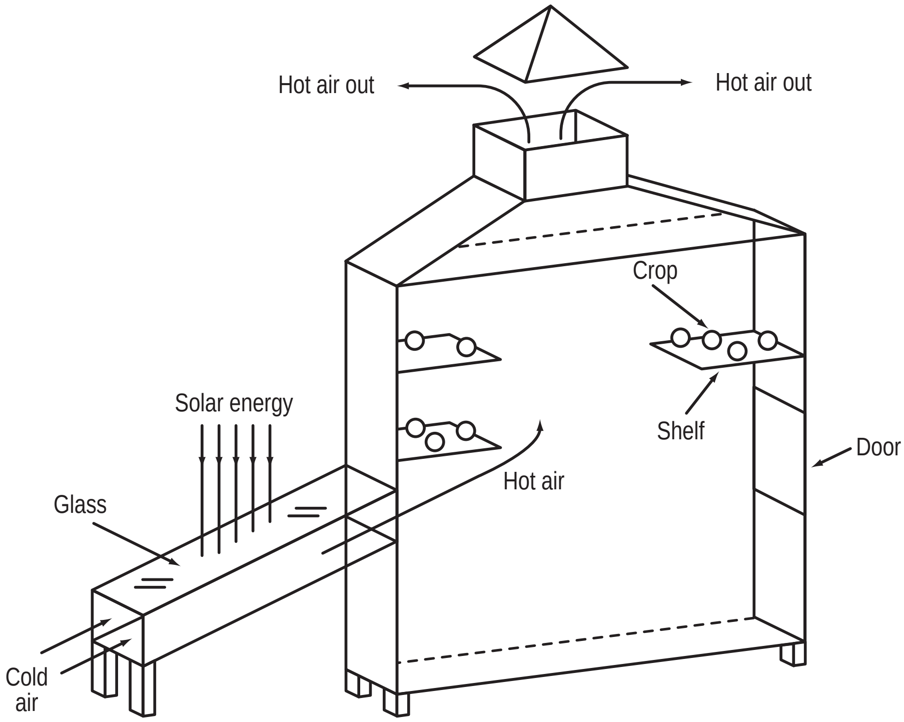


Figure 1.12: An indirect solar drier. This device is used to dry valuable crops.

Design a set of questions that will enable your pupils to explain how this technology works. Have the pupils construct a model indirect solar drier and ask them to suggest crops in their community or country that can be dried in such a device. Compare your list of questions with those below.

1. What is the function of the dark glass cover?
2. Why does the drier have a chimney?
3. Describe the function of the collector plate.
4. Explain why the tube is placed at an angle.
5. Describe the scientific principle on which the device is based.
6. What type of solar radiation is used in this device?
7. How is the energy used?
8. State three advantages of this device.
9. What are its disadvantages?
10. Read and find out what a thermosyphon (SWH or Solar Water Heater) is.
11. What is it used for?
12. How does it work?

Examine the strategy of the questions that were asked in this activity.

- How does this strategy compare with yours?
- Why were you asking questions?
- Is there a better way to get pupils to learn about uses of solar energy?
- Identify lower order questions.
- Which questions are higher order questions?

Compare your answers to these questions with the following:

- This answer or comment can only come from you.
- Questions are used because we do not want to give information. Pupils' learning is directed by the questions. As they look for the answers, they learn about the uses of this technology.
- The other way would be to tell pupils about different uses but this can be boring and pupils may forget what they are told.
- Lower order questions are 1, 3, 5, 6, 8, 10, 11.
- Higher order questions are 2, 4, 7, 9.

Remember—these are only suggestions. Feel free to debate the responses and avoid the temptation to take things for granted.

Classroom Activity

In this activity we will investigate how wind power is used. The activity is intended to help you teach your pupils about the uses of energy from the environment without telling them. Let the pupils do their own research, however, remember that they may need guidance from time to time.

Write down a series of instructions and questions to guide your pupils to do research on wind and hydropower. Your questions and activities should focus on the use of wind, waves, and tide in the production of usable energy.

A good way to start is to ask your pupils to design and construct a wind-powered machine that can lift a small mass. Explain and draw diagrams to show how the machine could be modified to:

- pump water
- generate electricity

What are the possible problems you will face in the construction and use of the machine? How do you propose to overcome them?

How do these questions compare with yours? Can you find ways to improve the instructions and questions you prepared for this activity?

Other Uses of Solar Energy

The sun heats different parts of the earth at different rates. The amount of solar energy received on a specified area is called **insolation**. This is measured in mega joules or in kilowatt-hours per square meters. Different parts of the earth receive different amounts of insolation.

- How is the air around the earth affected by the difference in temperatures?
- What causes wind?
- What causes ocean currents?
- How can the energy in ocean currents be harnessed?
- What do we mean by high tide?
- How can the energy in tides be harnessed?
- Draw a diagram to illustrate a simple design you would use to trap and make use of energy from tides.
- Construct a model hydro-electric turbine that can be used to generate electricity.

Design an exercise that summarises the application, type of technology, and the energy output of the different methods of tapping solar energy. One way to summarise the information is to have your pupils enter it in a table.

Application	Type of Technology	Output
solar water heater	flat plate collector	heat
solar cooker	concentrator	heat
solar drier	flat plate collector	heat
solar power	solar cells	electricity

Design an exercise to help your pupils summarise the uses of solar energy. Since most of our energy comes from the sun, it may help your pupils to produce a mind map that has the sun at the centre. They can then illustrate the different ways we use solar energy.

Geothermal Energy

In addition to energy from the sun, energy is also produced by volcanism and geothermal activity. The following diagram in *Figure 1.13* shows how geothermal energy can be tapped.

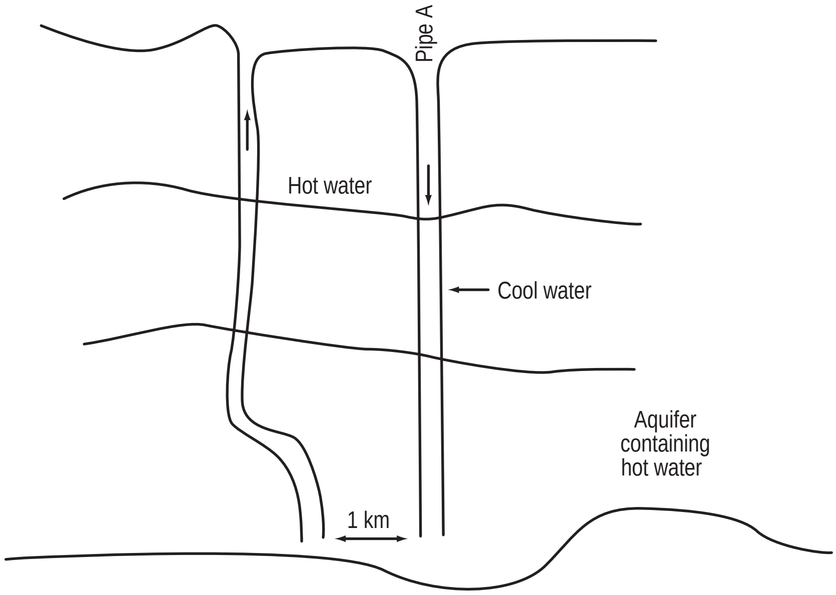


Figure 1.13: How to tap geothermal energy

Here is a set of questions that can help you understand the nature of geothermal energy.

1. What is likely to happen if water is forced into the molten rock through Pipe A?
2. How is the pressure likely to be balanced?
3. What is likely to come out through the safety outlet?
4. Why should that substance come out?
5. How can the substance be used to generate electricity?
6. Explain how natural hot springs are formed.

Possible answers (geothermal energy production process):

1. Water is heated and changes to steam.
2. It is balanced by releasing steam.
3. Steam.
4. Any fault in the rocks.
5. Use the steam to turn a turbine and the turbine turns on an electricity generator.
6. From the aquifer containing hot water (heat comes from hot matter deep in the center of the earth).

Summary

This unit focused on research and field trips as methods to teach the uses of energy from the environment. The main objective was to assist pupils to acquire the skills to plan research, collect data, analyse the data, and draw conclusions, using the uses of energy from the environment as the research subject. Ideas for planning field trips and guidelines for use during and after the field trip were suggested. Other activities and suggestions on how to teach the topic more effectively were also presented.

Reflection/Self Assessment

1. Did you come up with strategies to improve on the suggested methodologies?
2. Given a choice, would you use the suggested methodologies in your science lessons?
3. How successful were you in using the suggested methodologies for teaching and learning in this unit?
4. How successful were your field trips?
5. Were your pupils able to:
   - follow your instructions?
   - carry out research?
   - answer your questions?
6. Did your pupils enjoy their science lessons?
7. What are your final comments about this unit?

Unit 3 Assignment

1. Design and write two higher order questions to help pupils identify environmental problems to be researched.
2. Which questions are open-ended?
   a. Name a type of electromagnetic wave which is used by radar.
   b. Explain why, in hot countries, houses are often painted white.
   c. How does water in a heater get heated?
   d. What is the cost to play a cassette for an hour?
3. Design a model piece of technology which uses energy from the environment to make life easier in your local area.

Unit 4: Energy Conservation

Introduction

Energy conservation is a topical issue in the world today, especially when finite sources of energy such as coal and oil are becoming too expensive for the common person and the reserves are not likely to sustain humanity forever. As a result of this potential shortage of resources, other energy sources such as trees have, in most African countries, been over-exploited to the extent that the creation of deserts has become widespread.

This unit is intended to make you aware of the need to conserve energy, and to put into practice the energy conservation concepts you will learn. Once you develop a positive attitude towards energy conservation, it is hoped you will pass it on to your pupils.

This unit gives learning activities designed to help you teach about energy conservation through practical investigations. The activities are not presented in any particular order, and you are free to use them or create your own. When creating your own activities, remember to design practical exercises that will help your pupils understand the science of energy conservation.

By using environments that are familiar to both sexes, such as the home and the classroom, this unit presents user-friendly learning activities for both boys and girls.

Objectives

By the time you complete this unit, you should be able to:

- identify different types of waste produced in the home and school, and know how it can be used for energy conservation
- describe how energy can be conserved in the home, school, and local environment
- identify ways of helping pupils learn conservation measures through reclamation, re-use, and recycling of domestic waste
- design a method for assessing pupils as they carry out practical work in class or in the laboratory

Content

Topics in Energy Conservation

- Energy conservation processes
- Conservation measures in the home and school
- Reclamation, re-use, and recycling as conservation measures
- Energy conservation in the transport system

Teaching Strategies – Assessing Practical Assignments

- Questioning techniques
- Field work and research
- Assessment of pupils as they carry out practical work

If you have been teaching science for some time, you must have faced the problem of assessing practical assignments. Do you feel confident assessing practical assignments?

First, we should review why we ask the students to do practical assignments.

Practical assignments are a good way for students to learn the proper handling of apparatus, the manipulation of gadgets and equipment, how to read scales, etc. The general science syllabus may contain the following practical skills:

- follow instructions for practical work
- plan, organise, and carry out experimental investigations
- select appropriate apparatus and materials for practical work
- use apparatus and materials effectively and safely
- make accurate, systematic observations and measurements, recognising the variability of experimental measurements
- systematically observe, measure, and record results of experiments
- identify possible sources of errors in experimental procedures
- draw conclusions and make generalisations from experiments

By using this list of skills, you should be able to design an evaluation method to assess your pupils as they carry out their practical assignments.

Individual Activity

1. Design a work card that gives instructions for a practical assignment on energy use in a plant leaf.
2. Identify and list the skills you want your pupils to acquire during the practical assignment.
3. Decide how you will assess these skills. Will you use marks or will you use symbols?
4. How many pupils can you assess at any one time?
5. Why did you decide on that number of pupils?

By listing the skills, you are on your way to designing a marking scheme to assess pupils as they carry out the assignment. A marking scheme is a guide that gives the expected responses and the value of each response. Your marking scheme (evaluation instrument) should state the expected degree of competence and the value you place on each response. Try the marking scheme while pupils conduct the practical activity you have assigned.

Classroom Activity

Following is an example of a learning activity that you can use to teach about energy and test your evaluation scheme at the same time.

Have your pupils place four clear glass containers of water outside. Choose a location that is exposed to the sun but sheltered from the wind. Place a thermometer inside each container. Cover one container with a piece of cardboard, one with a piece of dark cloth, and one with a piece of light cloth. Leave the fourth container uncovered.

After one hour, have your pupils take the temperature of the water in each container and record it in a table. Compare the temperatures.

Use questions to encourage your pupils to interpret the results:

- What conclusion can you make from the results of your investigations?
- What are the implications of your conclusion on energy conservation?

While your pupils conduct this experiment, use the following marking scheme to assess their performance.

Pupil Name:	**Marking Grid**				
Skill	**1**	**2**	**3**	**4**	**5**
Following instructions					
Planning and organising					
Selection of appropriate apparatus					
Taking accurate measurements					
Recording results					
Drawing conclusions and making generalisations					

Decide whether you will have one or five as the highest mark. You can only attend to a few pupils at time so the assessment of the whole class will take a long time. Remember—all you have to do as your pupils carry out the practical is to make a tick mark (✓) in the appropriate column. Try this marking scheme and see how it works.

- How does this marking scheme compare with yours?
- Do you feel there is room for improvement on your marking scheme?
- Are there ways to improve the marking scheme?
- What are the advantages of this marking scheme?
- What are the limitations of this marking scheme?

Individual Activity

This learning activity involves carrying out a survey to find out how much waste is produced in the home or at school. You will have to decide what to do with the waste material at the end of your survey. Remember that some of the waste material can be used to generate energy that can be used in the home. It is important that you complete this activity before having your pupils try it.

Begin by asking your pupils a series of questions about waste and waste disposal.

1. What do you normally do with waste that has been collected?
2. What normally happens to the waste from your home?
3. If you do not know what happens to your waste, do research to find out.
4. How could you use this waste to generate energy?
5. Design a way to harness this energy and put it to use.
6. What types of waste are recycled in your country?
7. In some countries, a certain amount of money is levied on empty containers. In what way or ways is this a method of conserving energy?

Design a survey to find out how much waste you produce per day or per week. You might also decide to find out how much waste your family produces per day or per week. Whatever you decide, write down the unit of measurement you will use.

For the survey to be meaningful, the waste must be classified. Decide on a classification scheme. Why have you decided on this particular scheme?

You can use the table in the following example or design your own table to record the results of your survey.

Type of Waste	**Amount of Waste**
Glass	
Paper	
Plastic	
Total number of people in the home	
Average amount of waste per person	

How will you carry out this survey? Following are some suggestions.

- Place waste bins in strategic positions in the home.
- At the end of the day, empty and sort the waste according to your pre-determined classification scheme.
- Measure the sorted waste by weight, volume, or whatever method is most appropriate.
- Enter each measurement in your table.

Feel free to decide on other methods of estimating amounts of waste. Once you have filled in the table, assess the results.

- What type of waste is the largest amount? What is the reason for this?
- What type of waste is the smallest amount? What is the reason for this?
- Can you think of ways for your home or school to produce less waste?

One way to conserve energy is to avoid the production of waste. What better place to start practising good energy conservation habits than in the home?

Summary

- Energy conservation starts at home and in our environment.
- Domestic waste can be used to generate energy instead of throwing it away.

Reflection/Self Assessment

- What did you learn from the activities in this unit?
- Describe the shortcomings of using the activities suggested.
- How can you improve on the activities?
- Do the activities in this unit meet criteria of the summary shown above?
- Describe extra activities that could be used to demonstrate the points listed in the summary.
- Are there other areas of energy conservation that your pupils could investigate?
- List your reasons for carrying out practical assignments.
- How do you ensure that your pupils have mastered the practical assignment?

Unit 4 Assignment 1

1. How is electricity generated in your country?
2. Describe the environmental problems caused by the use of the energy resources in your country.
3. List the five most commonly used home appliances in your country and indicate the amount of energy each uses.

Home Appliance	Amount of Energy Used

4. List four ways to reduce the amount of energy used by each appliance.
5. Why do domestic stoves have heating elements of different sizes?
6. What are the advantages of heating a small pot on the large element of the stove?
7. What are the disadvantages of heating a small pot on the large element of the stove?

Unit 4 Assignment 2

- Design an activity for your pupils, where they are expected to:
  a. plan, organise, and carry out an experimental investigation
  b. systematically observe, measure, and record results of experiments
- Before you assign the activity to your students:
  a. identify the skills and knowledge they should acquire from this activity
  b. decide how you will assess your pupils, and indicate this on the assignment
  c. create a marking scheme for this activity
- Use your marking scheme to evaluate your pupils as they carry out the experiment.

Module 1: Suggested Answers for Activities

Unit One

Possible Answers to Unit Assignment

1. In designing an activity to investigate the properties of a given form of energy, here are some tips for the procedures.
   - Look for activities that pupils can carry out during their investigation.
   - All pupil activities should have clear instructions on how they are to be done.
   - Look for more than one task to lead to a particular conclusion.
2. The questions you ask your pupils should:
   - be based on the activities they have carried out
   - lead them to draw the desired conclusions

Unit Two

Possible Answers to Unit Assignment

Your activity should:

- include a practical task which involves pupils in planning the activity and choosing and assembling apparatus
- require pupils to carry out the investigation
- ask questions designed to guide and encourage the pupils to find information by themselves

Unit Three

Possible Answers to Unit Assignment

1. How can solar energy be used to dry high-value crops such as paprika? How can you harness wind power?
2. Open-ended questions are d and e.
3. A possible design would be for a solar drier, as shown in *Figure 1.14*. There are many variations of this drier.

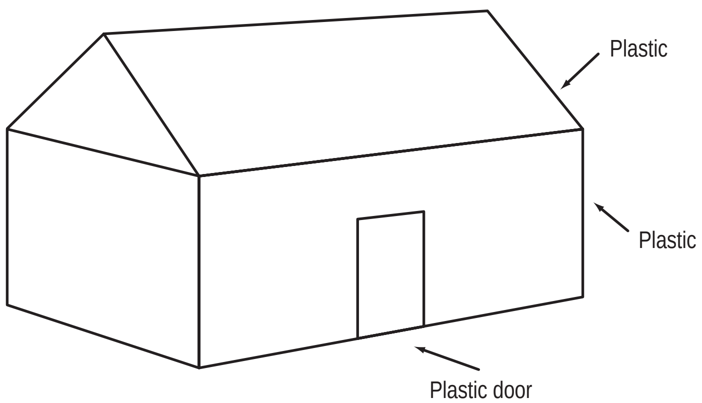


Figure 1.14: Model of a solar drier.

Unit Four

Possible Answers to Unit Assignment 1

Your pupils' answers may include some of the following:

1. In most countries, electricity usually comes from either steam turbines or hydro power. The steam may be generated by heating fossil fuels such as coal or oil.
2. The use of coal causes the production of air pollutants. Hydro power is environmentally friendly.
3. Depends on the appliances each country uses.
4. Depends on the type of appliances used.
5. Different size elements of a stove use different amounts of energy. Using the right sized pot on the appropriate element helps conserve energy.
6. The pot will heat up faster.
7. The element will lose a lot of energy that you will have to pay for.

Possible Answers to Unit Assignment 2

Evaluate this activity by asking yourself the following questions:

- Were your instructions clear and easily understood by your pupils?
- Did your pupils achieve the expected results from the experiment?
- Did your marking scheme effectively evaluate your pupils' performance?
- How can you improve your instructions for this activity?
- How can you improve your marking scheme?

Glossary

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Biomass: Any organic substance that can be used as an energy source. The most common examples are wood and agricultural products, solid waste, landfill gas, and alcohol fuels. Biomass has been used for thousands of years and is the oldest known energy source (e.g., burning solid waste for heating). It is a renewable energy source because its supply is unlimited; quantities can always regrow and be restocked in a relatively short time.

Electricity: A secondary energy source, which means that we must use primary sources to produce it. Coal, nuclear power, hydropower, natural gas, and petroleum are examples of primary sources used to produce electricity. Unlike the primary sources, electricity is not classified as renewable or nonrenewable.

Energy: The capacity to do work. The amount of work done is the same as the amount of energy transferred. The unit energy in the MKS system is the joule (J).

Energy Sources: The many primary energy sources include petroleum, coal, natural gas, nuclear power, hydropower, propane, geothermal, wind, solar, andbiomass. Primary sources of energy are divided into two categories, renewable and nonrenewable sources.

Energy Transfer: There are three modes of energy transfer: conduction, convection and radiation.

1. Conduction

A process of thermal or heat energy transfer in which energy is passed from atom to atom. The energy is transferred by means of collisions between the atoms making up the materials involved in the energy transfer. The energy flows from the hot material to the cold one when they come into direct contact.

2. Convection

The energy transfer process in which energy is carried around by atoms and molecules. This mode of energy transfer happens only in liquids and gases. For example, when you warm yourself up near a campfire, the heat energy reaches you by convection.

definition continues on next page

Energy Transfer — **3. Radiation**

continued from page 42

The transfer of energy by means of electromagnetic waves (light waves—both visible and invisible by the human eye). In general, this process of energy transfer implies that a radiant energy (infra-red) is given off by a hot object and absorbed by another object. For example, the majority of the energy received here on Earth gets to us by means of radiation from the sun.

Geothermal Energy: The energy that comes from the intense heat within the earth. The heat is produced by the radioactive decay of elements below the earth's surface. More than one kind of geothermal energy exists, but the only kind we use widely is hydrothermal energy. Hydrothermal energy has two basic components: water and heat. Water beneath the earth's surface contacts the heated rocks and changes into steam.

Hydropower: The energy that comes from the force of moving water. Hydropower is a renewable energy source because it is replenished constantly by the fall and flow of snow and rainfall in the water cycle. As water flows through devices such as a water wheel or turbine, the kinetic (motion) energy of the water is converted to mechanical energy, which can be used to grind grain, drive a sawmill, pump water, or produce electricity.

Nonrenewable Energy Sources: Sources of energy that can be exhausted over time. If we continue to use them, they will eventually run out. Fossil fuels such as coal, petroleum, and natural gas are examples.

Nuclear Energy: The energy stored in the nuclei of atoms.

Power: The speed or rate at which energy is transferred. Power equals Energy transferred divided by the time taken to complete the transfer.

Renewable Energy Sources: Sources of energy that can be replenished quickly or that are nondepletable. Examples include solar, hydropower, wind, geothermal, and biomass.

Solar Energy: The energy produced in the core of the sun through a process called nuclear fusion. The intense heat in the sun causes hydrogen atoms to break apart and fuse together to form helium atoms. A very small amount of mass is lost in this process. This lost matter is emitted into space as radiant energy. Less than 1 percent of this energy reaches the earth, yet it is enough to provide all of the earth's energy needs. The sun's energy travels at the speed of light, 300,000 kilometers per second, and reaches the earth in about eight minutes. Capturing the sun's energy is not easy because solar energy spreads out over such a large area. The energy received by a specific land area depends on factors such as time of day, season of the year, cloudiness of the sky, and proximity to the equator.

Wind Energy: Wind is air in motion caused by uneven heating of the earth's surface by the sun. Wind power has been used for thousands of years to convert the wind's kinetic (motion) energy into mechanical energy for grinding grain or pumping water. Today, wind machines are used increasingly to produce electricity.

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APPENDIX: EFFECTIVE CLASSROOM QUESTIONING

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This is an excerpt from a longer article which can be found on the World Wide Web at http://www.oir.uiuc.edu/did/booklets/question/question.html.
The authors have permitted quotation of the article in whole or in part, as long as credit is given to the source.

CONTENTS

FOREWORD

Some instructors believe that interjecting questions during instruction is a natural process which should be spontaneous. However, questions can become an effective teaching strategy when employed thoughtfully and less than effective when poorly employed. A timely, well-phrased question can capture students' attention, arouse their curiosity, focus upon important points, or even occupy a student's thoughts after class has ended. Students' responses to questions reveal their perceptions and comprehension of the material, level of experience with the topic being presented, and attitudes about the material or course in general.

Because the ability to develop adequate or even excellent questioning skills can be learned if some attention and practice is given to it, this booklet will try to explain and provide examples of two important components of successful questioning. These include devising the appropriate questions which will elicit responses consistent with your instructional goals and using the interpersonal skills which enable instructors to maximize student responses. This booklet can be used as a reference for instructors who wish to improve their questioning skills or review and assess their current questioning techniques.

LEVELS AND TYPES OF QUESTIONS

- Bloom's Taxonomy
- Lower and Higher Level Questions
- Open and Closed Questions

BLOOM'S TAXONOMY

Questioning should be used purposefully to achieve well-defined goals. An instructor should ask questions which will require students to use the thinking skills which he is trying to develop. A system exists for organizing those thinking skills. Bloom's Taxonomy (Benjamin Bloom (ed)., Taxonomy of Educational Objectives: Handbook 1 Cognitive Domain (New York: David McKay Co., 1956)) is a hierarchical system of ordering thinking skills from lower to higher, with the higher levels including all of the cognitive skills from the lower levels.

Below are the levels of the taxonomy, a brief explanation of each one, and examples of questions which require students to use thinking skills at each level.

1. **Knowledge** - Remembering previously learned material, e.g., definitions, concepts, principles, formulas.
    - What is the definition of "verb"?
    - What is the law of supply and demand?
    - What are the stages of cell division?
2. **Comprehension** - Understanding the meaning of remembered material, usually demonstrated by explaining in one's own words or citing examples.
    - What are some words which are commonly used as adjectives?
    - What does the graph on page 19 mean?
    - Explain the process of digestion.

3. **Application** - Using information in a new context to solve a problem, to answer a question, or to perform another task. The information used may be rules, principles, formulas, theories, concepts, or procedures.
    - Using the procedures we have discussed, what would you include in a summary of Bacon's essay?
    - How does the law of supply and demand explain the current increase in fruit and vegetable prices?
    - Based on your knowledge, what statistical procedure is appropriate for this problem?
4. **Analysis** - Breaking a piece of material into its parts and explaining the relationship between the parts.
    - What are the major points that E. B. White used to develop the thesis of this essay?
    - What factors in the American economy are affecting the current price of steel?
    - What is the relationship of probability to statistical analysis?
5. **Synthesis** - Putting parts together to form a new whole, pattern or structure.
    - How might style of writing and the thesis of a given essay be related?
    - How are long-term and short-term consumer loan interest rates related to the prime rate?
    - How would you proceed if you were going to do an experiment on caloric intake?
6. **Evaluation** - Using a set of criteria, established by the student or specified by the instructor, to arrive at a reasoned judgment.
    - Does Hemingway use adjectives effectively to enhance his theme in The Old Man and the Sea?
    - How successful would the proposed federal income tax cut be in controlling inflation as well as decreasing unemployment?
    - How well does the Stillman Diet meet the criteria for an ideal weight reduction plan?

LOWER AND HIGHER LEVEL QUESTIONS

At times instead of referring to a specific level of the taxonomy people refer to "lower-level" and "higher-level" questions or behaviors. Lower level questions are those at the knowledge, comprehension, and simple application levels of the taxonomy. Higher-level questions are those requiring complex application (e.g., analysis, synthesis, and evaluation skills).

Usually questions at the lower levels are appropriate for:

1. evaluating students' preparation and comprehension.
2. diagnosing students' strengths and weaknesses.
3. reviewing and/or summarizing content.

Questions at higher levels of the taxonomy are usually most appropriate for:

1. encouraging students to think more deeply and critically.
2. problem solving.
3. encouraging discussions.
4. stimulating students to seek information on their own.

Typically an instructor would vary the level of questions even within a single class period. For example, an instructor might ask the synthesis question, “How can style of writing and the thesis of a given essay be related?” If she gets inadequate or incorrect student response to that question, she might move to questions at a lower level of the taxonomy to check whether students know and understand material. For example, the instructor might ask, “What is the definition of ‘thesis statement’?” or “What are some variables in writing style?” If students cannot answer those questions, the instructor might have to temporarily change her teaching strategy, e.g., briefly review the material. If students can answer lower level questions, the instructor must choose a teaching strategy to help students with the more complex synthesis which the original questions requires, e.g., propose a concrete problem which can be used as a basis for moving to the more abstract synthesis. In the example used here, the teacher might direct students to Jonathan Swift’s “Modest Proposal” and ask, “What is Swift’s thesis?” and “What are some terms you can use to describe Swift’s writing style?”

It is not essential that an instructor be able to classify each question at a specific level. The Taxonomy of Educational Objectives is introduced as a tool which is helpful for defining the kinds of thinking skills instructors expect from students and for helping to establish congruence between the instructor’s goals and the questions he asks. Figure 1 provides a summary of the taxonomy and breakdown between lower and higher level questions. Another way to examine questions is described in the next section.

OPEN AND CLOSED QUESTIONS

In addition to asking questions at various levels of the taxonomy an instructor might consider whether he is asking closed or open questions.

A closed question is one in which there are a limited number of acceptable answers, most of which will usually be anticipated by the instructor. For example, “What is a definition for ‘adjective’?” requires that students give some characteristics of adjectives and their function. While students may put the answer in their own words, correct answers will be easily judged and anticipated based on a rather limited set of characteristics and functions of adjectives.

An open question is one in which there are many acceptable answers, most of which will not be anticipated by the instructor. For example, “What is an example of an adjective?” requires only that students name “any adjective.” The teacher may only judge an answer as incorrect if another part of speech or a totally unrelated answer is given. Although the specific answer may not be anticipated the instructor usually does have criteria for judging whether a particular answer is acceptable or unacceptable.

Both open and closed questions may be at any level of the taxonomy.

An open low-level question might be:

"What is an example of an adjective?"

An open high-level question might be:

"What are some ways we might solve the energy crisis?"

A closed low-level question:

"What are the stages of cell division?"

A closed high-level question:

"Given the medical data before you, would you say this patient is intoxicated or suffering from a diabetic reaction?"

QUESTIONING CATEGORY	BLOOM'S CATEGORY	STUDENT ACTIVITY	TYPICAL STEM WORDS
LOWER LEVEL	Knowledge	Remembering: Facts Terms Definitions Concepts Principles	What? List Name Define Describe
	Comprehension	Understanding the meaning of material	Explain Interpret Summarize Give examples ... Predict Translate
	Application	Selecting a concept or skill and using it to solve a problem	Compute Solve Apply Modify Construct
HIGHER LEVEL	Analysis	Breaking material down into its parts and explaining the hierarchical relations.	How does ... apply? Why does ... work? How does ... relate to ...? What distinctions can be made about ... and...?
	Synthesis	Producing something original after having broken the material down into its component parts.	How does the data support ...? How would you design an experiment which investigates...? What predictions can you make based upon the data?
	Evaluation	Making a judgment based upon a pre-established set of criteria.	What judgments can you make about ...? Compare and contrast the ... criteria for ...?

PLANNING QUESTIONS

Effective questioning sessions in classroom require advance preparation. While some instructors may be skilled in extemporaneous questioning, many find that such questions have phrasing problems, are not organized in a logical sequence, or do not require students to use the desired thinking skills. Below are some steps and suggestions for planning questions.

1. Decide on your goal or purpose for asking questions. Your goal should help you determine what levels of questions you will ask.
2. Select the content for questioning. Choose material which you consider important rather than trivial. Students will study and learn based on the questions you ask. Do not mislead them by emphasizing less important material.
3. Phrase your questions carefully.
   - Ask questions which require an extended response or at least a "content" answer. Avoid questions which can be answered "yes" or "no" unless you are going to follow with more questions to explore reasoning.
   - Phrase your questions so that the task is clear to students. Questions such as "What about foreign affairs?" do not often lead to productive answers and discussion. "What did we say about chemical bonding?" is too general unless you are only seeking a review of any material the students remember.
   - Be sure the questions allow enough flexibility so that students are not playing a guessing game. Avoid "guess what I am thinking" questions.

Example of "guessing game" questioning:

Instructor:	What is a symptom of Multiple Sclerosis?
Student 1:	Numbness.
Instructor:	What else?
Student 2:	Tingling.
Instructor:	What else?
Student 3:	Blurred vision.
Instructor:	I'm thinking of a different one.
Student 4:	Slurred speech.
Instructor:	O. K., that's the one I was looking for. Let's go on from there....

   - Your questions should not contain the answers. Avoid implied response questions when you are genuinely seeking an answer from the class. A question such as "Don't we all agree that the author of the article exaggerated the dangers of agent orange to strengthen his viewpoint?" will not encourage student response.

4. When planning your questions try to anticipate possible student responses. You might do this by considering:
   - What are some typical misconceptions which might lead students to incorrect answers?

- Am I asking an open or closed question?
- What type of response do I expect from students, a definition? Example? Solution?
- Will I accept the answer in the student's language or am I expecting the textbook's words or my own terms?
- What will my strategy by for handling incorrect answers? (See Handling Student Responses for suggestions).
- What will I do if students do not answer? (See Handling Student Responses).

Anticipating student responses should help in your planning by forcing you to consider whether phrasing is accurate, whether questions focus on the goal you have in mind, and whether you have enough flexibility to allow students to express ideas in their own words.

5. Until you are quite skilled at classroom questioning you should write your main questions in advance. Arrange your list in some logical sequence (specific to general, lower level to higher level, a sequence related to content). Should you think of additional or better questions during the questioning process, you can be flexible and add those or substitute them for some of your planned questions. However, having a prepared list of questions will help to assure that you ask questions appropriate for your goals and representative of the important material.

INTERACTION SKILLS

Effective use of communication skills by both instructors and students is conducive to the development of positive interaction in the classroom. In order to have successful exchanges between instructors and students:

1. Students should feel free to ask questions of the instructor and their peers.
2. Students should feel free to answer questions.
3. Students should not feel threatened by giving an incorrect response.

In this section we will consider some of the components of successful interactions including:

1. Physical setting.
2. Instructor attitude.
3. Hints for calling on students to maximize student participation.
4. Wait-time after asking questions.
5. Handling student responses to questions.
6. Responding to students' questions.

PHYSICAL SETTING

The instructor needs to be aware of the acoustics of the room in which he teaches. Can students hear you when you ask a question? Can students hear other students ask and answer questions?

1. If you teach in a large lecture hall and want to foster participation, it is a good idea to move students close to each other and close to the front of the room.
2. Facilitate interaction in a small seminar group by arranging students in a circle so that they face each other.
3. In a lab setting make sure students do not begin working on their own until you have finished the lecture/discussion part of the session. It is difficult for students to interact if they are not attentive or if other students are using equipment.

INSTRUCTOR ATTITUDE

An important aspect of atmosphere is “attending behavior” or what an instructor does while a student answers a questions. Generally the instructor should be listening to the student, encouraging him to continue, and helping to focus the attention of the class on the student who is responding to the question. This can be accomplished in several ways:

1. Maintain eye contact with the student answering. Some instructors find that they also glance around the room from time to time to determine whether class members are listening.
2. Use nonverbal gestures to indicate your understanding, confusion, or support--head nodding, facial expression, hand gestures which signal the student to continue, or physical stance which indicate that you are thinking about the student’s answer.
3. Listen to the student! Do not interrupt even if you think the student is heading toward an incorrect answer. At times a student may realize his own mistake. On other occasions you may simply have misunderstood where the student was going with his answer. Even on the frequent occasions when a student does reach an incorrect answer the other students may learn as much from the incorrect response as from a correct one. Furthermore, interrupting students does not create an atmosphere which encourages participation. You might try using some of these active listening suggestions:
   - Wait for a second or two following a student response to be sure that you have listened to everything and that the student has finished talking.
   - You might wish to paraphrase a long answer and check with the student to be sure your perception of his response is accurate. This technique, when judiciously applied, makes students aware that you are listening.
   - Use the student response to lead to the next question or to make a point. Again, this demonstrates that you are listening.
   - While listening to the student try to determine whether you do understand his point. If you don’t understand, ask for more information of explanation.
   - Listen for the content of what the student is saying, not simply for expected jargon or key phrases.
   - Focus your attention on the student, not on what you intend to do next (i.e., ask a question, or end the class).

CALLING ON STUDENTS TO MAXIMIZE PARTICIPATION

1. Call students by their names as opposed to pointing in their general direction. This avoids confusion as to who was called upon and also helps create a positive climate where students feel you know them as individuals.
2. Ask questions of the entire class and try to encourage all students to participate. The advantage of calling on only volunteers is that it may be less threatening. A disadvantage of calling on only volunteers is that a small number of students will be answering all your questions. It is possible to call on nonvolunteers in a nonthreatening manner by:
   - Speaking in a tone of voice which is friendly.
   - Using positive nonverbal cues while calling on the person, e.g., smiling, eye contact.
   - If the nonvolunteer is incorrect or cannot respond, accept his nonresponse without insulting him. Perhaps ask if another student in the class can help him out.

> *Example:*
>
> Kate: I don't know.
>
> Instructor: O. K., can anyone help Kate out?

3. In order to encourage nonparticipants, call on specific students to answer questions. You can phrase a question, then call on the student. If you call the student's name first, the rest of the class may not listen to the question.
4. Make an attempt to randomly select students to respond. Try not to follow any set pattern when calling on students. For example, if you call on each student in a row, students learn to listen only when it's close to their turn to answer.
5. Try to avoid repeating all student responses. Teacher repetition causes students to learn to listen to you, not their fellow students. In addition, hearing each response twice is boring.
6. Beware of the student who dominates in class by asking or answering all the questions. Try to encourage other students to respond by suggesting others volunteer or by calling on nonvolunteers.
7. Give students an opportunity to ask questions. Do not use "Any questions?" as your only form of feedback from students. Sometimes students are so confused they cannot even formulate a question. In addition many students will not participate because they do not want to make mistakes in front of their peers.
8. Avoid asking all of your questions at the end of the session. If a student was lost at the beginning, he has missed an entire session by the time you have asked a question. Students may also be less willing to answer at the end of the session as they are getting ready to leave.
9. Avoid looking down at notes after asking a question. You should be looking for volunteers and noting confusion or understanding of students.
10. Your nonverbal reactions should complement your verbal responses. For example, it is usually ineffective to say "good point" while looking away or reading notes.

WAIT-TIME

One factor which can have powerful effects on student participation is the amount of time an instructor pauses between asking a question and doing something else (calling on a student or rewording the question).

Research on classroom questioning and information processing indicates that students need at least three seconds to comprehend a question, consider the available information, formulate an answer, and begin to respond. In contrast, the same research established that on the average a classroom teacher allows less than one second of wait-time.

After teachers were trained to allow three to five seconds of wait-time the following significant changes in their classrooms occurred:

- The number of students who failed to respond when called on decreased.
- The number of unsolicited but appropriate responses increased.
- The length of student responses increased.
- The number of student statements where evidence was used to make inferences increased.
- The number of responses from students identified by the teacher as less able increased.
- The number of student-to-student interactions increased.
- The number of student questions increased. (Rowe, 1974)

Allowing wait-time after a student response or question also produced significant changes in classroom interaction. The most notable change was that the instructor made fewer teaching errors characterized by responding illogically or inappropriately to a student comment.

On the other hand, too much wait-time can also be detrimental to student interaction. When no one seems to be able to answer a question, more wait-time will not necessarily solve the problem. Experts say that waiting more than 20-30 seconds is perceived as punishing by students. The amount of wait-time needed in part depends upon the level of question the instructor asks and student characteristics such as familiarity with content and past experience with the thought process required.

Generally lower-level questions require less wait-time, perhaps only three seconds. Higher-level questions may require five seconds or more. With particularly complex higher-level questions some instructors tell student to spend two or three minutes considering the question and noting some ideas. Other instructors allow five to ten seconds of thinking time and then ask students what processes they are using to investigate the questions; this strategy makes students aware that thought process is at least as important as an answer and that alternative processes can be applied to arrive at an answer to the same question.

HANDLING STUDENT RESPONSES

An important aspect of classroom interaction is the manner in which the instructor handles student responses. When an instructor asks a question, students can either respond, ask a question, or give no response. If the student responds or asks a question, the instructor can use one of the following recommended questioning strategies: rein-force, probe, refocus, redirect. If the student does not respond the instructor can use either a rephrase or redirecting strategy. A description of each strategy follows:

1. **Reinforcement.** The instructor should reinforce in a positive way student responses and questions in order to encourage future participation. The instructor can reinforce by making positive statements and using positive nonverbal communication. Proper nonverbal responses include smiling, nodding, and maintaining eye contact, while improper nonverbal responses include looking at notes while students speak, looking at the board or ruffling papers.

   The type of reinforcement provided will be determined by:

   - The correctness of the answer. If a student gives an answer which is off target or incorrect, the instructor may want to briefly acknowledge the response but not spend much time on it and then move to the correct response.
   - The number of times a student has responded. Instructors may want to provide a student who has never responded in class with more reinforcement than someone who responds often.

   CAUTION: Vary reinforcement techniques between various verbal statements and nonverbal reactions. Try not to overuse reinforcement in the classroom by overly praising every student comment. Students begin to question the sincerity of reinforcement if every response is reinforced equally or in the same way.

2. **Probe.** Probes are based on student responses. The initial response of students may be superficial. The instructor needs to use a questioning strategy called probing to make students explore initial comments. Probes are useful in getting students more involved in critical analysis of their own and other students' ideas.

   Probes can be used in different ways. Probes can be used to:

   - Analyze a student's statement, make a student aware of underlying assumptions, or justify or evaluate a statement.

Example:	
Instructor:	What are some ways we might solve the energy crisis?
Student:	I would like to see a greater movement to peak-load pricing by utility companies.
Instructor:	What assumptions are you making about consumer behavior when you suggest that solution?

   - Help students deduce relationships. Instructors may ask student to judge the implications of their statements or to compare and contrast concepts.

Example:	
Instructor:	What are some advantages and disadvantages of having grades given in courses?
Student 1:	Grades can be a motivator for people to learn.
Student 2:	Too much pressure on grades causes some students to stop learning, freeze, go blank.
Instructor:	If both of those statements are true, what generalizations can you make about the relationship between motivation and learning?

- Have students clarify or elaborate on their comments by asking for more information.

Examples:	
Instructor:	Could you please develop your ideas further?
Instructor:	Can you provide an example of that concept?
Student:	It was obvious that the crew had gone insane.
Instructor:	What is the legal definition of insane?
Student:	It was a violation of due process.
Instructor:	Can you explain why?

3. **Adjust/Refocus**. When a student provides a response which appears out of context the instructor can refocus to encourage the student to tie her response to the content being discussed. This technique is also used to shift attention to a new topic.

Example:	
Instructor:	What does it mean to devalue the dollar?
Student 1:	Um – I'm not really sure, but doesn't it mean that, um, like say last year the dollar could buy a certain amount of goods and this year it could buy less – does that mean it devalued?
Instructor:	Well, let's talk a little bit about another concept, and that is inflation. Does inflation affect your dollar that way?

4. **Redirect**. When a student responds to a question, the instructor can ask another student to comment on his statement. One purpose of using this technique is to enable more students to participate. This strategy can also be used to allow a student to correct another student's incorrect statement or respond to another student's question.

Examples:

Instructor:	Bill, do you agree with Mark's comment?
Instructor:	From your experience, Roger, does what Carol said seem true?
Instructor:	Blake, can you give me an example of the concept that Pat mentioned?

5. **Rephrasing**. This technique is used when a student provides an incorrect response or no response. Instead of telling the student she is incorrect or calling upon another student, the instructor can try one of three strategies:
   - The instructor can try to reword the question to make it clearer. The question may have been poorly phrased.

Example:

Instructor:	What is neurosis?
Student 1:	(No response).
Instructor:	What are the identifying characteristics of a neurotic person?

- The instructor can provide some information to help students come up with the answer.

Example:

Instructor:	How far has the ball fallen after 3 seconds, Ann?
Student:	I have no idea.
Instructor:	Well, Ann, how do we measure distance?

- The instructor can break the question down into more manageable parts.

Example:

Instructor:	What is the epidemiology of polio?
Student:	I'm not sure.
Instructor:	What does "epidemiology" mean?

RESPONDING TO STUDENT QUESTIONS

There are many ways in which an instructor can respond to questions from students. However, all strategies begin with this important step:

LISTEN TO THE STUDENT'S QUESTION.

This is another time to use your active listening skill (See Instructor Attitude).

After you are certain you understand the question, be sure that other students have heard and understood the question. Strategies from this point include:

1. Answer the question yourself. This strategy is best when you have little time remaining in class. The disadvantage of this approach is that you do not encourage student-to-student interaction or independent learning.
2. Redirect the question to the class. This strategy helps to encourage student-to-student interaction and to lessen reliance on the instructor for all information.
3. Attempt to help the student answer his own question. This may require prompting through reminders of pertinent previously learned information. Or this strategy may require you to ask the student a lower level question or a related question to begin his thought process. The advantage of this strategy, as in redirecting, is that the student may learn the process of searching for answers to his own questions rather than relying on the teacher. The risk is that the process can be embarrassing or so threatening that the student will be too intimidated to ask questions in the future. Obviously some human compassion is called for when using this strategy.
4. Ask the student to stop after class to discuss the question. This strategy is most appropriate when a student raises complicated tangential questions or when a student is obviously the only one who does not understand a point and a simple answer does not clarify the point. Even in these situations there are risks in using this strategy. Students may be intimidated from raising questions in class. The instructor may think that only the questioning student does not understand when actually a number of students are having the same problem.
5. Refer the student to a resource where she can find the answer.
6. Defer the question until a more appropriate time but NOT THE QUESTION AND THE STUDENT; RETURN TO THE QUESTION at an appropriate time.

No matter which strategy you use you should return to the student after addressing the questions and determine whether the response has satisfied the student.

If you don't know the answer to a student question NEVER FAKE AN ANSWER. Admit that you cannot answer the question and then select one of these strategies or others you find appropriate:

1. Ask whether someone in the class can answer the question. Most times after class you should follow this with an attempt to determine whether the information provided was accurate or based on sound reasoning and credible sources.
2. Either propose a plan for obtaining evidence for answering the question or ask the students to suggest how the question could be investigated.

3. If possible, suggest a resource where the student can find information. The resource may be written material, another faculty or staff member, a student, or someone from the community.
4. Volunteer to find the answer yourself and report back to the class. Make sure you actually do return with the answer if you choose this option.

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