INTRODUCTION

Dear Student,

You are welcome to Unit 1 of Module SC/1.

AIM

The aim of this unit is to enable you learn about the nature (characteristics) of science so that you will be able to plan, organize and teach it to the primary school children effectively.

OBJECTIVES

By the end of this unit, you should be able to:

- Distinguish between science and non-science.
- Identify and explain steps in the scientific method and problem solving process.
- Apply the scientific method to solve a scientific problem.
- Identify and explain the Primary Science Process Skills and Attitudes.
- Explain the role of a teacher in the development of Science Process Skills.

This unit is divided into five (5) topics as follows:

Topic 1: What is Science?

Has 3 sub-topics.

(a) Definition of Science
(b) Characteristics of Science
(c) How Science develops

Topic 2: The Scientific Method and Problem-Solving Process

Has 2 sub-topics.

(a) The Scientific Method

- Nature and steps
- Importance and limitation

(b) Problem-solving Process

Topic 3: The Primary Science

Topic 4: Scientific Attitudes

Topic 5: What is Science Education?

Has four sub-topics

(a) Characteristics of Science Education
(b) Values and objectives of teaching Science in the Primary Schools
(c) Components of Science Education
(d) Integrated Science

SUBJECT ORIENTATION

Effective science teaching requires plenty of materials and commitment. Fortunately, materials for science teaching are all around you. Some of the activities in this unit require you to have a collection of such materials. So please, utilize your environment.

A list of references is given at the end of this unit. Be sure to note important points as you read on.

STUDY REQUIREMENTS

You will need a pen, notebook and a quiet place to study. At the end of each section, there are activities. Some of these activities are practical. Be sure to utilize your environment to obtain the necessary materials. Also ensure that you do the activities. You are encouraged to discuss some of these activities with a friend or colleague if there is an nearby. If there is none nearby, be sure to discuss them with your tutor or colleague during face to face.

TOPIC 1: WHAT IS SCIENCE?

(a) Definition of Science

Let us begin with a short activity:

ACTIVITY SC/1/1-1

1. In your notebook, write two or three sentences to explain what you think the term science means to you.

2. Discuss these sentences with your friend or colleague.

4 Check your answer with those given at the end of the unit.

Science is a particular activity carried out by people. It is a major area of human mental and physical activity. We all engage in it to some extent – you and I and the children in our schools. It is a way of life. We are "doing science" when we look for patterns and regularities in the living and non-living things that make up the world we live in and try to explain them.

ACTIVITY SC/1/1-2

List down four (4) examples of patterns or regularities that you observe in your daily life.

(a) .....
.....

(b) .....
.....

(c) .....
.....

(d) .....
.....

4 Check your answers with those given at the end of the unit.

Scientific activities generate a body of organized knowledge about the universe (universe: everything that exists. Includes all physical matter, all stars and planets). Science is both a process and a product. A process is a way of doing things. As a process, science comprises of activities that we do by ourselves.

These activities generate concepts, facts, knowledge, skills and attitudes as products of science. The definition of science is complex. But we can refer to it as a body of knowledge that is verified and validated. It is generated through the method of science

that involves observation, experimentation and rationality. This well-proven body of knowledge is known as scientific knowledge.

ACTIVITY SC/1/1-3

Distinguish between a process and product of a scientific activity.

.....
.....
.....
.....

4 Check your answers with those given at the end of the unit.

(b) Characteristics of Science

It is important for us to identify the distinctive qualities and features that separate science from other subjects. This will enable us teach the subject more effectively, say, as part of an activity where it is integrated with other subjects. Harlen (1993); P.8) identified the following characteristics of science:

- The physical world around is the ultimate (final) test by which the validity of scientific theories and principles are judged. This means that if science is about understanding, as we saw in our definition, then its theories must be judged by how well it does this.

- Science is about understanding. It involves arriving at relationships between observed facts that enable predictions to be made. The aim of learning and doing science is to create understanding and to have explanation for what is known from which predictions are made based on the available evidence. A scientist used these existing ideas to make a prediction and observes to see if these predictions fit the facts. If they do not, the theory has to be changed, if facts are undisputed.

- The understanding and theories are tentative. They are subject to change at any time in the light of new evidence.

- Science is a human activity and depends on creativity and imagination. It has changed in the past, and will change in the future as human experience and understanding changes.

ACTIVITY SC/1/1-4

1. Do you agree that scientific theories and understanding are tentative? Give reasons to support your answer.

   .....
   .....
   .....
   .....

2. Why is creativity and imagination important in science?

   .....
   .....
   .....
   .....

3. Briefly explain the importance of knowing the characteristics of science in our teaching.

   .....
   .....
   .....
   .....

4 Check your answers with those given at the end of the unit.

(c) How Science Develops

In the previous sub-topic it was recognized that all of us do science to some extent. It is therefore important that we develop this activity in our classrooms. To do this we should consider the following:

- Children's age level and experiences. This will enable the teacher to select appropriate activities for the children.
- Resources: These are materials that enhance/facilitate the learning process.
- Teaching sequence: Science work falls into three phases.

1. Setting up the Problem

(a) Ensure that the problem is meaningful to the children in terms of their experiences.

(b) Focus on the actual materials to be used or tested. Involve children in determining the materials they need. Collect their opinions.

(c) Establish the practical action that is needed to put opinions to the test. The following questions could guide you: "What could we do to find out?" What could we do differently?

2. Preliminary Exploration

Children explore materials. This is a trial stage where children and teacher identify and assess the level of their investigative skills. It is a diagnostic stage and should not be rushed. Most teachers are not patient with children and tend to rush them. Remember that for some children this exploratory stage may be sufficient as an early scientific experience thus a need to help them draw together what they have done.

3. Investigating

This involves the actual manipulation of variables making observations, recording, analysis data and drawing conclusion.

- **Class Organization**

There are as many ways of organizing science in the classroom as there are teachers. However, they fall in three main categories:

(i) **Whole Class**

A whole class is given the same kind of activity at the same time. They work as a class.

(ii) **Small Groups**

Class is divided into smaller groups (e.g. in two's, three's or four's). Each group is given a particular activity to do. At the end, each group presents its findings to the rest of the class to discuss. Alternatively all groups could be the same activities at ago. So that any point left out by one group, another group can being it out.

(iii) **Out of Class Time**

Science activities are organised and done outside of the normal class time. It can be during science club meetings or projects. This allows ideas to be tried out with well-motivated children.

ACTIVITY SC/1/1-5

1. Describe one activity that you have done or you are planning to do with your class to help them develop their scientific experiences.

---

2. Share this activity with your friend or colleague.

---

4 Check your answers with those given at the end of the unit.

TOPIC 2: THE SCIENTIFIC METHOD AND PROBLEM-SOLVING PROCESS

(a) The Method of Science

Over the years, people have developed special methods of working that enable them find out about the world in a systematic way. This special method is called the Method of Science. Through this method, people have gradually built up a framework of scientific knowledge – a set of ideas that enables us to interpret the world in a particular way. This framework of scientific knowledge is:

- Coherent (carefully connected and understandable)
- Logical
- Extensive
- Continually being extended as new discoveries are made.

The validity of the scientific knowledge all rests on the nature of the process that is used to create it.

ACTIVITY SC/1/1-6

List down four (4) characteristics of scientific knowledge.

1. ---
2. ---
3. ---
4. ---

4 Check your answers with those given at the end of the unit.

Nature of the Method of Science

The method of science consists fundamentally of a search for evidence – empirical evidence based on observation and experiment that can be used to support ideas and explanations that have been put forward. Sometimes the evidence shows that the ideas are wrong. In this case the ideas have to be modified to take account of the available evidence. The process of subjecting ideas to the test ensures that they survive only if they accurately reflect and interpret what is being observed in reality. The method of science incorporates observations, explorations, experimentations and rational thinking.

The method of science is also called Empirical Method.

ACTIVITY SC/1/1-7

1. Why is it important to subject ideas to test?

---

2. Why is observation important in the method of science?

---

4 Check your answers with those given at the end of the unit.

Steps in the Method of Science

Steps in the method of science are illustrated in the following example, in which a group of students was investigating the relationship between the height to which a ball bounces and the type of surface on which it was dropped.

- Children <u>observe</u> something in the world around them.

  {The ball is red and round. I thing it does not bounce}
  {Very high on the carpet or foam}

- They <u>raise questions</u> about the things they have observed.
  {What makes the ball bounce high?}

- Children formulate a hypothesis which is a tentative answer to their own questions and which they can test in a scientific way.

  {A ball bounces higher on a harder surface}.
- Children plan and carry out an experiment investigation to test whether this hypothesis is correct or not. They measure how high the ball bounces on a foam mattress, sand, and on concrete surface floor).

- Children look at the results of their experiments and interpret the data they have collected and using this to decide whether or not their hypothesis was correct.
  {Yes, our ball did bounce higher on a harder surface}

- Children select the most appropriate way in which to communicate their findings to other people.
  {The group describes to the whole class the work that they have been doing}.

ACTIVITY SC/1/1-8

Using your own experience, briefly describe how you might have used/applied a Scientific Method to solve a problem. Be sure to identify clearly the steps in the Scientific Method.

.....
.....
.....
.....
.....

4 Check your answers with those given at the end of the unit.

Importance of Methods of Science

The Method of Science

- Enables children acquire skills that will enable them make sense of the world by themselves.
- Trains the children to be orderly and systematic in approaching problems.
- Builds on children's natural curiosity and impulse to find out things, thus helping them to be critical.

Limitations

- The method of science is very tiresome to apply. Children may not be able to apply it.
- Requires a lot of patience and perseverance on the side of the children.

ACTIVITY SC/1/1-9

Think of other importance and limitations of the Scientific Method. Write them down in your Notebook.

Compare your list with that of your friend or colleague.

(b) Problem Solving

The following passage illustrates the nature of problem solving. Read it carefully and do the activity that follows.

The children has just watched a video about the four basic types of bridges as part of the topic on waterways. The teacher explained that the problem was to make a bridge that would span (cross) a distance of a half a meter and support a mass of half a kilogram at any point along its length. Construction materials cost money, so the lighter the bridge, the better.

The children decided to construct a beam bridge. After an unsuccessful attempt at using a single piece of paper, they realized that they would have to increase its rigidity in someway. They thought of various ways of doing this and drew plans to help them. The group measured and constructed five triangular paper beams, which they then taped together. They tested their bridge and found that it successfully fulfilled the conditions. They began to wonder how they could improve on their design so that it used fewer materials. The completed work was displayed for parents to see at the school open day.

ACTIVITY SC/1/1-10

1. Identify the steps in the Problem-Solving process illustrated above.

---

2. Compare your answers with that of your friend.

---

4 Check your answers with those given at the end of the unit.

Problem solving is an activity that involves children finding a solution to an open-ended question (question that has no specific answer). This type of problem is linked to practical applications of scientific ideas or technology. If children are able to apply what they have learned in this way, the ideas become more relevant to them.

In the bridge-building example, the children set out to solve a problem posed by their teacher, but often they think of their own. Problem solving can often arise out of other types of activities, particularly when children need to make special equipment. Problem solving can also lead to other scientific activities. The bridge-building group may have gone to test which type of paper would be best for the job.

ACTIVITY SC/1/1-11

List down three characteristics of problem solving.

1. ----------

   ----

2. ----------

   ----

3. ----------

TOPIC 3: THE PRIMARY SCIENCE PROCESS SKILLS

When children use existing ideas to attempt to make sense of new experiences, and when their ideas change as a consequence, that outcome – the learning – depends on the way in which they select, gather, process and use information.

The term scientific process skills refers to the mental and physical skills that are involved in obtaining scientific knowledge. The process skills however are not easily separable in what children do.

In the following sections, we shall discuss the process skills that are thought to be important for a primary school child. We shall also discuss the nature of these skills, and how they can be identified and developed.

The Science Process Skills

There are many process skills in science and not all the skills will feature in anyone lesson. The following skills are worth emphasis at the primary level: measuring, manipulation, observing, classifying , using hypothesis, testing ideas (investigating) and communicating. These match their levels of cognitive development.

Observation

Observation involves the use of our senses to gather information. It is a mental activity and not just a response to stimuli. As mentioned earlier, existing ideas and expectations play a significant role in this activity.

Teacher's Role in Developing Observation

The main purpose of developing observation in children is to enable them use all of their senses appropriately and safely to gather information from their investigations of things around them. At the beginning, the teachers' role is to provide:

- Opportunities for children to make wide ranging observations.
- Interesting materials/objects for children to observe.
- Appropriate aids to observation e.g. magnifiers.
- Sufficient time for children to observe materials
- Invitation for children to observe
- Encourage discussion of what is observed.

Indicators of Observation

Children will exhibit (show) the following behaviour:

- Make use of several senses in their observations.
- Notice relevant details of the object and its surroundings.

- Identify similarities and differences in the observed objects.
- Recognize the order in which events take place.
- Use aids to the senses for studying details.

Remember:

Observation is at the foundation of science. It is an activity and to understand it, you must do it.

ACTIVITY SC/1/1-12

For this activity, you need: 2 spoonfuls of common salt, sugar, glucose (white dextrose), white chalk powder, maize flour, cassava flour and water.

- Examine each of the substances above carefully.
- Record your observations.
- Reflect on the following:

  - Did you use all of your senses in your observation?

  - Did you consider safety in handling these solids?

  - When did you decide how to record your observations?

  - Did you make any measurements?

  - Did you use scientific words life "dissolve?"

    ---

4 Check your answers with those given at the end of the unit.

Hypothesizing

A hypothesis (P1. hypotheses) is a statement put forward to explain some happening or feature. When hypothesizing, a suggested explanation need not be necessarily correct,

but should be reasonable in terms of the available evidence and possible in terms of scientific concepts or principles.

Concept: Perceived idea or a mental picture/image about an object or event.

Principle: Summary of what usually happens under given conditions. Usually formulated after a series of experiments have been conducted under various conditions.

Teachers' Role in Developing Hypothesizing

- Encourage children to ask questions that require thinking of:

    - Why do you think some leaves turn brown?
    - What do you think could be the reasons for leaves turning brown?

- Encourage children to give details of their suggestions and share them with others.

- Explain children's shared observations so that they feel they have the ability to make sense of things around them.

- Encourage children to use their existing ideas in their explanations.

Indicators of Hypothesizing

Children will:

- Suggest an explanation that is consistent with the available evidence and some scientific concepts or principle.

- Apply previous knowledge in attempting an explanation.

- Realize the tentative nature of any explanation.

ACTIVITY SC/1/1-13

1. Hold a plastic bottle horizontally, level with your mouth.

   Carefully place a pea (seed) inside the neck of the bottle.

   - What do you think will happen if you blow into the bottle?

     ---

2. Holding the bottle still, bow into the bottle with a hard but short and sharp breath. Observe what happens. Repeat the experiment until you are sure your observations are reliable.

   - What do you think causes the effect you have observed?

   - Suggest explanations for the effect and derive tests which will provide evidence for or against the explanation.

   - Write as many hypotheses (tentative explanations) which can be tested, as possible.

     ---

   4 Check your answers with those given at the end of the unit.

Prediction

A prediction is a statement about what may happen in the future or what will be found that has not been found so far. It is based on some hypothesis or previous knowledge.

Example

If you know how far a motor cycle can go on ten litres of petrol, it is possible for you to predict how far it will go thirty litres of petrol. Please not that even if there is a strong basis for a prediction, there is a possibility that it will not be supported by evidence of finding out what really happens. Variation may stretch to positive or negative. There is a need to extrapolate (applying a relationship beyond the range of available evidence) or interpolate (applying a relationship within the range of available evidence).

Teachers' Role in Developing Prediction

- Provide opportunity for children to observe and make predictions.
- Provide opportunity for them to discuss their predictions

Indicators of Prediction

Children will:

- Use evidence from past, or present experience in stating what may happen.
- Use patterns in evidence to extrapolate or interpolate.
- Justify a statement about what may happen or be found using the present evidence or past experience.
- Be cautious in making assumptions about a pattern applying beyond the given evidence.
- Distinguish between a prediction and a mere guess.

ACTIVITY SC/1/1-14

In your daily life, describe an occasion when you used the available evidence to make a prediction.

---

4 Check your answers with those given at the end of the unit.

Investigating

This begins from when a question for investigation is raised or a prediction made on the basis of a hypothesis, to the collection of evidence and the subsequent interpretation of data. It involves putting together different types of thinking and action concerning planning and carrying out investigation.

Teacher's Role in Developing Investigation

- Provide problems and not instructions for solving them. Children will do the planning.
- Provide a framework for planning that is suitable to children' experiences (questions that guide them through the steps of thinking about what variables are to be changed, controlled or measured).
- Review what is being done during an investigation according to the original plan, bearing in mind that not everything can be anticipated before hand.

- Discuss activities with children at the end to consider how the investigation could have been improved.

Indicators of Investigation

Children will:

- decide the variables to be changed (independent variables) and the ones to be kept constant (controlled).
- manipulate variables
- identify the variables to be measured or compared (dependent variables).
- make measurements or comparisons of dependent variables using appropriate instruments.
- work with appropriate degree of accuracy.

ACTIVITY SC/1/1-15

Partly fill a bottle with water and tap it with a spoon. Add some more water and tap again.

(a) What do you observe about the pitch of the two sounds?

(b) Design and carry out investigation to find the relationship between the pitch obtained by tapping and the amount of water in the bottle.

(c) Discuss whether it is the amount of water that is important or something else related to it.

(d) Propose a hypothesis to account for this relationship.

(e) Test your hypothesis using different sets of bottles

4 Check your answers with those given at the end of the unit.

Interpreting Findings and Drawing Conclusions

Interpreting involves putting together results so that patterns or relationships among them can be seen. Patterns may be regular or irregular. The ability to recognize patterns in data/evidence enables children to make sense a mass of information that would be difficult to grasp as isolated events or observations.

Teachers' Role

- Provide opportunities in form of activities where simple patterns or general trends can be found – practical work.
- Enable children talk about their findings and how they interpret them – by questioning and listening.
- Expect children to check interpretations carefully and to draw only those conclusions for which they have evidence – discussion and practical work.
- Organize for interpretation of findings to be shared and discussed critically.

Indicator of the Skill

Children will exhibit the following behaviour.

- Put various pieces of information together to make a statement of their combined meaning.
- Find patterns or trends in observations or results of investigations.
- Identify a relation between one variable and another.
- Make sure that a pattern or relationship is checked against all the data.

ACTIVITY SC/1/1-16

Repeat the experiment in the previous activity, but instead of tapping, try blowing across the top of the bottles to obtain the notes.

- Is this further evidence for or against your hypothesis?

- When a bottle is filled from a steady stream of water falling directly into it, the pitch of the noise of the bottle filling changes. Use your hypothesis and the evidence to make a prediction as to how the pitch changes. Test your prediction.

  ---

4 Check your answers with those given at the end of the unit.

Communication

Talking, writing, drawing or representing things in various ways are not only means by which we let others know about our ideas, but also as sort out what we think and understand. Communication is important in learning process, communication in science involves using conventions of representation, which help in organizing information and

conveying it effectively. Graphics, tables, symbols, etc. swerve this purpose. They have to be selected to suit particular kind of information.

Communication is a two way process and involves the ability to take information from written sources, use information presented in graphical or tabular form, thus expanding the evidence that can be used in testing ideas.

Teachers' Role in Developing Communication

- Organize the class so that children can work and discuss in groups.
- Provide a framework/structure children's tasks that encourages group discussion and keeping of formal notes/records.
- Introduce a range of techniques for recording information and communication results using conventional forms and symbols.
- Discuss appropriate ways or organizing and presenting information to suit particular purposes.

Indicators of Communication

Children will be:

- talking, listening or writing to sort ideas and clarify meaning.
- making notes of observations in the course of an investigation.
- selecting an appropriate means of communication so that it is understandable to others.
- using secondary sources of information e.g. books, newspapers, radio, television.

Communication can be verbal – involves talking, or non-verbal – use of symbols, tables, signs, etc.

ACTIVITY SC/1/1-17

Briefly describe an activity you can give to your class to develop communication.

---

4 Check your answers with those given at the end of the unit.

TOPIC 4: SCIENTIFIC ATTITUDES

In topic 1, we mentioned that attitudes are one of the products of science. But what are attitudes? What is their importance in science and how can we develop them? You will be able to find answers to these questions by the end of this topic.

Attitudes are defined as the state of being prepared to react in a particular way to particular objects, situations or persons. Scientific attitudes are used to describe people's (children's) reactions to science as a subject and to the activities of scientists (Harlen, 1993: P.72). There are many attitudes of value to science teaching and learning. In the following section, we shall consider those that are though to be relevant to the primary school children.

Curiosity

Curiosity is an individual's natural questioning or wanting to know. It facilitates (enhances) learning of all kinds, particularly by inquiry. Curiosity often manifests (shows) itself in form of questioning. Questioning brings satisfaction to children if it enables them share their pleasure and excitement with others. Children will also develop interest in finding answers to their questions. Because curiosity appears as wanting to know, the desire to find out stimulates effort to find out, perhaps by investigation, use of library, visits or asking a friend or teacher for information.

ACTIVITY SC/1/1-18

List down two characteristics of a child who is curious.

How does curiosity enhance/bring about learning in Science?

---

4 Check your answers with those given at the end of the unit.

Respect for Evidence

Science is essentially the process of gathering and using evidence to test and develop ideas. Therefore, the use of evidence is crucial in scientific activities. Obtaining

convincing evidence requires a high degree of perseverance. Perseverance, as an aspect of respect for evidence is willingness to try again accompanied by learning from earlier failure so that later attempts or ideas are modified by experience. One should not be discouraged by failure. The second aspect of respect for evidence is open-mindedness. Its starting point is being ready to listen, or to attend to different points of view. A scientist accepts knowledge as far as it is true at the time.

Willingness to consider conflicting evidence is another aspect of respect for evidence. This calls for the need to listen to others and the extent to which each of them shows open-mindedness.

ACTIVITY SC/1/1-19

List down three aspects of the attitude respect for evidence.

1. ----------
2. ----------
3. ----------

4 Check your answers with those given at the end of the unit.

Flexibility

As we mentioned in topic one, scientific concepts, knowledge and understanding are tentative. As children become older their ideas undergo changes. Flexibility involves willingness to reconsider ideas and recognizing that ideas are tentative. It is important that children change their ideas as new evidence is obtained. Flexibility harmonizes the experiences that conflict with the existing ideas that would otherwise cause confusion and create a rival ideal instead of modifying the existing one.

Flexibility is important in adapting existing frameworks to fit increased experience.

ACTIVITY SC/1/1-20

Explain in your own words the importance of flexibility in learning science.

---

4 Check your answers with those given at the end of the unit.

Critical Reflection

This refers to looking back over what has been done to see if procedures could have been improved or ideas better applied. It is related to respect for evidence and flexibility. It is much more concerned with making more conscious effort to consider alternatives to what has been done.

Critical reflection may be seen in form of self-critical moments, in repeating part of an investigation, or starting again in another way or just recognizing the useful action done. Other indicators include: reflection of what has been done and using it as something to learn from, pausing instead of continuing without a second thought, with another activity. The importance of this attitude is that it increased the potential for learning.

ACTIVITY SC/1/1-21

1. List down four indicators of critical reflection

   (a) ---
   (b) ---
   (c) ---
   (d) ---

2. What is the value of critical reflection in the learning process?

   ---

4 Check your answers with those given at the end of the unit.

Sensitivity to Living Things and Environment

Environment is a magnificent resource for science learning. Children are therefore encouraged to investigate and explore their environment so as to understand it and develop skills for further understanding. It is important that children become sensitive and responsible toward environment and all the living things around them. Elstgeest and Harlen (1990) p. viii & ix) emphasize that getting to know the environment is a very personal experience for the child who is at centre of it.

ACTIVITY SC/1/1-22

Do you agree that environment plays a significant role in the learning of Science? Give reasons to support your answer.

---

4 Check your answers with those given at the end of the unit.

Teachers' Role in Developing Scientific Attitudes

Attitudes cannot be directly taught. They are developed over a long period of time. In order to enhance their development in children, a teacher should:

- Show an example worth copying (emulating). He/she should be a role model.
- Create a classroom climate that gives approval to the behaviour that demonstrates the attitude.
- Provide opportunity for the attitude to be shown, in the case say of flexibility, exposing children to alternative ideas.
- Make allowances for individual differences
- Encourage children to dissociate ideas from their sources

ACTIVITY SC/1/1-23

Reflect on your own teaching and describe one instance when your actions encouraged the development of any one scientific attitude in your class. Name the attitude.

---

4 Check your answer with those given at the end of the unit.

END OF UNIT ASSIGNMENTS

1. List four ways in which the method of science is similar to problem-solving process.

   (i) ----------
   (ii) ----------
   (iii) ----------
   (iv) ----------

2. Given a bird's feather, explain how you can use it to develop the skills of observation and communication.

3. List down two characteristics of a scientific attitude.

   (i) ----------
   (ii) ----------

4. Discuss briefly five reasons why science should be included in the primary school curriculum.

5. Look at the primary school science syllabus. List down the aspects that make up the subject science.

TOPIC 5: SCIENCE EDUCATION

(a) Characteristics of Science Education

Science is a discipline (subject) in the school curriculum. Science education emphasizes a 'process' approach to the teaching and learning of science. That is, it stresses the way in which a scientist thinks and works, rather than the facts or concepts of science. This means important knowledge should also be taught.

As s discipline, science education has:

- Well defined philosophy (line of thinking that guides its activities).
- Central concepts, (for example: gravity, acidity, heredity, etc).
- A network of relationships formed by various concepts (for example: aids corrode metals, metals conduct electricity, etc).
- A body of knowledge that is organized and systematic.
- Processes and methods that are peculiar to it.
- Results from a synthesis of content and processes.
- Science education is an interactive force with society, i.e. science contributes to the well being of a society. On the other had society too contributes a great deal to science, by way of resources to enhance learning.
- Science Education has its own language and conventions that are used to convey scientific concepts and ideas.
- Science Education has a method of assessment.

ACTIVITY SC/1/1-24

Discuss what you consider to be the philosophy of science with a friend or colleague.

ACTIVITY SC/1/1-25

Think of as many arguments as you can to support the case for teaching science to primary children.

There are several reasons why science is an important subject for the primary school. The following are some of the reasons:

- Science teaches children important skills e.g. analyze, count, experiment, etc.
- It teaches them to think in a clear and logical way.

- It helps them to solve simple practical problems.
- Science also helps children to develop their physical skills e.g. Ability to handle things.
- All these skills are useful to children when they grow up to live a better life.
- Science is important to other subjects and other subjects are important to science e.g. mathematics, and language development.
- Science is a 'doing' subject. Children like to do things and will enjoy the subject and develop positive attitude.
- Science teaches children important knowledge.

  In the primary we should be emphasizing the process of learning science rater than the 'facts' but the facts will emerge.

- Primary school is terminal for many children in many countries and this is the only opportunity they may have to explore their environment logically and systematically.

ACTIVITY SC/1/1-25

Discuss the importance of projecting science as a human activity. Compare your answer with that of your friend.

4 Check your answer with those given at the end of the unit.

(c) Components of Science Education

Science education comprises of the following disciplines: Biology, Health Education, Environmental Education, Physics, Astronomy, Chemistry, Agriculture and some elements of Geography and Mathematics, (Math and Geography (SST) appear on timetable as separate subjects). Math abilities (skills) are considerably required in Science Education.

ELEMENTS OF THE INTEGRATED SCIENCE CURRICULUM

Definition of Curriculum

A curriculum is the sum of all the experiences a pupil/learner undergoes. This means the learning experiences a pupil undergoes in a school system can both be planned and unplanned.

The curriculum can be classified into two as: formal or official and informal curriculum.

The official/formal curriculum

This is the planned curriculum which goes on at school. The activities are timetabled

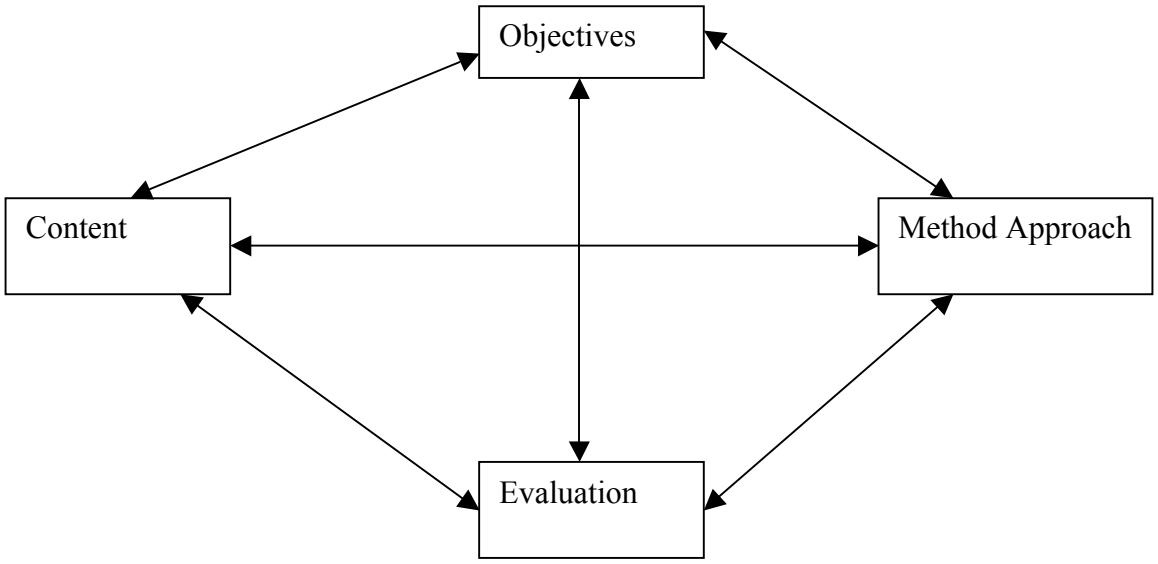
The informal curriculum

These are informal activities, unplanned and learned unconsciously.

Elements of the Formal Curriculum

There are four major elements of the formal curriculum: Objectives, content, methods/approach and evaluation.

Curriculum



ACTIVITY SC/1/1-26

Outline reasons why you should vary methods in a science lesson.

3Check your answer with those given at the end of the unit.

ANALYSIS AND INTERPRETATION OF THE INTEGRATED PRIMARY SCIENCE SYLLABUS

Definition of syllabus

A syllabus is the way the learning experiences are organized. A syllabus is made up of the following components:

- A syllabus should have objectives
- It should have the methods
- It should have the content
- It should have assessment and evaluation methods.

Integrated Primary Science Syllabus

Integration in science involves using skills, concepts ideas, knowledge and attitudes in one subject area of the curriculum to enhance science learning.

The primary science is integrated at four levels:

(a) Integration of subjects: the primary science is not divided into different subjects e.g. Biology, Chemistry, Physics, etc, but integrated body of knowledge.

(b) Integration of school science and community. This means science learnt in classroom is applied at home and community.

(c) Integration of the environment and the classroom environment. That is, the school is not isolated from the environment, what is learnt in the classroom is integrated into environment.

(d) Integration of theory and practice.

Advantage of Integration in Science

- Enhances acquisition of skills, knowledge and attitudes.
- Maintains learner' interest because the barriers imposed by subject fragmentation are broken.
- Cheaper because the same materials can be used for other subjects.
- Enables learners to easily identify patterns and trends in content, and how these relate to one another.
- Emphasizes holistic nature of learning.
- Facilitates the application of various skills acquired in other areas of the curriculum.
- Stimulates the application of various skills in other areas of the curriculum.
- Stimulates the development of a curious and questioning mind.
- Enhances problem solving.

The Primary Science Curriculum uses an integrated approach. Components of Science Education are taught as a single subject without any identical subject boundaries.

ACTIVITY SC/1/1-27

Explain how you can use the concepts/skills in SST to teach science in the primary school.

---

4 Check your answers with those given at the end of the unit.

ACTIVITY SC/1/1-28

(a) What are some of the challenges facing the integrated primary science curriculum?

(b) Suggest possible solutions to the challenges

4 Check your answers with those given at the end of the unit.

SCHEME OF WORK

Definition

A scheme of work is a plan which organizes a syllabus content by breaking it up into lessons. It puts the content in a logical order for learning purposes. The plan identifies how much time is actually available for teaching.

What to Consider when Drawing a Scheme of Work

1. The teaching syllabus should be studied to know the amount of work to be covered.
2. The scheme of work should reflect the learners ability and interest.

3. Know the school calendar e.g. the length of the term, how many periods are provided in a week and interruptions e.g. public holidays.
4. Know the method of assessment e.g. continuous assessment.
5. Consider the amount of work covered by other teachers in the same class.

The Importance of Scheme of Work

1. It helps a teacher to read ahead and therefore build academic confidence in advance.
2. It helps the teacher to identify areas of integration.
3. The teacher is able to budget time in terms of syllabus content.
4. Incase of a new teacher taking over a class the scheme of work helps him/her to find out where to start from.
5. The teacher will be able to sequence the content logically.
6. It increases the teachers creativity for teaching.
7. The preparation of lesson will be easier if the scheme of work is well made.

SCHEME OF WORK

School: _____

Class: _____

Year: _____

Number of Pupils: _____

Week	Period	Topic	Content	Objectives	Method	Activities	Instructional Materials	Reference	Comment

ACTIVITY SC/1/1-29

Imagine you arrive at a primary school as a new teacher. You are expected to teach science.

(a) What kind of information would you seek?
(b) How would you decide what you will teach in your science lesson?

4 Check your answers with those given at the end of the unit.

LESSON PLAN

Definition

A lesson plan is the breakdown of the schemes of work into specific teachable outline. A lesson plan can also be defined as a procedure to be followed in the teaching-learning process.

The lesson plan requires the teacher to have creative mind before actual lesson planning on paper.

What Does Making a Lesson Plan Involve

Making a lesson plan involves the following:

1. Stating in advance what you want the learners to learn in terms of instructional objectives.
2. Specifying the sequence of content and activities.
3. Describing the teaching methods and instructional materials.
4. Describing how learners will participate in the teaching learning process.

The Importance of a Lesson Plan

1. It helps a teacher to remember what, when, why, where, how and who to teach the planned content.
2. It enables the teacher to gain a reading culture and make lesson notes.
3. It also makes a teacher to develop confidence during teaching because he/she has reference material.
4. A lesson plan also helps for a logical development and presentation of the lesson.

The Lesson Plan Format

Different subjects offer different formats of lesson plans e.g. tabular, in phases, in stages etc.
All the different lesson plans must have the following characteristics:

1. Preliminaries
2. Topic/Unit/Theme/Aspect
3. Objectives. The objectives must be SMART
   i.e. S - Specific
   M - Measurable
   A - Achievable
   R - Realistic
   T - Time bound
4. Instructional materials. These provide support to the methods and activities in a given lesson.

5. Lesson presentation has four major divisions:

   (i) The introductory phase. The introduction depends on the teacher. A teacher may choose to draw the attention, arouse interest or establish continuity with the previous work. An introduction sold be short e.g. 2 – 3 minutes.
   (ii) Experience phase. Gives learners practice or inquire. This is a phase where the learners are busy doing.
   (iii) Sharing phase. During this phase the pupils and the teacher discuss and share experiences in the activities.
   (iv) Evaluation phase. The teacher and learners bring out the important ideas from the experiences. The evaluation can be divided into two as:

      (a) Summary and
      (b) Exercises; let these experiences be written in the books and property planned.

Lesson presentation forms the main body of the lesson plan and enables teaching in a logical sequence. Lesson presentation can be drawn in a tabular form. See the example below:

Phase	Time	Content	Teacher's Activities	Pupils' Activities

ACTIVITY SC/1/1 - 30

Select a topic of your own choice from the primary science syllabus:

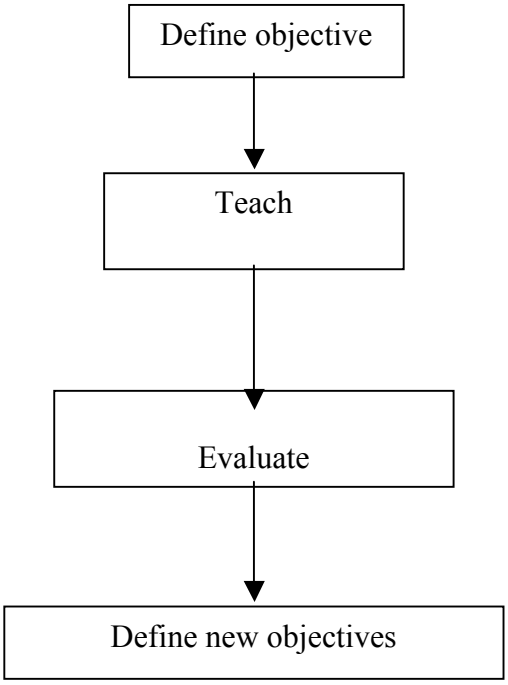
(a) Draw a scheme of work for two weeks in which science is taught four periods per week in P.3 class of 45 pupils.

(b) Make a lesson plan for any one lesson from the scheme of work you have drawn in (a) above.

* Use the guidelines given in the module to check your answer.

EVALUATION OF CHILDREN'S PROGRESS

Evaluation means to assess the children's progress.
Why do we need to evaluate?
We evaluate to discover if we have achieved the lesson objectives



Types of Evaluation

1. Formative Evaluation

It is on-going evaluation (continuous assessment). It provides feedback to the teacher and the learners early enough for appropriate action to be done. It helps to detect weakness before it is too late.

2. Summative Evaluation

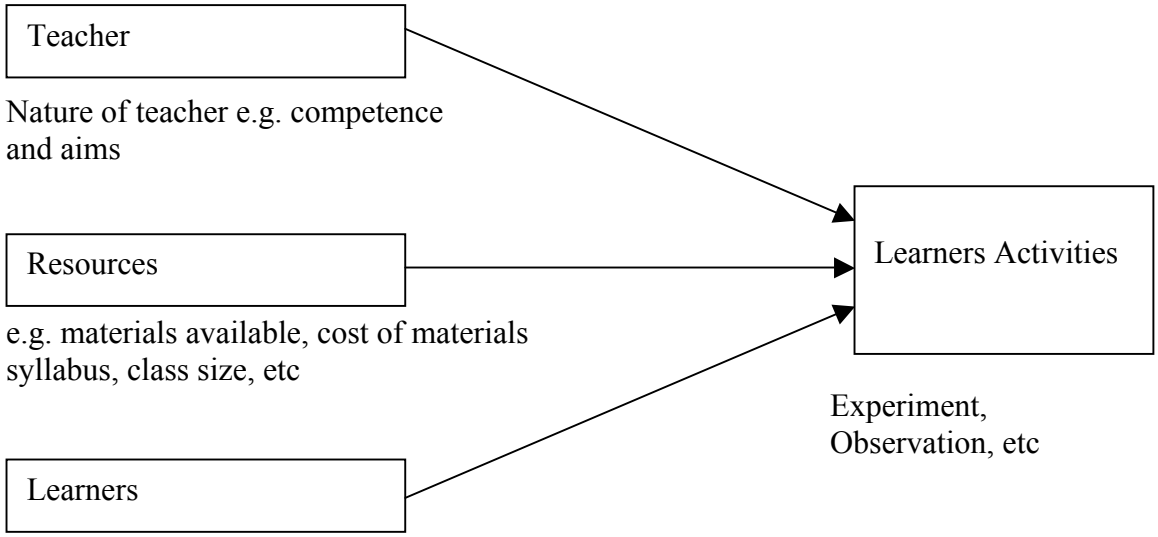
This is done at the of the programme e.g. Primary Leaving Examinations, etc.

TEACHING METHODS

A teaching method is a way of facilitating learning. The choice of a method of teaching depends mainly on 3 factors:

1. The nature of the learners; the ability, the level of the learners, their interest and their background.
2. Resources available for teaching e.g. boots, equipment, teaching aids, etc.
3. The teacher; does he/she have the ability?

Choice of Method of Teaching



SOME EXAMPLES OF TEACHING METHODS

Discovery/Inquiry Method

The teacher provides a variety of learning materials so that the pupils can discover a specific knowledge. The teacher helps to correct wrong concepts.

The teacher should ask guiding questions and give instructions and correct some mistakes. Allow the pupils to make guesses (hypothesis).

Advantages of Discovery Method

- There is high retention by learners
- Helps develop scientific skills e.g. observation
- Learners build confidence in their work
- Allows learners to learn to use equipment
- Makes the learners to be creative.

Disadvantages of Discovery Method

- It requires longer time for children than other methods.
- Requires materials which may be lacking.

Demonstration/Illustration Method

A teacher or expert performs a skill or an activity as the learners observe and later given chance to practice.

Advantages of Demonstration

- Can be used with limited apparatus.
- A wide coverage can be done quickly.
- It is easier to demonstrate than to explain.
- It holds pupils' attention.

Disadvantage of Demonstration Method

- It is teacher centred.

Chalk and Talk/Lecturer Method

The teacher talks and writes down main points and gives assignments.

Advantages of Chalk and Talk/Lecture Method

- A lot of content can be covered in a short time.
- Does not require use of materials
- Less expensive
- Pupils learn at the same time and the same information.

Disadvantages of Chalk and Talk/Lecture Method

- Pupils are passive in learning.
- Lesson are only on teachers' interest, wishes and abilities.
- It encourages cram work.
- Does not cater for practical work.
- Does not encourage pupils to think critically.

Discussion Method

A discussion involves at least two people. The teacher tells what to discuss. The teacher also guides the pupils not to go off topic. The teacher should also establish a good, favourable atmosphere.

ACTIVITY SC/1/1 - 31

(a) What are the advantages of discussion method of teaching?
(b) What are the disadvantages of the method?

3 Check your answers with those given at the end of the unit.

Project Method of Teaching Science

A project is a cooperative study of a real life situation by an individual or group of learners under the guidance of the teacher. It allows learners to be deeply involved and accept responsibility towards science.

Advantages of Project Method

1. Encourages spirit of inquiry.
2. Pupils learn to cooperate with each other
3. It makes science connected with real life situation.
4. Develops self-reliance and confidence among learners.

Disadvantages of Project Method

- Time consuming
- Requires the teacher to be alert in following pupils work.
- May require a lot of materials which may be unavailable.

ACTIVITY SC/1/1 - 32

What do you consider when planning for a project?

3 Check your answer with those given at the end of the unit.

HOW TO INCREASE PUPILS' PARTICIPATION IN A LESSON

This can be done in the following ways:

1. Adequate preparation i.e. clear lesson objectives, varied teaching methods, teaching aids, appropriate activities.
2. Good questioning techniques e.g. distribution of questions, giving time to think about the questions, frequency of the questions.

3. Good quality of the teacher's explanations e.g. clear explanations. It is also good to use the pupils' contributions.

4. Effective classroom control and management.

5. Effective lesson presentation.

6. Being alert to unique pupil behaviours and problems

7. Good teacher pupil-relationship. Do not be tool friendly that the pupils do not respect you and do not be too harsh to scare the pupils.

8. Teacher should respect personality of the learners. Shame and embarrassment, should be avoided because they tend to produce loss of confidence and frustration.

9. Securing attention and enthusiasm in the learners.

10. Rewards and punishments should be appropriately used to effect future conduct favourably.

ANSWERS TO UNIT 1 ACTIVITIES

ACTIVITY SC/1/1-1

1.
- Science is a body of organized knowledge.
- Science is a process. It is a way of doing things.

2. To discuss with peer/friend or tutor.

ACTIVITY SC/1/1-2

Examples of patterns or regularities in life

- Rising and setting of the sun.
- Season of the year.
- Number of fingers in one's hands.
- Steps in a storey building.
- Rising and setting of moon.

ACTIVITY SC/1/1-3

Process: Way of doing something/way of obtaining knowledge, facts or concepts. Involves observation, hypothesizing, investigation, etc.

Product: Result/what is obtained as a result of the process. They are in form of facts, concepts and knowledge.

ACTIVITY SC/1/1-4

1. Yes. They are changed/their truth hood is changed as new evidence is found. What may be true today may not be true in the next few years.

2. Creativity and imagination are important because they are the basis of all scientific discoveries. Children are naturally creative.

3. Knowing the characteristics of science enables as to identify clearly the features of science that make it different from other subjects e.g. history.

    - We are able to select the appropriate content and methods of delivering it to the children.
    - We are also able to select suitable activities and assessment procedures for the children.

ACTIVITY SC/1/1-5

Activities will vary from student to student. It is important that you share yours with a friend or colleague.

ACTIVITY SC/1/1-6

Characteristics of scientific knowledge.

- Coherent - carefully connected together.
- Logical - obtained as a result of systematized inquiry.
- Extensive - not limited to a specific area.
- Tentative - can be changed in view of new evidence.

ACTIVITY SC/1/1-7

1. So that they accurately reflect what is observed in reality.
2. Enables us become aware of the existence of the problems. It is a foundation of all science.

ACTIVITY SC/1/1-8

In the examples the following steps should be clearly identified.

- Occurrence and definition of the problem.
- Statement of hypothesis.
- Experimentation/testing hypothesis.
- Observation/recording data and interpretation.
- Drawing of conclusions.
- Making results public/communication.

ACTIVITY SC/1/1-9

To discuss with a friend or tutor during face to face.

ACTIVITY SC1/1-10

1. Steps in the problem solving process:

   - Problem posing
   - Making hypothesis
   - Designing and carrying out experiments.
   - Testing and refining the observations, data, results.
   - Communication/display.

2. Compare your answer with that of your friend.

ACTIVITY SC1/1-11

Characteristics of problem solving

- Involves children finding out a solution to a problem by themselves.
- The problem is open-ended and of practical applications.
- Can lead to further or other scientific activities.

ACTIVITY SC/1/1-12

Self-reflections to be discussed during face-to-face

ACTIVITY SC/1/1-13

1.
- Seed will be pushed into the bottle
- Bottle will make/produce sound
- The seed will dance up and down inside the bottle

2. (a) The seed
   (b) Vibrations of the seed
   (c) To be discussed during face-to-face

ACTIVITY SC1/1/1-14

Be sure to present this for discussion during face to face

ACTIVITY SC/1/1-15

(a) Pitch will be higher in the second attempt.
(b) Two bottles of the same type are needed.
Half-fill one bottle with water. Fill the second bottle ¾ way. Tap, both bottle with the same spoon and note the difference in their pitch.
c – e Discuss with a friend or tutor during face to face.

ACTIVITY SC/1/1-16

To discuss with a friend or tutor.

ACTIVITY SC/1/1-17

Example

Bring a bird's nest into the class. Ask the children to describe it either verbally, or in written form. Let the children have a close observation of the materials used for making it, the type of bird and builds that type of nest, etc.

Children can draw these birds, and their nests. In this way you will be helping them communicate their ideas to others.

ACTIVITY SC/1/1-18

1. A curious child:

- Wants to know
- Asks questions about whatever he comes across and idea s with others.

3. Children are able to share their experiences and idea with others.
   Curiosity stimulates a child to find out and ask questions.

ACTIVITY SC/1/1-19

Three aspects of respect for evidence.

- Perseverance
- Open-mindedness
- Willingness to consider conflicting evidence.

ACTIVITY SC/1/1-20

Flexibility enables an individual to fit/accommodate new experience.

- Discuss your explanation with a friend or tutor.

ACTIVITY SC1/1-21

1. Indicators of critical reflection

- Individual is self-critical.
- Repeats part of an investigation/procedure or the whole of it.
- Recognizes what has been done.
- Uses the previous activity as a pre-requisite to another.

2. Critical reflection enhances the motivation to learn.

ACTIVITY SC/1/1-22

Environment:

- Source of scientific content
- Resources

ACTIVITY SC/1/1-23

Self-reflections to be discussed with a friend.

ACTIVITY SC/1/1-24

- Discuss your philosophy with a friend or tutor during face to face
- Philosophies may vary with individuals

ACTIVITY SC/1/1-25

Science as a human activity:

- Reveals personal commitment of scientists for children to emulate (copy).
- Creates awareness of the range and importance of emotions experienced by children during science lessons.
- Encourages impersonal and objective scientific reporting and freedom of expression.
- Leads to the development of attitudes, particularly: curiosity and inquiring mind, and respect for other people's ideas and respect for all living things.

ACTIVITY SC/1/1-26

Why vary teaching methods in a science lesson.

- To motivate learners
- To cater for different learner abilities
- To emphasize points
- Specific contents my require specific methods
- To develop different abilities of the learner
- Particular situations in a lesson may require particular methods in a lesson.
- Improve class control
- etc

ACTIVITY SC/1/1-27

You can use concepts in SST to teach science as follows:

- Important discoveries and history of great scientists e.g. Benjamin Franklin, Dalton, Darwin, etc.
- Teach the history of science in conjunction with these great personalities.
- Teach the historical development of science e.g. the evolution and origin of life.

ACTIVITY SC/1/1 - 28

(a) Some challenges facing integrated primary science syllabus.

- Lack of enough trained teacher
- Inadequate teaching materials
- Does not give appropriate skills (vocational skills)
- Budget constraints in Ministry of Education
- Poor teacher motivation
- Poor parent involvement school activities
- Etc

(b) Possible solutions

- Training more teachers through e.g. DEPE, in-service, etc.
- Improvisation of teaching materials
- Vocationalise the curriculum by reviewing it.
- Government to allocate more money to education sector
- Improving teachers conditions of service
- Involve parents more in school activities.
- Etc

ACTIVITY SC/1/1 - 29

(a) Information you would seek as a new teacher.

- Existing scheme of work.
- Syllabus
- Science teacher responsible.
- Time table
- School situation e.g. rural/urban
- Apparatus/equipment
- Work already done
- etc

(b) Considering approach

- Process approach: subject matter should be chosen according to process i.e. problem solving.
- Considering other factors e.g.
  - Age of children
  - Background
  - etc

ACTIVITY SC/1/1 - 30

See the formats of scheme of work and lesson plan provided use them to guide you. Or use any other formats that has all the components as the formats provided in the module.

ACTIVITY SC/1/1 - 31

(a) Advantages of discussion method:

- Pupil learn to communicate.
- Learner-centred
- Pupils learn to cooperate
- Generates an inquiring mind, etc.

(b) Disadvantages

- Some learners can be passive.
- Can be disruptive
- Learning is not uniform in all groups, etc.

ACTIVITY SC/1/1 - 32

What to consider when planning a project.

- How long project will take.
- Nature of project
- Resources
- Tasks (activities)
- Method

END OF UNIT ASSIGNMENTS

1. List four ways in which the Scientific Method is similar to problem-solving process.

   (i) ----------
   (ii) ----------
   (iii) ----------
   (iv) ----------

2. Given a bird's feather, explain how you can use it to develop the skills of observation and communication.

3. List down two characteristics of a scientific attitude.

   (i) ----------
   (ii) ----------

4. Discuss briefly five reasons why science should be included in the primary school curriculum.

5. Look at the primary school science syllabus. List down the aspects that make up the subject science.

6. How would you increase pupil's participation in a science lesson?

7. Why do you evaluate children's progress in class?

8. What do you consider when choosing a method of teaching of teaching science.

REFERENCES

Elstgeest, J. and Harlen, W. (1990), Environmental Science and the Primary Curriculum, Paul Chapman, London.

Harlen, W. (1993), Teaching and Learning Primary Science. Paul Chapman, London.

Harlen W. (1992), The Teaching of Science. David Fulton, London.

Harlen W. and Jelly S. (1989), Developing Science in the Primary Classroom. Oliver & Boyd. Hong Kong.

Harlen W. et al. (1990). Progress in Primary Science. Routledge, London.

Shayer M. and Adey P. (1983). Towards a Science of Science Teaching. Heinemann Educational Books, London.

Young B.C. (1982), Teaching Primary Scinece. Yu Luen. Hong Kong.

Dowdeswell W.H. (1981), Teaching and Learning Biology. Fakenham Press Ltd, London.

Michael S. & Philip A. (1983), Towards a Science of Science Teaching. Richard Clay Ltd, London.

Douglas J. N. (1978), Principles of Learning. Newbery Award Records. New York.

INTRODUCTION

Dear Student,

You are welcome to Unit 2 on Science Education in which you will learn about the role of practical work and assessment in Science Education.

AIMS

This unit will enable you:

- to appreciate the importance of practical work in science.
- To use practical work in the teaching and learning of science.
- Use exploration and investigation based on the environment in the teaching and learning of science.

OBJECTIVES

By the time you have worked through this unit, you will be able to:

- Distinguish between different types of practical work in science.
- Identify the functions of practical work in science.
- Discuss the importance of improvisation in science teaching.
- Identify major areas of safety concern in teaching of science and how to carry out first aid in science laboratories.

The unit is divided into six (6) topics as follows:

Topic 1: Practical work in Science

(a) What is practical work in science?
(b) Organizing practical work.

Topic 2: Improvisation of Instructional Materials and Safety Precautions

(a) What is improvisation?
(b) Why is it important to improvise?
(c) Things to buy or collect.

Topic 3: Project Work in Primary Science

Topic 4: Exploration and Investigation of the Environment in Science

(a) Exploration
(b) Investigation

Topic 5: Safety and First Aid in science Teaching

(a) Safety as a positive activity
(b) Safety in science rooms and laboratories.
(c) First Aid
(d) Treatment of accidents

Topic 6: Assessment in Context

(a) What is assessment
(b) Why assessment.
(c) Summative assessment
(d) Formative assessment.
(e) Mode of assessment.

TOPIC 1: PRACTICAL WORK IN SCIENCE

(a) What is Practical Work in Science?

Practical work in science relates to all kinds of experimental and observational activities, and in which reasoning is involved. It is an integral part of the teaching and learning process of science.

Values and Purpose of Practical Work

Values, purposes and aims of practical work are many. Kerr stipulates the main ones as:

- To encourage accurate observation.
- To develop manipulative skills.
- To verify or confirm facts and principles.
- To elucidate and make theoretical work comprehensible.
- To develop communication skills.
- To arouse and maintain interest.
- To promote scientific method of thought or reasoning.
- To provide hand-on experience.
- To make phenomena more real.
- To provide problem-solving skills.
- To develop ability to cooperate
- To develop positive attitude towards science.

Types of Practical Work

Woolnough and Allsop propose three types of practical work, namely;

- Practical exercises
- Investigations
- Experiences

Practical Exercises

These are routine laboratory experiments to verify a theory or determine a quantity and involve the use of work sheets. A practical exercise has a format.

- Aim of experiment
- List of apparatus
- Method or procedure
- Results
- Conclusion

For a practical exercise, the results and conclusions must fit closely with the theory; that is, it must provide the right answer. It is good for developing primary science skills in observation, measurement, estimation, manipulation, recording and communication (following instructions).

Examples of practical exercises are:

- To show that light travels in a straight line.
- To determine the boiling point of water.
- What happens when a candle burns?
- What are the conditions for rusting of iron?
- To determine the conditions necessary for germination of seeds.
- To show that leaves give off water vapour.
- To test for starch in foodstuffs.

Practical exercises are closed. But they are important for teaching primary science because they help in developing primary science skills mentioned above.

Investigation

Investigation involves the use of the inquiry mind. Investigation ideas and theories are generated and tested to confirm or refute them. This experiment is designed and performed to investigate or test the ideas in an open-ended way. There may be more than one answer to an investigation. Examples of investigations are:

- How can shoe polish be made?
- How does sound travel from one point to another?
- Where do seeds come from?
- Can enzymes be used to tenderize meat?

Planning an experiment and carrying it out is the essence of investigation. It is important in primary science because it helps a great deal in developing the process skills in science including the ability to plan and select equipment and materials. Investigations are generally free-range and can be approached from different directions.

EXPERIENCES

These are investigations or explorations of problem solving nature linked with real life situations. Experiences are important because they provide a feel for phenomena. They help in developing a wide repertoire of process skills, in particular problem solving skills of scientific and technological nature. Example of experiences are:

- Can a car fuel be obtained from sugar cane?
- How can bricks be made long lasting?
- How can fruit juice be preserved?
- How can work be made easier?

- What causes ebola disease?

Experiences are complex and involve a cycle process:

- Understanding the problem
- Devising strategies or plan
- Carrying out the plan
- Evaluating the solution.

It is very important to understand a problem. One can advance through the problem solving cycle only when the problem is understood. Note that experiences involve complex methods and the use of expensive equipment.

(b) Organizing Practical Work

Practical work for children should be environment based and full of explorations and investigations as well as fun. But practical work can also be laboratory based. In organizing practical work, the teacher should give consideration to the following:

- Class size
- Availability of materials/resources
- Nature of practical work/experiment
- Instructional time.

Class Size

It is difficult to handle a large class. The class could work individually or in small group usually of 5 – 6 children. The tasks could also be divided so that each individual or group of individuals, work on different tasks. A circus approach is fun to children. Here a series of tasks is given. A task is at each station, and the tasks are performed in rotations or relays.

Instructional Materials

Ensure that instructional materials or resources are available in sufficient quantities and they are of good qualities. The materials must be useable and of good qualities even if they are cheap and locally made.

Nature of Experiment

Some experiments could be potentially dangerous such as those dealing with blood, micro-organisms and explosives. The danger of such experiments should be highlighted; and they should be conducted by demonstration technique. Some experiments are complex. The class can perform them in groups and as projects.

Instructional time

Sufficient time must be given to a worthwhile practical activity. Some experiments are simple while others are complex. The latter will certainly take more time to carry out. It is important to plan the time as you organize practical activities.

ACTIVITY SC/1/2 - 1

Building a dug out canoe

1. Provide children with wood.
2. Instruct them to make a dug out canoe

What skills are developed through this activity?

3 Check your answers with those given at the end of this unit.

ACTIVITY SC/1/2 - 2

Building bridges

1. Provide the class with pieces of wood and metallic materials.
2. Instruct them to design and build a bridge.

What skills are developed through this activity?

3 Check your answers with those given at the end of this unit.

ACTIVITY SC/1/2 - 3

Observing a grasshopper

1. Let children collect grass hopers and observe them under a magnifier.
2. Ask them to describe and draw the insect.

What skills are developed through this activity?

3 Check your answers with those given at the end of this unit.

TOPIC 2: IMPROVISATION OF INSTRUCTIONAL MATERIALS

(a) What is Improvisation?

If you are to teach science well, you need a well, organized science room and apparatus of the right kind and amount. Many teachers of science in the primary schools often think that they cannot teach science without the standard, expensive and sometimes complicated apparatus. It is certainly true that some standard apparatus is necessary but many of the things needed for science teaching at primary school level can be collected or made locally. This is called improvisation. Quite often pupils themselves are more than willing to help the teachers in this exercise of improvisation.

Improvisation refers to making an alternative equipment using locally available materials for teaching and learning science concepts meaningfully when the commercially produced equipment is not available.

As teachers of science, we make simple pieces of apparatus or models using whatever materials we can find to assist us in our teaching when the equipment or materials we need are not readily available.

(b) Why is it Important to Improvise?

Much of the standard equipment we use has to be bought, sometimes quite expensively. You will probably find that you have no funds for buying such equipment.

The commercially produced equipment or apparatus in a school may get damaged by moisture, rats, cockroaches, red ants, dust or rough handling and therefore not easily replaced.

In this circumstance, the teachers are expected to improvise equipment or apparatus to effectively teach science.

Improvisation has been found to be valuable in that:

- Improvisation encourages pupils to learn about science and also to do science through local materials.
- Local materials are cheap. So enough pieces of apparatus can be made for individual pupils or small groups within the class.
- Involvement of pupil in making the equipment gives them chance to have hands on experiences which makes learning of science more real.
- Use of local materials demystifies science.

Many teachers often feel that asking/expecting them to make equipment is asking too much of them. They are in a way right to raise such complaints because teaching is a demanding job. As teachers, have to prepare your lessons, teach, correct pupils work and organize your classrooms.

However, there is no way science can be taught effectively without teachers having to make some of the equipment for themselves.

It is now widely recognized that science is a process and an activity as much as it is an organized body of knowledge. Science cannot be learned in any deep and meaningful way by reading and discussion alone. Neither it always possible to have readily at hand the recommended equipment for the prescribed experiment.

The teacher should always bear in mind that improvisation does not mean making of complicated apparatus.

(c) Things to Buy or Collect

As a science teacher, you may have noticed that even when you are to make an equipment, there are certain things you have to inevitably buy.

You will have to buy some tools. These include scissors, saws (tenon and hack-saws) pliers, nails, metre rules, tape measures, hand drill, hammers, screw drivers, files and many others. Some of these may be borrowed from the neighbourhood of the school.

Much of the equipment you may buy for day to day use can be used in science teaching in other subjects as well.

Such materials include; match boxes, polythene bags, plastic tubes, plastic bowls, wax candles, cotton thread or string, dry cells, commercial balances, liquid measures such as jugs, and cylinders, cellotape, glue, rubber bands, pins, clips. Some of he common materials which have to be collected include scrap in form of old tins, bottles jars, plastic containers, wood, strings, wires, cardboard boxes, etc.

Heat Sources

For many experiments in science you need a source of heat. In science laboratories, this is provided by bunsen burners. These are not normally available in many colleges and rural primary and secondary schools.

Alternative sources of heat that can be used include paraffin and charcoal stoves, candle wax cut into shorter pieces.

ACTIVITY SC/1/2 - 4

1. What factors do you consider when purchasing equipment?
2. What apparatus do you need to teach science in the primary school?

3 Check your answers with those given at the end of this unit.

TOPIC 3: PROJECT WORK AND PROBLEM SOLVING ACTIVITIES IN PRIMARY SCIENCE

The teaching of science in most of our schools is mainly teacher-centred and deductive where the stress is on transmission of knowledge. The practical work in our science classrooms are in the form of teacher demonstration work. Any individual pupil participation in either teacher demonstration or pupil experiment is rigidly structured and prescriptive. The children and processes in he experiment but only in the final result.

The children pass their science examination but do not see the relevance of the science they have learned.

(a) Project Work

One way of making science interesting and relevant to the children is to use project work.

Project work is a practical activity in which children are personally involved over an extended period of time. In this activity the children:

- Develop scientific skills and processes.
- Solve real life problems.
- Make useful artifacts.
- Verify scientific phenomena and principles.
- Develop useful practical workshop skills.
- Learn to explain scientific phenomenon.
- Appreciate the usefulness of scientific knowledge.
- Use scientific knowledge to solve problems.

A project work has to be simple for primary school children to cope with. Very simple and clear instruments should be provided so that they can get to meaningful outcomes fast enough.

List of necessary apparatus and materials required should be given.

However, before you give a project to your pupils, make sure you have carried it yourself before. This enables yu to know the possible problems and how to overcome them.

Some further points a teacher should bear in mind when planning a science project for his/her class:

- The activities involved should be at the intellectual capacities and experience of the children.
- The project should require readily available materials and simple apparatus.

- Each project should be assigned to a smaller number of children.
- The instructions should point out potential hazards/difficulties and how to avoid them.
- The necessary information required to carry out the project.
- The tie required to complete the project, or pay attention to it should be short enough.

Science projects should not be prescriptive but for the children to use their own ideas, share experiences and express them.

ACTIVITY SC/1/2 - 5

1. Why should the:

   (i) Activities in a science project be within the experience of the children?
   (ii) Project require readily available materials and simple apparatus?
   (iii) Time required for a project be short?
   (iv) A project be assigned to a small number of pupils?

2. What makes project work pupil-centred approach?

3 Check your answers with those given at the end of this unit.

(b) Problem Solving Activities

The problem solving activity is a teaching learning strategy that encourages pupils' active engagement in learning tasks.

There are two ways in which problem-solving strategy can be utilized in science lessons:

- The pupils can be asked to initiate the questions or problems from everyday experience or
- The teacher can initiate the problem/question from the lesson topic.

In either cases, the teacher introduces the problems/questions in the form of activities for the pupils to do by themselves.

Problem solving activities are open-ended and involve the use of process skills. They therefore enhance meaningful development of scientific concepts and procedures.

The characteristics of good problem solving activities are:

- They relate to real life situations.
- They challenge the activities of the pupils.

- They promote speculation.
- They encourage investigation through the use of process skills.
- They promote imagination, creativity and critical reflection.
- They encourage accepting failures or success.
- They provide a wide route to learning new ideas.
- They permit pupils to make choices and take discussions.

Science teachers can use the problem solving approach by for example beginning a lesson with a problem or turn a pupil's question into a challenge which the pupil can readily try to solve by herself or himself.

The problem solving activities are basically process-oriented activities. The roles of the teacher in these activities are mainly:

- To define the objectives of the pupils into a problem to be solved.
- To set probing questions for the pupils to discuss and design appropriate approaches to answer them.
- To observe the pupils and assist them as they carry out the investigation.
- To set evaluation questions to help the pupils make sensible observations and conclusions from the investigations.

ACTIVITY SCEd/3/6

1. Suggest possible solving activities for pupils basing on the syllabus for the level you are teaching.
2. Discuss it with your colleagues and centre tutor.
3. Try out the activities with the pupils when you go back to school and see if they work. (Do self-evaluation)

3 Check your answers with those given at the end of this unit.

TOPIC 4: EXPLORATION AND INVESTIGATION OF THE ENVIRONMENT

(a) Exploration

Exploration in science based on the environment may go beyond the classroom.

It involves:

- Examination or inquiry into aspects thoroughly or
- Traveling into or through an area for purposes of discovering what is there; why they occur in the way they do.

Exploration leads to increase in knowledge about the environment. This lets children gain experience that does sharpen their sensory perception and help them to think about aspects of their surroundings.

Exploration involves field work. Field work deals wit ways and means of producing the facilities, equipment and raw materials children need for all stages of their outdoor investigations.

With exploration, scientists create awareness of the many ways in which living things and environmental conditions affect each other. From such studies, consequences of disturbing organisms and their surroundings get to be known.

This knowledge is required as a basis for changing attitudes towards the use of plants, animals, land, water in view of the ever increasing demands a rising world populations and desire for better standards of living will continue to make.

Now try out this activity.

ACTIVITY SCEd/3/7

How can you make old paper into something useful?

Materials: A range of paper products: newspaper, writing paper, toilet tissue, paper bags, envelopes, grease proof paper.

What are the differences between the above named types of paper?

What useful item could be constructed from some old paper?

3 Check your answers with those given at the end of this unit.

ACTIVITY SC/1/2 - 8

Another activity that could be tried out is to find out why different fences are made by different people.

This requires exploring reasons for a fence in your home area. List them.

3 Check your answers with those given at the end of this unit.

(b) Investigating

When you investigate, you gather information about a topic.

In what ways can this be done?

- By using your senses to notice things.
- By using instruments.
- By reading
- By talking to people

You may wish to find out how people choose their soap for bathing. Therefore, you will be investigating how people choose what to buy.

How could you find out how people choose the soap to use?
One way is to use a questionnaire. What questions would you ask in a questionnaire? You may ask.

Which soap do you buy for use in bathing?
How much does it cost?
What do you like about it?
Who buys this soap in your home?
Who uses it?

It then means that you design your own questionnaire.

ACTIVITY SC/1/2 - 9

Design a questionnaire that would provide answers to all the above questions.

3 Check your answer with those given at the end of this unit.

Remember that the questionnaire is designed but which is your target group?
How could the questionnaire be used to survey your class?
How could you survey the whole school?
How could you survey the public?

Decide with your tutor what survey may be easily carried out in your area.

Whatever is found out during your investigation is recorded and presented in a form that is easily understood.

ACTIVITY SC/1/2 - 10

Other than the questionnaire, what other ways can be used to gather information in science?

3 Check your answers with those given at the end of this unit.

TOPIC 6: ASSESSMENT

Assessment in Context

What is assessment?

The definition of the term assessment is complex. There is little consensus about its meanings and definition, even among acclaimed authorities. Often the term connotes testing, measurement and evaluation. It covers activities included in grading, examining and certifying. It is a general term encompassing all methods of judging performance, rate of progress, or difficulties experienced by a pupil.

It principally concerns pupils' learning and the placing of judgment on performance. It extends to incorporate the learning milieus, the evaluation of teachers' own practice and, consequently, the setting of objectives "which are suitably poised for the abilities and aptitudes of the pupils". Further, assessment entails the gathering of information that can ultimately be used in decision-making. Educational assessment is apparently so vast that we cannot specifically define or identify it. The concept of assessment is broad.

> Identify practical skills to be assessed at primary level of children doing science or agriculture or sports science.

Why assessment

The assessment of pupil's performance in schools is an important issue in education. There is scant literature about assessment in Ugandan schools. Still, experience shows that Uganda apparently ascribes much value to assessment (by external examination) particularly for the reasons of qualification and selection. Assessment serves a variety of functions, overt and hidden, based on educational, social, economic and political considerations.

First, it is used for measuring pupils' achievement, usually for the purpose of qualification and certification. In this aspect is usually norm-referenced.

Second, and on the heels of the preceding, assessment is used as an instrument of selection, in which the pupils are selected on the basis of their achievement for continuation of education or for some kind of occupation. The qualification and selection functions seem important to the pupils, parents and employers.

Third, and for reasons of accountability, assessment is used to monitor standards (measured in term of outcomes) and efficiency of schools. This function is particularly

important to the education authorities. The schools are though to receive and utilize enormous resources. The schools have to pay dividends or "give value for money" (Lawton, 1982). Their standards have to correspond to the provisions they receive and consume. Besides, the education authorities may use the information obtained about the standards of schools for the development of educational policy and the allocation of resources. In Uganda, the well-established schools, whose standards are usually perceived high in terms of grade results produced in the external examination, tend to be provided with adequate resources. Payment by results appears to be the norm. Sometimes head teachers and teachers whose schools produce poor results in the national examinations are punished or severely reprimanded.

Fourth, assessment is used to control the curriculum (content and teaching). It seems to dictate, "what counts as knowledge in the school system", and to ensure the teaching of those subjects that are considered important in the school curriculum. Moreover, in a hidden function, assessment tends to raise the status of those subjects which are assessable and the pupils inevitably become attracted to them. Those subjects which are not assessable, notwithstanding their worth, are relegated to a state of derogation and shunned by pupils. So far, the functions of assessment can be described as significantly summative.

ACTIVITY SC/1/2 - 11

- Which subjects in the primary curriculum are not currently assessable?
- What is the attitude of teachers and students towards the subjects? Discuss.

3 Check your answer with those given at the end of this unit.

Summative Assessment

The foregoing describes summative functions of assessment as opposed to formative assessment. Summative assessment is undertaken when the development of learning program is already completed rather than on-going. It is intended to obtain evidence about the summed effects of learning outcomes in order to allow conclusions to be drawn about how well learning has been achieved or instruction has worked. It usually comes, as in Uganda, in the form of external examinations. In these circumstances, summative assessment focuses upon products of learning rather than processes of learning. This approach perhaps indicates a major defect of summative assessment. It is totally inadequate to reflect the breadth and depth of education each student receives through such summative assessment.

Formative Assessment

Emergent views on assessment now suggest that formative assessment is more educationally rewarding, in particular to the pupils and teachers, than summative assessment. This may well signal a caution to Uganda which still relies on summative assessment.

In my mind, formative assessment is imperative. It aims at informing the programme of learning through the collection and interpretation of data obtained during the process of learning. It is important for the classroom teacher to know that their pupils are learning effectively and to appraise the teaching materials as well as the strategies employed in the process of teaching and learning. It is equally important that pupils know their progress in learning so as to understand themselves well in terms of "self-concept of ability". This necessitates an assessment that is an integral part of the process of education rather than one that is merely terminal and a bolt-on. It has to be on-going. UNEB is currently carrying out a study under the National Assessment of Performance in Education, (NAPE), to find out the best way to implement formative assessment in primary schools in Uganda.

Formative assessment functions fit more closely with the concept of assessment as an integral part of teaching and learning. From various literature, the main functions of formative assessment may be summarized as follows:

1. To diagnose individual learning difficulties and remedy teaching.
2. To monitor pupils' progress over time, feedback being used for guiding the pupil.
3. To provide feedback on teaching.
4. To enhance teacher and pupil motivation.
5. To evaluate the curriculum.

The strength of formative assessment is thought to reside in its being an on-going undertaking which permits early diagnosis of individual learning difficulties. Hence, appropriate corrective measures can be taken with a view to improving pupils' performance. A student may experience learning difficulties and show weakness. Should the weakness not be corrected in time and allowed to persist, the student cannot be expected to perform well in subsequent activities of a similar kind or where application of knowledge is required. Summative assessment will only intervene too late to correct the weakness. Therefore, formative assessment is necessary if the aim is to improve teaching and learning. It is important that the feedback is communicated to the students in such a form that they can earnestly work towards the improvement of their performance. Continuous assessment is a form of formative assessment; and is usually criterion-referenced. This means an individual's performance is measured against a set of well-established criteria.

Mode of Assessment

Teachers measure pupils' performance in science in terms of bloom's cognitive domain. The domain encompasses knowledge, comprehension, applications, analysis, synthesis and evaluation.

Knowledge deals with knowing or recognizing or recalling or performing something. This entails knowledge of facts, concepts, specifics, principles and theories. It will also entail knowledge of certain practical skills such as measurement of length, time or temperature. Knowledge tends to emphasize memory or role learning.

Comprehension deals with basic understanding of what is being communicated. It may involve translations, interpretations, explanations or extrapolations without necessarily perceiving the full implications of the communication.

Application deals with the use or transfer of existing knowledge in a novel situation. It is a way of solving a problem, for example a steel bridge is built on a roller to allow for expansion.

Analysis deals with the breakdown of communication into constituent elements to show hierarchy of ideas. It may involve analysis of elements, relationship or structures.

Synthesis deals with putting communicated materials together to form a new whole or a new pattern. It may involve product of a plan or a proposed set of operations.

Evaluation deals with placing judgment on a communication such as experimental results. Evaluation has to be critical; and should take accuracy, consistency, reliability and rationality into account. It may also consider the applicability and variability of the communication.

ACTIVITY SC/1/2 – 12

Do this exercise before you continue.

Categorize the following questions into Bloom's Cognitive domain?

1. How would you reduce loss of heat from a body?
2. Name the organ that pumps blood in mammals?
3. What are the forms of energy involved when a nail is driven into wood with a hammer?
4. What factors would you consider in sitting a poultry farm?
5. Describe the water cycle.

3 Check your answer with those given at the end of the unit.

Pupils bring affective domain with them into the classroom. The affective domain refers to attitude and values. Willingness, curiosity, preferences, needs, co-operation and others are subsumed by attitude and values. They are difficult to measure in the conventional way.

The mode of assessment of pupils performance in science incorporates objective type of questions and essay questions. The objective type of questions are the multiple choice item, the multiple completion items, assertion reason items and structured questions. Multiple choice items, structured questions can be valuable at the primary level. But for some good reasons, UNEB appropriates structured questions at the primary level.

A multiple choice (MC) item consists of a stem and usually four options or responses. Of the responses, their is only one correct answer, the rest being distracters. The correct answer is also known as the scoring key. MC items are many and easy to mark with consistency can be sampled widely from the syllabus, all items re answered by all students and they can be pretested. Besides they provide high reliability and validity.

A structured question consists of several parts based on a single topic or a common set of data. The parts are liked to each, have hierarchy and follow a logical sequence. The questions are specific and invoke free response whereby the answers will vary in completeness and accuracy.

ACTIVITY SC/1/2 - 13

What are the indices of examination malpractices. Discuss measures for curbing them.

3 Check your answer with those given at the end of the unit.

NOTES AND ANSWERS TO ACTIVITIES

ACTIVITY SC/1/2 – 5

1.
- To be able to carry it out successfully and gain confidence and enjoy it.
- To avoid pupil being frustrated by lack of materials or their interest being diverted by complex apparatus
- To be able to complete it while still enthusiastic.
- To make every pupil actually participate.

2. Pupils actively participate in it. They are not prescriptive.

ACTIVITY SC/1/2 – 6

Check differences in:

- Colour
- Strength
- Thickness
- Printed or not
- Shape
- Surface finish

The question on what is the best use for old paper has more than one correct answer e.g. making of boxes, lining tables, shelves of cupboards.

ACTIVITY SC/1/2 – 7

List of reasons for a fence:

- To keep something out.
- To keep something in.
- To shield from the wind.
- To hide an area from view.
- To mark a boundary.
- To look attractive.
- For security against intruders.

ACTIVITY SC/1/2 – 8

Bathing soap survey – Questionnaire Number 001.
What soap do you use?

Why do you buy the above mentioned soap?

Cheap

Easily forms lather

Colour

Soft on body

ACTIVITY SC/1/2 – 7

The skills are:

- Observation
- Manipulation
- Experimenting
- Measuring
- Planning
- Hypothesising
- Evaluating

ACTIVITY SC/1/2 – 2

The skills are:

- Manipulation
- Measuring
- Designing
- Selecting (materials)
- Experimenting
- Observing
- Hypothesising
- Evaluating

Mother
700

ACTIVITY SC/1/2 – 3

The skills are:

- Observing
- Drawing
- Communicating
- Recording
- Classifying

ACTIVITY SC/1/2 – 4

Factors to consider when purchasing equipment.

- Price
- Robustness
- Portability
- Buy in bulk for cheapness
- Buy what cannot be iprovised bt is necessary
- Sensitivity

Easily available

Smells nice

Any other reason

How much does it cost?

Who buys this soap in your home?
Indicate father, mother, sister, etc

ACTIVITY SC/1/2 – 9

Other than the questionnaire, other methods that could be used are:

- Observing
- Interview

ACTIVITY SC/1/2 – 10

Common sites of accidents

Playgrounds, science rooms, workshops, school garden, etc

ACTIVITY SC/1/2 – 11

Music, Physical Education, Art and Craft, Drama and so on.

Negative, low status, not examinable, future career, ...

ACTIVITY SC/1/2 – 12

- Application
- Knowledge
- Analysis
- Evaluation
- Synthesis

ACTIVITY SC/1/2 – 13

External assistance, smuggling, leakage, impersonation, collusion, copying, script substitution.

Measures:

Canceling results, prosecution, withdrawal of centres, disciplinary actions, barring from sitting future exams, checking candidates thoroughly, vigilance of invigilation, ...

REFERENCES

1. ASE (1981), 8th Edition, Safeguards in the School Laboratory John Murray (London).

2. Blue Prints: Science Teachers, Resource Book Series by Stanley Thomas Publishers Ltd.

3. Collis M. (1974). Using the Environment Investigations. Macdonald Educational, London.

4. David Jordan and Brian Davis (1999). Science; Knowledge, Understanding Exploration, Teachers' Guide. Stanley Thomes (Publishers) Ltd.

5. N.S.T.A, (1970), Conditions for Good Science Teaching in secondary Schools.

6. Young B.L. (1989). Teaching Primary Science, Longman.

7. John Wray Team Leader (1987). Science in Process. Part 1, Heinemann Educational Books Ltd.