

SCIENCE METHODOLOGY 2

This module on science methodology consists of ten units which are inter-related. As an intending science teacher, you need to be aware of the resources available to you for science teaching, the science laboratory as a work place, various approaches you could use for teaching and how to evaluate your students. So, the module is broken down into 10 units as follows:

- Unit 1:** Resources for Science Teaching
- Unit 2:** The Science Laboratory in Schools-definition, purpose and design.
- Unit 3:** Safety and Regulations in the Science Laboratory.
- Unit 4:** General Hazards and First Aids in the School Laboratory.
- Unit 5:** Laboratory Management.
- Unit 6:** Teaching Methods (Demonstration, Project and Group method)
- Unit 7:** Teaching Methods (expository, discussion, inquiry and discovery methods)
- Unit 8:** Innovations in Science Teaching.
- Unit 9:** Evaluation in Science Education (summative and Formative).
- Unit 10:** Evaluation in Science Education (Test types and Construction of Test Items)

UNIT 1: RESOURCES FOR SCIENCE TEACHING

INTRODUCTION

This is the first unit in this module on Science Methodology II. It introduces you to the resources necessary for science teaching. For any meaningful learning to take place, these resources must be available. These resources will be considered under human and material resources. Unit 5 will also give you more details on the human resources.

OBJECTIVES

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

1. discuss the main human resources necessary in the teaching of science.
2. describe some of the methods militating against human resources.
3. describe the usefulness of the environment as regards the community based resources.
4. state some importance attached to equipment, apparatus and instructional aids in science teaching.
5. state reasons why a science teacher must improvise in the process of teaching.

HOW TO STUDY THIS UNIT

1. This is the first unit in the module, so start by reading through properly to get a grip of it.
2. You must be used to most of the resources mentioned in the unit. So try and bring up more examples.
3. Go through all the activities which will help you understand the unit.
4. Attempt your assignment using as many references as possible to support your points.

STEP 1: THE HUMAN RESOURCES

ACTIVITY I

1. In the process of learning science in the classroom, the students come across various individuals that aid their learning –who are these?

You may have listed the science teachers, other science students, the laboratory assistants/ technicians and so on. These are called the human resources. Resource persons from the immediate school community e.g. blacksmiths, carpenter, etc should also be included.

For qualitative science education to be acquired there must be the availability of human resources.

This implies development of teachers, technicians, students etc. But the teacher factor will be emphasized at this stage.

ACTIVITY II

1. What are some of the factors militating against human resource development?

Some of your answers might include:

- (i) Insufficient funds – Most schools are over equipped with the necessary equipments and have no funds even to buy the necessary materials for science teachers. This limits the teachers’ effectiveness in his teaching and self- development.
- (ii) Lack of retraining – Most teachers do not attend workshops, seminars and conferences to improve themselves on innovative skills. Even for study leave or in service training, some are denied.
- (iii) Status of teachers - Quite a number of people would stay away from education courses because they do not want to be teachers. This is because of the low status accorded to the profession which is presently changing.

STEP 2: THE ENVIRONMENT AND THE COMMUNITY BASED RESOURCES

It is almost impossible for a single school to have all the necessary facilities for science teaching, then it will be important for the science teacher to look into the environment for community based resources.

But some teachers hardly get out of their classrooms and the need for getting out into the immediate environment where the students can explore nature and their surroundings must continually be emphasized.

The contact with the environment or community resources could be through an excursion or visit to the National Life Park, Museum, Ponds etc. Whatever is learnt in the environment could also help buttress what is learnt in classroom.

Ikerji et al. (2002) summarizes the following as ways to make more effective the use of community based resources.

- Motivation of teacher resourcefulness. The teacher should be motivated to look inwards to see alternative uses of community resources in the day to day instruction
- An initiative for cordial-social-community relationship. The community hosting every school should be made to accept their roles in conducive environment where the learning can take place.
- Retraining and workshop for science teachers. There is need for science teachers to be retrained for effectiveness.

STEP 3: EQUIPMENTS, APPARATUS AND INSTRUCTIONAL AIDS

Various researches point to the inadequacy of equipment, apparatus or materials in the school laboratories and classrooms. This is usually associated with lack of funds. Although the inadequacies differ in grade from one laboratory to another, the funding required also differs. Equipping a chemistry laboratory in the secondary school for instance may be more expensive than equipping a physics laboratory. But despite the peculiarities, equipment and instructional materials overlap in the sciences.

The introduction of the modern equipment like the computers, Multimedia projectors, video cameras and recorder has been able to supplement these facilities and facilitate the teaching and learning process.

No wonder some schools now make use of computer simulations for their practicals.

STEP 4: IMPROVISATION IN SCIENCE**ACTIVITY III**

1. Have you been faced with practicals fixed and cancelled?
2. What reasons were you given for the cancellation?

The need for the initiative to improvise or create workable substitute is an attribute of a good science teacher. These improvised materials should be kept safe and reliable. According to Anchor (2002) the following are necessary in improvisation of school materials.

- (i) Teachers, instructors and technicians should emphasize during improvisation creation of alternatives that will be used with high degree of accuracy.
- (ii) More mark should be allotted during evaluation to encourage learners to always emphasize reliability, applicability and accuracy while improvising.
- (iii) All store rooms and laboratories should be decongested of less useful improvised materials after due assessment
- (iv) Teachers, instructors and technicians should be taught improvised skills and supplied with necessary working tools to improvise in areas of needs
- (v) Uniformity in assessment should be encouraged in the evaluation of the improvised equipments.

SUMMARY

- In this unit you have learnt about the resources available to you as a science teacher and how to make the best of these resources. And where the resources are unavailable, the need to improvise was also considered.

ASSIGNMENT

1. Make a list of materials/equipment available that overlap in the Chemistry, Physics and Biology laboratories.

REFERENCES

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- Ikeoji C.N, Agwuubike C.C and Nmalada N.A.(2002) Community Based Resources in teaching Agriculture in Secondary Schools-An alternative strategy for sustainable development in Africa. **STAN proceedings**, 41, 201-205

UNIT 2: THE LABORATORY IN SCHOOLS

INTRODUCTION

Although you must have worked in one laboratory or another, have you ever stopped to consider the definition, function and layout of these laboratories?

In this unit you will learn about the laboratory in school- the definition and its functions. Factors that you should consider in siting and choosing an appropriate shape for the laboratory are also considered. This unit will be most useful for you if your school is considering building a new school laboratory.

OBJECTIVES

After reading this unit you should be able to:

1. Define a laboratory
2. List two functions of a laboratory
3. Differentiate between the indoor and outdoor laboratory
4. Advance reasons why schools opt for the indoor laboratories
5. Choose an appropriate shape in the design of the laboratory.
6. List some factors to be considered in the sitting of the laboratory

HOW TO STUDY THE UNIT

1. This unit will require your reflections on former laboratories you have been used to.
2. Cast your mind as you read through the units, thinking on the advantages and disadvantages of these laboratories as regards design and function.
3. Imagine what it will take to have a better laboratory.

STEP 1 THE LABORATORY DEFINITION AND FUNCTION

The laboratory which is a distinctive feature of science instruction has continued to occupy a central role in the science curriculum.

ACTIVITY I

1. Do you have a laboratory in your school? How would you describe a laboratory to your students?

The school laboratory is an instructional facility used by the teacher to help students learn about science and how the scientists investigate the world around them. That is, it is that school building set aside for scientific discovery/ inquiry. Students are brought in direct contact with materials, manipulating them through procedures that reflect scientific thinking.

In fact, there are various ways you could define a laboratory depending on the functions it performs.

STEP 2 INDOOR AND OUTDOOR LABORATORIES

ACTIVITY II

1. If the laboratory is where students learn what science is and investigate the world around them, then list two places where these activities take place and can be called laboratories.

There are many locations within and outside the school building that could serve as a means of helping pupils do science. For example, the school garden, the River side the mechanic work shop etc. Since these also provide meaningful science learning experiences for the students, they could be called outdoor laboratories.

ACTIVITY III

1. As a science teacher, since the outdoor laboratory would be less expensive with lots of space for student teacher interaction, then why the emphasis on having a building?

Despite the usefulness and cost effectiveness that could be associated with the outdoor laboratory, there are many problems, which necessitate the designing, planning and provision of an alternative within the closest range. Some of these problems include; the weather, proximity and organisation of outdoor activities, students' distraction and over-crowdness of the school timetable (that may not allow sufficient time for students to move to designated locations).

Some of these problems made it necessary for schools to have indoor laboratory, designed, built, equipped, organized and managed to help students learn what science is and how scientists work.

STEP 3: SITTING OF THE LABORATORY

ACTIVITY IV

1. If your proposal for a new science laboratory is accepted. Where would you want the laboratory sited?

The siting of laboratories is as important as the function they perform.

You should therefore consider the following in making your decisions.

- a) The blocks of laboratories should be sited at the end wing of the college. This is to prevent other buildings from the hazard that could arise from the laboratories e.g.

radiation, fire, explosion hazard. Also it is easier to expand the building when sited at the end wing of the school or college.

- b) All the laboratories should be sited at the same part of the school so as to enhance:
- i. Inter disciplinary works.
 - ii. Reduce walking distance between other laboratories for staff, apparatus and students.
 - iii. Share common facilities like science resource centre, workshops.
 - iv. Minimize the cost of installation of basic services like water, electricity and gas.

- c) Environmental Consideration

The laboratory should be sited along E-W direction so that the windows are made to face the N-S direction, a great illumination by the sunlight from the E-W direction is reduced. Also the E-W wind could be avoided.

STEP 4: VARIOUS SHAPES OF THE SCHOOL LABORATORY

ACTIVITY V

1. What is the shape of your school laboratory?
2. Have you noticed any disadvantages associated with the shape?

There are many shapes a laboratory can take, some of these are: rectangular, square, circular and T shapes.

- a) **The Rectangular shape**



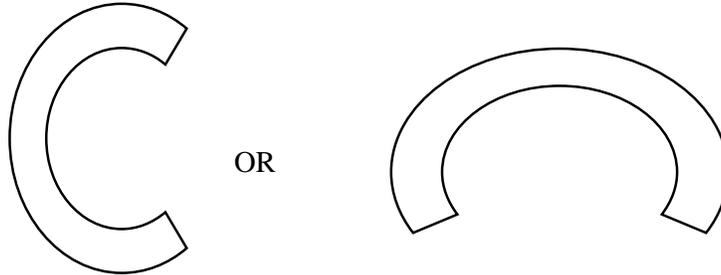
The rectangular shape has the disadvantages of having long distance between the teacher and the students at the back. Although this design is cheap, it makes teacher's supervision difficult.

- b) **The Square shape**



The square shape reduces the distances between teacher and the students and enhances supervision. Since it is cheap to design, most school opt for this.

c) **The Semi Circular Shape**



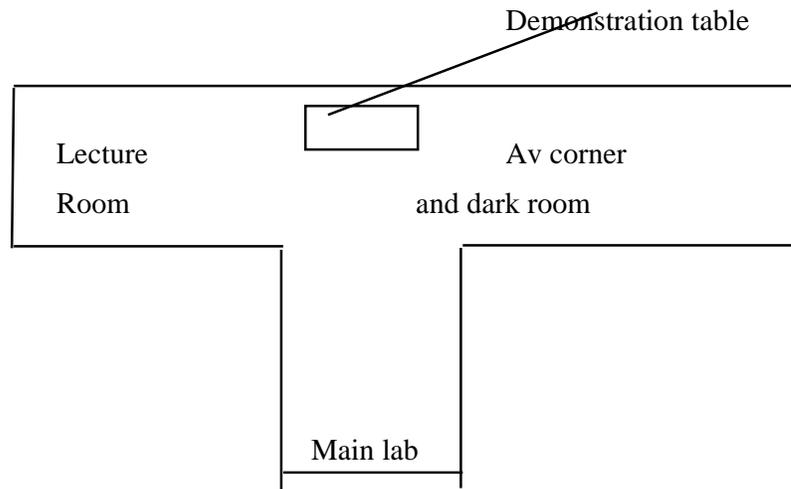
The semicircular shape brings all the students to about the same distance to the teacher and reduces the teacher-student distance to the nearest minimum. Also teacher supervision is enhanced.

Although it has advantages over the square and rectangular shape, it is quite expensive to design.

d) **The T Shape**

T-Shape has provision for the experimental work, demonstration and lectures for students as well as for audio-visual aid usage. However, because of the materials and human resources needed for this type of design, it will be very expensive. It has the advantages of saving time for movement from the lecture class to the laboratory. All the needed and available facilities could be used within the building.

The T-Shaped laboratory is quit similar to the modern laboratories proposed in unit 4 in which the classroom and the laboratory are combined.



A sketch of T-shaped laboratory

STEP 5: OTHER FACTORS TO BE CONSIDERED IN BUILDING A SCHOOL LABORATORY

After sitting and choosing the shape for the laboratory, the following should be also considered.

- a. **Purpose:** What purpose will the laboratory serve? Will it be used for Biology, Physics, Chemistry, and Integrated Science or will it be used at the ordinary or advanced level. The purpose and level will determine the inner design, organization, materials management and maintenance.
- b. **Local Condition:** Most tropical countries experience very high humidity and temperature. Hence the laboratory must be designated to have good ventilation, heat installation and enough droughts to prevent mould.
- c. **Soil Condition:** The drainage capacity of the land must be examined. Also the type of soil sand, clay, loam or the humus content. It is also necessary to consider its orientation in terms of whether it is uphill, downhill, flat plan and water table level.
- d. **Availability of Funds:** Before embarking on building any laboratory it is necessary to consider how much fund is available. For building materials, science equipment and materials have become quite expensive with the growing rate of inflation.

SUMMARY

- In this unit, you have been introduced to the school laboratory and the functions. Factors that would help you in siting and choosing the shapes of laboratories have also been considered. So should you be in a position to advice in building a new science laboratory-this unit will be handy.

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UNIT 3: SAFETY REGULATION IN THE LABORATORY

INTRODUCTION

In this unit, you will be introduced to procedures to ensure safety in the laboratory, the rules and regulations. The causes of accidents in the laboratory and general preventive measures towards those accidents have also been discussed. Also our legal obligation in ensuring safety at all times in the laboratory has been emphasized.

OBJECTIVES

After studying this unit you should be able to

1. list four (4) reasons why accident occur in the laboratory
2. state ways in which the institution or staff can be legally responsible for accidents in the laboratory.
3. list two preventive measures in ensuring safety in the laboratory.
4. list the obligation of the teachers and head of the institution towards safe working conditions in a laboratory.
5. discuss the need for rules and regulations in the laboratory.
6. state the need for wearing appropriate protective clothing in the laboratory.
7. explain the hazards of ignoring the rules and regulations in the laboratory.

HOW TO STUDY THIS UNIT

1. Read though this unit carefully because of the importance attached to safety.
2. As you read along, make a long list of safety rules and regulations that could be pasted on the laboratory wall.

STEP 1: OBLIGATION OF THE SCIENCE TEACHER/HEAD OF DEPARTMENT IN ENSURING SAFETY IN THE LABORATORY

As a science teacher or head of department has it ever occurred to you that you have to ensure that the students under your care in the school laboratories are kept safe? Many teachers are not aware of what the law requires of them as regards the protection of their students from accidents while in the laboratory. This needs to be emphasized.

ACTIVITY I

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| <ol style="list-style-type: none">1. List 4 reasons why these accidents occur. |
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STEP 2: CAUSES OF ACCIDENTS IN THE LABORATORY

Accidents occur in most instances due to:

1. **Lack of awareness:-** In some cases, the students are not told or aware of certain hazards (implications) of their actions in the laboratory. So the need for the rules and regulations for the uses of the laboratory.
2. **Lack of Control:-** There are cases where the teacher finds it difficult to control the science practical class either due to the large number, students behaviour or seating arrangement, thus making it difficult for the teacher to supervise.
3. **Lack of Knowledge:-** With the inquiry and discovery nature of science, most students want to find out through experimentation without adequate knowledge of how to go about it. Also inexperienced science teachers and unqualified laboratory assistants may cause this.
4. **Lack of the right attitude:-** Carelessness or insufficient care for instance can lead to injury of students and staff and also damage to equipments.. For instance using the mouth to pipette liquids, which are toxic or corrosive. This is an example of undesirable students' attitude. But over carefulness on the other hand could waste time. Money and reduce the students experience. It can also deflect attention from real to imaginary hazards and produce undesirable attitude.

Although there is no law that is directly concerned with the legal liability for laboratory accidents in educational institutions, but in the event of an accident, the teacher, head of department, laboratory staff concerned would have to establish that reasonable steps have been taken and necessary care exercised to avoid such offence.

If the student who is not a minor is found guilty of such an accident due to carelessness, he/she could be responsible for the acts performed and reprieved of compensation for injuries. If it is established that the institution is responsible, then compensation is claimed by the student and the teacher or laboratory staff or department may face court action for negligence of duty. This comes under the law of **Torts**. This refers to an injury or damage for which monetary compensation could be claimed in a civil court action.

ACTIVITY II

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| <ol style="list-style-type: none">1. State one thing you as the science teacher or head of department can do to avoid these accidents. |
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The head of department has a particular responsibility as the leader of the team of staff to encourage a positive attitude towards safety in the laboratory. Each student and staff in the department should be given safety rules in the laboratory. The rules should contain information on necessary procedures to prevent danger, how to contain it and medical procedures where necessary. You are to note the following measures which will be of assistance to you:

STEP 3: GENERAL PREVENTIVE MEASURES**ACTIVITY III**

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| 1. List 2 preventive measures you would take to ensure safety in the laboratory. |
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The following are the general preventive measures taken to prevent accident in the science laboratory.

- (i) Your students should not have access to the laboratory except you or the technician is around.
- (ii) You should always be the last person to leave the laboratory after each laboratory lesson. This is to make sure that your laboratory assistant turns off the gas, water electricity and cleans up.
- (iii) In addition to having a suitable fire extinguisher, a fire cupboard for noxious or unpleasant gases, a sand bucket, a scoop with a long handle, a fire blanket etc. is necessary to curb all sorts of accidents in the laboratory.
- (iv) The design of the laboratory should permit your free movement to supervise the students.
- (v) The students should not be too overcrowded in the laboratory so that you can control them.
- (vi) The fittings on the laboratory walls and floor should not stick out into the pathway in the laboratory.
- (vii) It should be possible for your students to open the laboratory windows without climbing the stools or worktables. In the design, the main control for the gas, electricity and water should be accessible to you and students to operate in case of emergency.
- (viii) To keep the laboratory clean and safe, design a daily routine of duties for the laboratory assistant.
- (ix) You should have first aid kits available and accessible to your students, laboratory assistants and other teachers.

STEP 4: THE NEED FOR RULES AND REGULATIONS IN THE LABORATORY

So many accidents as you were told in unit 2 usually occur due to lack of knowledge, control, right attitude, and awareness on the part of the students or teacher. This means that with greater precautional measure, the laboratory which is a potentially dangerous working environment could be made safe. The students learn faster from what they see you or the laboratory attendants do since they feel you are the experts. Hence your responsibility among

others is to build the right attitude, knowledge and skills to carry our students along and avoid accidents in the laboratory. So the need for rules and regulations for the staff and students.

STEP5: RULES AND REGULATIONS FOR LABORATORY STAFF

ACTIVITY IV

1. You have rules and regulations for the laboratory staff and attendants in your former school. List two of them.

Below is set of rules you must follow while working in the laboratory.

- (i) Never eat, drink or smoke in a laboratory.
- (ii) Always wear your overall coat at every practical lesson.
- (iii) Get familiar with the locations of fire alarm, first aid kit, fire extinguisher, telephone (where applicable) and other safety equipment.
- (iv) Get familiar with the position of the main switches for water, gas and electricity supply to the laboratory.
- (v) Long hair or head ties should be well packed and avoid lose jewelry in the laboratory.
- (vi) Be familiar with the emergency route and procedure.
- (vii) Avoid looking into the mouth of the test tube while heating or adding reagents.
- (viii) Ensure there are no obstruction with the door ways and emergency exits.
- (ix) Never allow your students to work alone in the laboratory without supervision.
- (x) Always wash your hands before leaving the laboratory.
- (xi) While diluting strong acids, pour the acid a little at a time to water. Never add water to acid.
- (xii) Never try to slow down or stop a centrifuge with your hand.
- (xiii) Always label containers accurately with the name and concentration of contents.
- (xiv) Avoid testing chemicals, or eating seeds or plants meant for biology practicals.
- (xv) Do not sniff materials that may be toxic.
- (xvi) Always use the fume cupboard in carrying out experiment that produces harmful gases.
- (xvii) Do not handle materials or operate equipment you are not familiar with.
- (xviii) All apparatus not in immediate use should be kept in cupboards.
- (xix) Make sure the laboratory is kept clean after each practical exercise.

- (xx) Make sure all services e.g. gas, water, electricity are put off at the end of the days work.
- (xxi) Inform other staff members of any breakage, faulty equipment and other defects.
- (xxii) Check that all bunsen burners are put off and there is no naked flame before using flammable solvent.

Above are some of the rules for you and other laboratory staff members. These rules are not exhaustive, so space has been provided for you to add more.

ACTIVITY V

STEP 6: PROTECTIVE DEVICES FOR THE STAFF

Although under the rules and regulations, some of personal protective devices such as shoes and lab coat have been mentioned, there is the need to discuss some details to minimize the risk of personal injury and damage through various contacts with the following:

- a) **Safety Spectacles**
 You need to use the safety spectacles to protect your eyes from splashes of chemicals or fragments of dust or glass etc.
- b) **Gloves**
 You should always put on gloves while mixing or transferring toxic, radioactive and carcinogenic compounds, intents and corrosive liquids. This should however not be throughout a practical exercise as the hands get very moist and sweetly, prone to skin infection and the gloves make it difficult to grip wet glass thereby resulting into accident.
- c) **Safety Shoes**

You should always make sure you put on your shoes while in the laboratory. These should be covered shoes not open-toed to avoid any injury and contamination.

d) **Lab Coats**

Your lab coat should fit well and buttoned up. It is advisable to have one made with cotton as it absorbs more liquid and offer more protection against spilled chemicals than those made with nylon. It also does not generate sparks by static electricity that would ignite highly flammable organic solvents.

e) **Aprons**

Apart from the lab coat, a rubber apron is necessary for work with some amount of chromic acid, hydrofluoric and other highly corrosive liquids.

SUMMARY

- We have seen that the watchword in any laboratory is safety and so the need to have rules and regulations in the laboratory is emphasized in this unit. Also some of these rules as it effects laboratory staff members were stated and the importance of the staff having protective devices during practical lessons was also mentioned.

ASSIGNMENT

1. Discuss in detail two preventive measures that can be taken to ensure safety in the next practical lessons you have to organize in the laboratory.

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UNIT 4: GENERAL HAZARDS AND THE FIRST AID IN THE SCHOOL LABORATORY

INTRODUCTION

In unit 3 you learnt about the causes of the various accidents in the laboratory. In this unit you are introduced to some of the hazards that could be caused by glasswares, chemicals or electricals. Also the use of the first aid in case of any accident. So the objectives and the general features of the first aid is discussed in this unit.

OBJECTIVE

After studying this unit you should be able:

1. state the hazards involved in handling use and disposal of glasswares.
2. explain the hazards involved in handling large glass containers by the neck.
3. explain why glass tubings are usually carried vertically not horizontally.
4. advance reasons why pipetting liquid using the mouth should be avoided.
5. advance why reagents in glass bottles should not be stored in direct light.
6. list the different classes of hazardous substances.
7. explain handling aspects of hazardous chemical substances like labels, packing.
8. match the colours with the nature of the chemicals.
9. describe how the human body should conduct electricity.
10. state the danger involved in having a wrong connection in appliances.
11. state the danger of colour blindness.
12. advance reasons why some worn out equipment are still kept in the laboratory
13. state the importance of the proper choice and use of fuse.
14. list some causes of electrical mishaps or shocks.

ACTIVITY I

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| <ol style="list-style-type: none">1. Define first aid2. List the content of a first aid box3. Describe the general features of the first aid procedure. |
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HOW TO STUDY THE UNIT

1. Before starting this unit, think about your last practical lesson and list all the hazards associated with that practical.

2. This unit is quite large and will require your full concentration.
3. As it pertains to some of the hazards in laboratory, it will help you to go through the unit step by step.
4. Make sure you attempt all the activities involved.
5. Also make reference to other materials that could help you with your assignments and activities.

STEP1: GLASS WARES

ACTIVITY1

1. What is the commonest accident during your practical lesson?

With the number and frequent usage and breakage of glassware in the laboratories, it is important to guard against the risks from it.

Glass wares are produced and used in vast quantities in most laboratories but the production from the factories differs in quality. So while some are more durable, some easily break.

Broken glass needs to be treated with particular cover and should be cleared up as soon as possible. Small piece of glass could be collected by means of a piece of plasticine and should be discarded in a clearly marked container used exclusively for the purpose.

Most students have also been observed using chipped or cracked glassware. This is so common with burettes, pipettes, test tubes, beakers and others. You should try to avoid this because of the danger it constitutes to the students in handling.

Breakages are expected although this does not mean carelessness. Where you establish the latter, then the students should be made to pay for it.

Dirty glassware can be washed with hot water and small amount of detergent. You should make sure gloves are worn by whoever does the washings to prevent cuts. It may also be necessary to spread plastic mat in the sink to avoid breakages.

STEP2: GLASS TUBINGS

ACTIVITY 2

1. Fati has just collected a burette from the laboratory attendant for her titration. She held the burette horizontally and was walking hurriedly back to her titration desk. Ayo mistakenly clashed with her. What do you think happened?

It is most likely that the burette will get broken and the students injured.

Glass tubings are usually the course of many unnecessary accidents in the laboratory. The glass tubing should be carried vertically and not horizontally. Also it should not be stored above the head height.

Another aspect that constitutes risks from glassware is when passing glass tubing or a thermometer through a cork or rubber bung. It is very important to use the correct technique. That is the cork – borer, which is lubricated to use glycerol and of slightly greater diameter than the tubing is passed through the bung or cork.

STEP3: PIPETTES AND BURETTES

ACTIVITY III

1. Have any of your students in the process of using the mouth operated pipettes got some of the liquid into the mouth? Or has any burette slipped and broken because it was not properly clamped? What did you do?

You could have so many accidents while performing practicals with pipettes and burettes. In fact they can be dangerous if they are not properly used.

Although mouth-operated pipettes are inexpensive to purchase, most schools would do with pipette fillers. This helps to prevent the hazards resulting when students fail with the mouth operated pipettes.

You should also emphasise to your students the danger of using the mouth pipettes to draw up volatile liquids, aqueous ammonia, concentrated acids or alkali and toxic liquids. Always wash pipettes or buttes immediately after use and store in proper racks.

Laying a pipette on a laboratory bench could also contaminate the mouth piece.

You should make sure that your students burettes are properly clamped and brought down below their eye level. This should be done before they fill the burettes using a funnel. Climbing of stools by students in order to fill liquid into the burettes should be avoided.

STEP4: HUMAN CONTACT WITH CHEMICALS

You must be used to working with chemicals in your laboratory. It is always good to assume that all the chemicals are toxic and flammable unless you are sure of its nature.

ACTIVITY 4

1. List two ways by which your body can contact chemicals in the laboratory.

Human contact with chemicals can take place through the following ways:

- (i) Ingestion
- (ii) Direct contact from spills or by improper handling
- (iii) Inhalation of vapours, fumes or dust.
- (iv) Indirectly e.g. through explosion

STEP5: CLASSIFICATION OF HAZARDOUS CHEMICALS

Types of hazards are classified into eight classes as follows (IGNOU, 2001):

Class 1: *Explosives*

There are commercial explosive preparations and substances used as blasting agents, ammunition, fireworks etc.

Class 2: *Gases*

Gases can be divided into 3 subclasses on the basis of their hazardous nature.

Human contacts with chemicals can take place through

- (i) flammable gases.
- (ii) toxic gases.
- (iii) non-flammable non-toxic gases.

Class 3: *Flammable liquids*

Flammable liquids are those liquids containing solids in suspensions or solutions that give off flammable vapour of temperature not more than 60, 50c.

Class 4: *Flammable Solids*

These are substances that are flammable or liable to spontaneous combustion or emit flammable gases when in contact with water.

Class 5: *Oxidizing Substances*

This includes oxidizing substances and the organic peroxides.

Oxidizing substances are by themselves not combustible but by feeding oxygen to other substances cause or contribute to their combustion.

Class 6: *Poisonous and Infectious Substances*

These are substances liable to cause death or serious injury to health if swallowed or inhaled or allowed to come in contact with skin.

Class 7: *Radioactive Substances*

These are substances which undergo spontaneous disintegration to form atoms of different elements. The disintegration is usually accompanied with different types of radiation that can cause damage to body tissue.

Class 8: *Miscellaneous Dangerous Substances*

This includes other hazardous substances.

STEP6: THE HUMAN BODY AND ELECTRICITY

Your body can conduct electricity and its resistance varies widely from one person to the other. It is also dependent on the condition of the body. If it is wet, the resistance is very low and electric shock can be very dangerous resulting in severe injury or death. With dry skin, the resistance may be higher and this would allow some current to pass through the body and could also be less fatal.

For this reason, switches, sockets and electrical equipment's should not be placed near or close to taps, sinks and other areas where water could easily splash on them.

STEP7: IMPROPER WIRING

There might be times when you need to change the plug in an appliance. It might be from a round plugs mouth to square plug in order to fit the socket on the laboratory tables or workstations. It is important to make sure the connections are correctly and firmly done.

The colour codes should be followed while wiring a plug. These are

Earth	:	Green and Yellow
Live	:	Dark Brown
Neutral	:	Light Blue

ACTIVITY 7

1. Unscrew one of the plugs on any of your appliances.
2. What colour code does it have? Does the connection conform with the codes above?

You need to note the implication of colour blindness in this connection. So if you are colour blind, always get assistance in your connections to avoid electric hazards.

STEP8: WORN OUT EQUIPMENTS/APPLIANCES

Look around at some of the electrical equipments you have in your laboratory, check the records how long ago they were brought. Some are so old that the cables have given up. Do you have such cables commonly called "black taped" equipment in your laboratory? It is high time you made request to the school authority for replacement.

STEP9: FIRST AID AND ITS OBJECTIVES

First Aid is the immediate treatment and care given to a victim (who might be your student) of an accident or sudden illness until the necessary professional medical assistance is available. The treatment in the first aid is only temporal and it is given to achieve three (3) major objectives.

1. to sustain or preserve life.
2. to prevent the victim's condition from getting worse.

3. to promote the victim's recovery

You have been told previously that laboratories are potentially dangerous working places and as a science teacher, you should know how to provide first aid depending on the nature of the injury.

ACTIVITY 8

1. Has any of your students ever had an accident or injury while working in the laboratory?
2. What was the nature of the injury and how did you cope with it?

Always remember that first aid is a skill which you have to learn by proper training and practice. And your responsibility to provide first aid ceases as soon as a professional medical assistance is available. But a report of the first aid you provided must be given to the doctor.

STEP 10: THE GENERAL FEATURES OF FIRST AID PROCEDURE

Remember your first objective of first aid is to save life. Not to lose one in order to save the other, so it is essential to keep calm and assess the situation rapidly before deciding what steps to take. For one or two minutes can make a difference between life and death.

The action you should take in an emergency should depend on the circumstance. Below is a suggested procedure (IGNOU, 2003)

- (i) Quickly remove the victim from the hazard (provided it is safe to do so).
- (ii) Ensure that the patient's breathing is maintained (if the victim is not breathing, begin artificial respiration immediately. If the heart beat is absent, begin resuscitation. For these, the services of a trained person is helpful.
- (iii) Control serious bleeding to prevent heavy loss.
- (iv) Treat for shock.
- (v) Treat burns and deal with localized injuries (such as cuts or foreign bodies in the eye).
- (vi) Reassure the casualty and help lessen the anxiety.
- (vii) Do not allow people to crowd around as fresh air is essential. Get them to contact the ambulance and doctor.
- (viii) Where necessary, your last action is to hand over the victim to the doctor or take him to the hospital.

ACTIVITY 9

1. An accident has just happened and the whole students in the class are gathered. What would you do?

SUMMARY

- In this unit, you were again reminded of the various hazards that could occur in the laboratory from glass wares, chemicals to electrical as you get your students engaged in practicals. The first aid procedures required are also emphasized.

ASSIGNMENT

1. As a science teacher, what precautionary measures would you embark upon if your next practical lesson involves some titrations?

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UNIT 5: LABORATORY MANAGEMENT

INTRODUCTION

In previous units 2-4, you have learnt about the laboratory design, organisation and safety. But there is need to know how the laboratory itself is run on day to day basis or managed. This unit deals mainly with the human resources in the laboratory.

OBJECTIVES

After studying this unit you should be able to:

1. Discuss the major roles of the head of the department.
2. State the responsibility of the head of department as regards timetable, notice board, filing of information and establishing resources centre.
3. Outline what the head of department should do to keep his/her members cooperative.
4. Advance reasons for the importance of identifying staff members' talents and capabilities.
5. State the need for adequate maintenance of the various equipment and services in the laboratory.
6. Discuss the importance of having well trained laboratory assistance and technicians in the laboratory.
7. State the role of the teacher in helping to recruit the laboratory assistant and technicians.

HOW TO STUDY THIS UNIT

1. This unit is directly linked with unit 1.
2. Go through this unit carefully making reference to unit 1.
3. Try to identify your role in managing the lab as a Science Teacher.
4. Relate this to that of the Head of Department and Laboratory Technician/Attendant.

STEP1: THE HEAD OF DEPARTMENT

The task of managing the affairs of the science department is visualized as a joint responsibility of the head of department and other staff members. This includes the science teaching staff and laboratory attendants/technicians. The head of department who is one of the human resources in the department has three major areas to be concerned about.

- (i) **Organisation and coordination of duties** – there should be an open and effective communication channel between him and other staff members that is he/she should operate an “open door” policy for corrections, advice and suggestions towards the progress of the department.

- (ii) **Delegation of responsibilities** – he should identify staff members with their talents and capabilities and delegate duties like wise.
- (iii) **Training of personnel** in department should be a major concern of the department. He should make sure that the staff members under him are recommended for promotions, attend conferences, workshops and seminars and are given study leave when appropriate. The above are very sensitive areas that easily frustrate some staff members by not giving them job satisfaction.

ACTIVITY I

1. What other role do you think your head of department should play to enhance productivity in the department?

STEP 2: SOME RESPONSIBILITIES OF THE HEAD OF DEPARTMENT

a) **The School and Science Timetable:**

The head uses the general school timetable for scheduling the department's time table involving the staff members and displayed in the laboratory.

b) **Notice Board:**

The head of department should provide up to date information on a notice board in the science department as an aid to communication. The notice board should be divided into sections and labelled using section headings and different colours. (e.g. Red for Urgent or Emergency).

The headings could be:

- School time table.
- Science laboratory time tables.
- Science teachers time tables.
- Departmental notices.
- Science club activities.
- Today's announcement.
- Teacher's centre information.
- Urgent.

ACTIVITY II

1. Do you have a science department notice board? List other headings that you have?

c) **Filing Information:**

The head of department should be responsible for storing and retrieving information by maintaining two separate filing cabinets or shelves. The “confidential” files should contain examination information, student’s records, correspondence and confidential reports on students and staff etc.

The “open – access” files should contain past question papers, science syllabuses, career information, catalogues for books and science equipment, safety information etc.

ACTIVITY III

1. Do you have the confidential and open files in the department? What else do you have?

d) **Staff Resource Centre:**

A resource centre within the science department for the staff members should be arranged. For close maintenance, this could be a room adjacent to the head of department’s office. The following could be included in such resource centre:

Reference library, audiovisual aids, worksheet, store stationary, duplicating facilities, projection facilities, Computers

e) **Money Management:**

The Head of department needs to consult with other staff as regards the needs of the department. This is presented to the college or school. The estimates should be broken down to include:

- (i) equipment cost
- (ii) running cost
- (iii) stationary
- (iv) books and audio – visual aids
- (v) workshop/conference, seminar needs
- (vi) living organism funds
- (vii) replacement funds
- (viii) practical examination funds

ACTIVITY IV

1. Space has been provided for you to add more to this list.

STEP3: THE SCIENCE TEACHER AND THE LABORATORY

The responsibility of the science teacher towards the laboratories depends on the particular laboratory used for students. It is a joint responsibility of all teachers and laboratory assistants concerned.

The science teacher is responsible for the following:

- (i) **Preparation of materials, solutions and specimens:** It is the responsibility of the science teacher to operate all necessary materials or items for practical lesson to take note of all the inadequacies.
- (ii) **Training of the laboratory assistants:** It is necessary for the laboratory assistants to be well trained since students learn a lot of things from them either directly or indirectly. So the need for them to continually improve their skills by attending workshops.
- (iii) **Stock control, requisition and receipt of supplies:** As a science teacher, you should make sure you record the incoming and out going stock from the store, have a requisition book for your request and always issue a receipt or sign for supplies made to the store room
- (iv) **Recording Breakages:** There are so many breakages especially with glassware's in the laboratory. These breakages should be recorded for replacement.
- (v) **Proper Storage and Distribution of Materials:** Materials should be stored according to their nature and the storage procedure should be simple for safety and ease of retrieval.
- (vi) **Implementation of Safety Regulations:** It is one of the teacher's duties to make students and other supporting s
- (vii) taff keep to these rules.
- (viii) **Supervision and control of Laboratory Assistants:** The science teacher should highlight the duties of the lab assistant and paste it where it can easily be referenced to. There is need to have a close supervision and control of the lab assistant at all times to ensure safety in the laboratory.

STEP 4: THE SCIENCE TEACHER AND SUBJECT MATTER

Each science teacher should be assigned the subject in the area of specialization for teaching. But this is not the practice in most schools where there is scarcity of science teachers. There are instances where a graduate in Biology Education is made to teach Integrated Science or a graduate in Physics Education made to teach Mathematics.

It is always important for you as a science teacher to teach in your area of specialization. Since this is an areas of expertise and you should feel more comfortable with it. Also you need to continuously develop your knowledge and skills by attending conferences, workshop and seminars. This will keep you abreast with recent developments in science.

Other Responsibilities of the Science Teacher

- (i) **Wall chart:** The science class or laboratory should be a conducive and attractive environment for learning science. So the science teacher should get resource packs to paste on the wall from which students can easily learn certain concepts.
- (ii) **Films:** Most students love to watch films. So it would be exciting if you could get scientific films that your students could watch during their science or practical classes.
- (iii) **Library:** As mentioned early, there is the need to have a resource library in the science department. One of the science teachers should be responsible to keep track of the resource materials.
- (iv) **Secretary:** In any departmental meeting, one of the science teachers could act as a secretary and take the minutes of the meeting. This should be typed, circulated to each staff for the next meeting and filed. In fact there should be a particular file for departmental meetings.
- (v) **Examination:** Each science teacher is responsible to set and mark assignment, continuous assessment and examination question. The marking scheme for the examination should also be attached.
- (vi) **Safety:** As mentioned earlier, the safety of the laboratory should be of concern to the science teacher who is legally liable for whatever careless accident to any students. So the safety rules and regulations should always be emphasized.
- (vii) **Science Teaching Scheme:** For every teaching subject allocated to a science teacher, there is need at the beginning of each term to break it down according to the number of contact hours and content converge during each period.
- (viii) **Displays and Exhibitions:** The Science Teachers Association of Nigeria at its annual conference each year encourages schools to bring the students' unique exhibitions for display. The best exhibitions are identified and given prizes. There are other Science Fairs that are taking place all over the nation. So your students should be encouraged to take part in exhibitions and fairs.
- (ix) **Science clubs:** Science students should be encouraged to join the science clubs where they could interact in a more relaxed atmosphere and learn from one another. You as the science teacher could be a patron to such clubs to coordinate their activities.

The Laboratory Technicians

Do you have laboratory technicians in your school? Well trained laboratory technicians are sometimes rare to come by and most science departments usually employ the services of the laboratory attendants and train them on the job to play both roles.

Your school may be lucky to have a laboratory technician. If this is so, it is important to note that the amount of servicing and repair of equipment which can be undertaken by a laboratory technician in a school is limited. So attention should be given to the manner in which the equipment is used and the type of environment it is subjected to.

Also the protection of these materials from dust, vibrations, corrosion and excessive heat will enhance the maintenance of the equipment.

The Laboratory Attendants

In order to facilitate the effective management of the laboratory, the choice of a good laboratory assistant is very important. So a space should be created for him, close to the teachers' preparation room to make him accessible to both the teachers and the pupils.

Selection of a Laboratory Assistant

The head of department and staff should have a say in the employment of a laboratory assistant where there is a vacancy. This laboratory assistant should be trained by the teacher in laboratory organisation and maintenance. In-service courses in the polytechnics or university will also be helpful in increasing his competence and efficiency.

Duties of a Laboratory Assistant

Any science teacher should work better in a well equipped laboratory assisted by a qualified experienced laboratory assistant. The duties of the laboratory assistant should include:

- preparing materials, specimens and apparatus required for practical work
 - setting up and testing demonstrations under the supervision of the science teacher before any practical work
 - assisting in the use of visual aids
 - assisting in stock taking and ordering
 - ensuring security in the laboratory etc
(you can list more in the space provided).
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SUMMARY

The management of the department has been seen to be a joint responsibility of the head of department and other staff members.

In this unit, you learnt that:

- the head of department has joint responsibility with other staff member to manage the department
- the head of department should organise and coordinate the duties of other staff members
- he/she should have an open and effective communication channel for advise, corrections, suggestions from staff members

- the head of department should delegate responsibilities and encourage the training of his staff members (staff development)
- the head of department has other responsibilities concerning the time table, notice board, filing of information and establishing the staff resource centre
- the need for a well trained technician
- the need to protect equipment's from dust, excessive heat, and rust
- the need to service and use instructional manuals for the equipment
- that the laboratory assistant are valuable asset to the science teacher, if they are well trained and experienced
- the science teacher should assist in the recruiting of the laboratory assistant or technician

ASSIGNMENT

1. As the head of science department in your school, discuss your roles and responsibilities.

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UNIT 6: TEACHING METHODS (*DEMONSTRATION, PROJECT, GROUP WORK AND COOPERATIVE LEARNING*)

INTRODUCTION

Research work has shown that teachers' mode of presentation of various science concepts affect achievement. In the next 3 units, we will be considering some teaching methods and techniques available to the classroom science teacher. The question should be, how best can you put across these concepts to the students?

For, according to Asoko (2000), in all countries, teachers are the key to realizing the curriculum aims and the quality of science education which students receive rests ultimately on them.

OBJECTIVES

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

1. compare three methods of teaching by listing the advantages and their disadvantages
2. describe a situation in the classroom where each method will be appropriate
3. describe a situation in the classroom where you can combine any of the methods

HOW TO STUDY THIS UNIT

1. To be a trained teacher, you must know how to decide on your methods of teaching. So read the next three units very well.
2. These three units are interlinked and so as you read try to highlight the merits and demerits of each teaching method.
3. Also visualize how you can combine any of the methods in a classroom set up.

ACTIVITY I

- | |
|---|
| <ol style="list-style-type: none">1. Describe the several methods your lecturers used during your university education. |
|---|

There are various teaching methods and techniques in science teaching, but whereas the methods or techniques are means or ways of impacting scientific knowledge to students, the strategies are the skills required for using these methods effectively. So effective teaching of science does not depend on teachers' knowledge of the methods, but his skill to use the appropriate method or combination of methods. No particular method is labelled good or bad, it all depends on how the teacher uses them. So let's start off with demonstration method.

DEMONSTRATION METHOD**ACTIVITY 2**

1. Supposing you want your students to perform an experiment of high risk for the first time, how do you intend to go about it?

Most teachers will do it first and allow the students to watch, because of the high risk involved. The demonstration method is a process used to introduce some specific skills in the course of instruction. The teacher here is able to do some activities while the learners are watching; it could involve setting up some apparatus/equipment or showing how a reaction should be performed and their limitation. As the teacher performs these activities, the students are supposed to be involved except dangerous reactions and manipulations are involved.

ACTIVITY 3

1. While the teacher is demonstrating, what activities do the students perform? What is the advantage of this method? Any disadvantages?

Usually the students are able to carefully observe, infer, predict, classify.

It is teacher centred and so it is economical as regards the resources used. So it can be used when the school only has a set of equipment or apparatus or when the activity involved is of high risk. According to Busari (2004) to make demonstration effective, in either teacher demonstration or teacher-student demonstration, the following criteria are essential:

1. Organise the demonstration to make it visible to all students.
2. Attempt to carry out the demonstration before the lesson begins.
3. Avoid having too many demonstrations in a lesson not to confuse the students.
4. Be systematic, that is performing the demonstration in a scientific manner.
5. Attempt to time each demonstration and pace it to enable the students grasp the message.
6. Be audible for everyone in the class.

STEP 3: THE PROJECT METHOD

In the demonstration method the teacher mainly carries out the activity. But there are cases where the student can be involved individually or in group. Can you think of such situation?

Well, the project method involves investigation and solving problems by an individual or a small group. Usually the project method allows a student to satisfy his curiosity and learn more on his/her own or as a group. For instance, at the end of your undergraduate course, you must have written a project or group project.

ACTIVITY IV

1. Can you remember your topic? What are the advantages of the project method?

The advantages of the project method include:

- (i) Ability to investigate a problem, and look for ways to solve the problem.
- (ii) Ability to cooperate and learn from each other, if a group project etc.

STEP 4: GROUP WORK

Although this might look similar to the project method but it's different because this usually takes place during a class period. The teacher might divide the students in various groups to perform certain activities. There are instances where you have your practicals too in groups.

ACTIVITY V

1. What are the advantages of this group method?

It allows the learners to cooperate and work in groups and It also helps in situations where the school has not got enough apparatus to go round individual members of the group.

ACTIVITY VI

1. What is the main disadvantage of the group method?

One disadvantage is that the introverts are usually covered by extroverts.

CO-OPERATIVE LEARNING

In whole-class instruction, only one person can speak at a time and shy or slow-learning students may be reluctant to speak at all. When students work in groups of two to four

however, each group member can participate extensively, individual problems are more likely to become clear and to be remedied and learning can accelerate.

Co-operative learning means more than merely assigning children to small groups. Teachers must also carefully design and prepare for the small group setting. Students need instruction in skills necessary to operate successfully in small groups. Decisions must be made about the use of individual or group accountability. Care must be taken in establishing the mix of strengths and needs represented by students in the groups. Attention to these details will increase the likelihood that the co-operative groups will produce increased learning (*UNESCO, 2000*).

ASSIGNMENT

Compare the four methods discussed in these units listing their advantages and disadvantages.

SUMMARY

- In this unit, you have gone through three methods of teaching. As said earlier, no method can be classified as 'good' or 'bad'. It all depends on what the teacher makes out of it.

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UNIT 7: TEACHING METHOD: (EXPOSITORY, DISCUSSION, INQUIRY, DISCOVERY AND LECTURE METHOD)

INTRODUCTION

In unit (6) you dealt with the demonstration, project and group methods of teaching. In this unit, we will be considering the expository, discussion, inquiry, lecture and discovery method.

OBJECTIVES

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

1. describe the inquiry, discovery, discussion or lecture method.
2. distinguish between the five methods of teaching.
3. compare and contrast the five methods of teaching.
4. create a table to show a comparison of all the methods discussed so far.

HOW TO STUDY THIS UNIT

1. Read through this unit step by step
2. Make reference to unit 6 for clarity
3. Attempt all the activities which will help you through the units
4. Make a comparison of the teaching method so far

STEP 1: EXPOSITORY METHOD

ACTIVITY I

Apart from those discussed in Unit 6, was there any other method of teaching, one of your lectures used during your undergraduate days?

Some of these lecturers come to the classrooms to use the traditional talk and chalk method. It is the traditional lecture method called the expository method. Busari (2004) gave a typical description of this method as the teacher introduced the lesson as follows:

- (i) giving a summary of the previous lesson; this previous knowledge as often defined by most teachers centres on what has been covered during the last lesson which may have little or no bearing with the present lesson
- (ii) indicating how the present lesson follows from it either as a statement or as a question; this is mostly used as the introduction of the lesson

- (iii) presenting the concept of the lesson; in most cases, diagrammatic illustrations are used to reinforce the understanding of the concept, more so that learning passivity is noted among the students
- (iv) soliciting occasionally for questions from students as the lesson progresses mostly in form of “any question”?, “do you understand”?, “any problem”?, “is it clear”?, etc
- (v) summarizing what has been presented by highlighting the main points and
- (vi) providing some questions for students to answer which rests on what has just been taught and /or the teacher gives assignment on the topic taught or to be taught next

ACTIVITY II

- | |
|--|
| 1. What are the disadvantages/advantages of this method? |
|--|

This method neither considers the individuality of teachers in the classroom nor gives opportunity for students to inquire. But it's an advantage when there is no so much to cover within a limited time to a large group of students. It also tasks reasoning faculty to imagine and question the feasibility of some explanations.

According to Brune (1966), teachers using this method have the possibility of talking too much, he likely misses the essentials of the lessons or goes out of the topic. Though it is a general conception that more topics are covered within a short period but at the end, what have the students learnt? What can they retain in their memory? How do they relate the concept to its application in practice? All these were considered when Bruner advocated for discovery method/inquiry method.

STEP 2: INQUIRY METHOD

ACTIVITY I

- | |
|---|
| 1. List 2 disadvantages of the expository method. |
|---|

Well, one of the disadvantages you may have listed is the fact that it does not allow the learner to inquire.

According to Suchman (1972), inquiry method is a method of teaching that encourages a child to solve problems by asking questions so as to gather information. Also according to Velch, Klopfer, Aikenhead & Robinson (1981), inquiry is a method by which human beings seek for information or understanding. Teaching by inquiry may involve discovery in which there is creativity and students' participation in a well equipped laboratory or in a well-planned and produced lecture (discussion) or in a stimulating reading assignment (project work) or a simple novel situation (problem-solving).

In a typical classroom situation, the inquiry could be guided and directed by the teacher or left open ended or directed by the students themselves. Where there is time constraint, then the former should be preferred.

STEP 3: DISCUSSION METHOD

Schwab (1960) referred to inquiry as techniques which uses a semi structured discussion intended to develop skill in probing. The discussion lessons usually involve a topic being raised by the teacher and each learner contributing to the topic. Here there are diversified opportunities for learners to raise analytical questions, to help them comprehend and acquire new scientific concepts and principles; to answer or provide some classifications on certainties arising from previous lectures or practical classes, and so on.

The teacher obliges to less domineering discussion and direct feedback. In addition, the teacher is obliged to plan the right kind of perseverance, willingness, curiosity, carefulness and caution among students. There is a strong case for teachers to guide the students toward acquiring and maintaining these effective attributes and be careful about the mode of handling discourse of no interest to learners.

ACTIVITY II

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|---|
| 1. When can you use the discussion method in the classroom? |
|---|

According to Busari (2004). The following can assist the science teacher to have effective discussion in science lessons:

- (i) The discussion can extend to laboratory work, projects, field trip or concepts that deal with imaginations alone.
- (ii) It is necessary for a science teacher to have an in-depth knowledge of the area in science before presenting for discussion.
- (iii) The selection of questions before lessons begin is necessary.
- (iv) Questions for discussion should elaborate on scientific explanations and understanding of phenomena.
- (v) Encourage students to initiate discussion especially those that bother on scientific day-to-day life experiences. Where students tend to shy, a teacher may start discussion and gradually but timely allow students to carry the brunt of the discussion.
- (vi) Encourage the discussion of students' reports on laboratory work, field trip coverage, project, assignment and so on. This attempt, though made consistent should focus at improving the oral and written expressions (communication skills) and correct their errors of observations. Sometimes, it may be necessary to involve every student in order to award marks to each contribution so as to motivate students.

STEP 4: DISCOVERY METHOD

Discovery is another inquiry method which allows the learner to “find out” through the use of process skills. The learner is put in a situation where all necessary materials are provided to allow him/her discover and generate new knowledge. According to Busari (2004). The procedure for this method includes:

- (i) Providing all the materials necessary for each learner to discover the concept himself and
- (ii) Explaining the procedure but not the concept where necessary by the teacher. The students may then request for teachers’ guidance on procedural matters especially when the learning of higher-order principle is involved. For the Senior secondary School Science Curricula, the discovery method may not be appropriate for all students in the sense that some may spend a lot of time in determining what exactly they are to find out due to their low reasoning ability.

ACTIVITY III

- | |
|--|
| 1. What will be the teachers’ role in this method? |
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Although the discovery method could be guided or not, the teacher should always guide the discovery method to make it goal-directed and relate to the topic being taught.

ASSIGNMENT

1. Compare the five methods in this unit stating the advantages/disadvantages of each method?

SUMMARY

- In this unit, you have learnt about the expository inquiry, discussion, discovery and lecture methods. A good selection of these methods for any particular lesson will go a long way to produce a good lesson.

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UNIT 8: INNOVATIONS INTO THE SCIENCE TEACHING

INTRODUCTION

In this unit, we will be considering other innovations you could introduce to your teaching to make it effective. This includes the use of Information and Communication Technology (ICT), field trips and the use of good questioning techniques:

OBJECTIVES

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

1. define information and communication technology.
2. describe ways in which ICT could be used in the teaching of science.
3. describe instances where you could use field trips in teaching some topics.
4. distinguish between low and high order level questions.

HOW TO STUDY THE UNIT

1. Read through this unit step by step.
2. See the possibility of adding the innovations to the various teaching methods you studied earlier
3. Attempt all the assignments.
4. Refer to the references to help you.

STEP 1: ICT IN THE TEACHING OF SCIENCE

Information & Communications Technology as cited by Sambo (2002) are part of the globalising agent used in turning the world to a “global village”. It refers to the technologies used in collecting, storing, editing and passing on information in various forms. This includes the use of communication satellite, radio, television, telephones, video, tape recorders, compact discs, floppy disks and the computers.

So, science teachers at all levels should have access to these facilities so as to join the technology drive. Of recent, most schools in Nigeria are now being equipped with computers and so the need for the teachers to be skilled in it becomes inevitable.

ACTIVITY I

- | |
|--|
| <ol style="list-style-type: none">1. Supposing you are given a computer for your science classroom, how will you utilize it for the learning of science? |
|--|

Some teachers have successfully used the computer as:

- (i) An interactive teaching tool; performing and directing activities.
- (ii) A laboratory tool for performing a range of teaching and training activities including reasoning and analysis of data.
- (iii) An information manager through the use of data (Abba 2003).

In fact, ICT will help to generate, recall and compare information. The use of computer simulations and modeling has been quite helpful in science practicals, especially in topics such as how systems like the human body, weather, and demographic variables react to changes in certain situations (Carter 1983, Weiner 1986).

It is important to note that ICT revolution has posed a number of challenges in science education in Nigeria. It prepares students to learn in a world increasingly rich in information.

STEP 2: FIELD TRIP

ACTIVITY II

1. During your student's days as science students, did you ever get to go for a field trip?
2. If you did, how did you find it?

Field trip provides an opportunity for an outdoor visit where learning experiences are acquired. As a science teacher, this could be used to reinforce and supplement whatever is being taught in the classroom. There are various set ups that the students could be taken to on field trips. These include museum, industries, film houses, workshops (automobile, craft, and electrical) and farms etc. According to Busari (200), the merits of field trips in science teaching include:

- (i) Broadening the student's experiences by bridging the gap between science inside and outside the laboratory
- (ii) Advancing cognitive abilities of both students and teachers
- (iii) Improving student's attitude to learning science
- (iv) Developing process skills in students and their application to solving problems
- (v) Promoting socialization skills among students and between students and the people outside the school
- (vi) Reinforcing classroom lessons

But before embarking for a field trip, there is need for proper planning by the science teacher and the school authority should be very much involved in this planning. These planning should include Busari (2004)

- (i) Visits to locations to identify the relevant area of need and seek for approval
- (ii) Seeking for the parental approval through the school or Parents Teachers Association (PTA)
- (iii) Setting objectives that would guide both students and the host on what is required of them in the explanatory processes
- (iv) Identifying the kind of teaching techniques that will be used in that mode
- (v) Possessing enough facilities like writing materials, instruction, collecting materials, and so on
- (vi) Identify the feedback process required of students

STEP 3: QUESTIONING TECHNIQUE

In every science lesson, you would expect questions in both directions. From the teacher to the students, and students back to the teacher. And where the students are on their own, from student to student. It is very important the way you as a science teacher control these questions. In this section, the questioning technique of the teacher as he directs questions to the students will be considered.

ACTIVITY III

- | |
|--|
| 1. When do you expect questions from the teachers? |
|--|

Questions to the students from teachers can come up at anytime during the lesson to give directions, stimulate interest and be sure the students are being carried along. This could be at the beginning of the lesson, during and before the wind up of the lesson.

Questions asked during these periods could be of various levels and the teacher needs to acquire the proper techniques to ask the appropriate question. For instance the low – cognitive order questions are those that allow the students to recall while higher – order questions allow the students to apply, analyze, syntheses and even question what is being asked. So each science lesson must focus more on the highest level questions which behavioral objective is directed to draw, design, distinguish, relate, discuss, compare justify, etc.

SUMMARY

- In this unit, you learnt about the innovations you could include in your various teaching methods. As a science teacher, there is need to have an effective science teaching method that makes an interesting lesson.

ASSIGNMENT

Choose a topic in the SSIII syllabus and describe an innovation you could use or add on to make your lesson more effective?

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UNIT 9: EVALUATION IN SCIENCE EDUCATION: SUMMATIVE AND FORMATIVE

INTRODUCTION

In this unit, you will be introduced to the meaning, purpose and importance of measurement and evaluation in Science teaching; also emphasis will be laid on continuous assessment.

OBJECTIVES

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

1. describe and distinguish the two main forms of evaluation
2. define evaluation.
3. advance reasons why it is important to evaluate.
4. describe the models that show the planned formative assessment and interactive formative assessment.

HOW TO STUDY THE UNIT

1. This unit is directly linked with unit 10.
2. So to get the grip of the topic on evaluation, you need to read the two units (9 and 10) very well.
3. Attempt all the activities under the units.
4. Make reference to the references as much as possible.

STEP 1: DEFINITION, IMPORTANCE AND PURPOSE OF EVALUATION

ACTIVITY I

1. What do you understand by evaluation and why is it important to evaluate in the classroom?

Evaluation or assessment has been defined as:

- (i) “The process used by teachers and students to recognize and respond to student learning in order to enhance that learning during learning” (Cowie and Bell 1996).
- (ii) The teacher giving feedback to the students, the teacher and (or students taking an action to improve learning during the learning and self-assessment (Sadler (1989), Gipps (1994) and Black & Wiliam (1998).

- (iii) Evaluation is a measurement of the extent to which objectives set for a particular event has been achieved (Busari (2004).

So it is evident that evaluation in education is to inform and improve students' ongoing learning According to Busari (2004).

The major purposes of evaluation are to:

- (i) Diagnose the learner's difficulties in curriculum_proper.
- (ii) Appraise teacher's instruction.
- (iii) Clock learner's progress and guide accordingly through the feedback.
- (iv) Assess instructional **programmes**.

So evaluation is important as it has been linked to improved learning and standard of achievement. (Black & William, (1998).

It is also an important aspect of teaching for conceptual development. For giving feedback to students about their existing concepts relate to the scientifically accepted ones and helps them to modify their thinking accordingly (Bell 2000).

STEP 2: FORMATIVE AND SUMMATIVE EVALUATION

ACTIVITY II

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| 1. Distinguish between these two forms of evaluation. |
|---|

Formative evaluation is a periodic, intended or development meant to enhance teaching and learning. An example of this is the continuous Assessment (CA). While **summative evaluation** is the usual terminal assessment of students' performance. Since formative evaluation usually comes up more often than summative in the classroom, emphasis will be placed on it.

STEP 3: CONTINUOUS ASSESSMENT IN SCIENCE TEACHING: FORMATIVE EVALUATION

ACTIVITY III

- | |
|---|
| 1. Why do you need to continually evaluate your students? |
|---|

Among the reasons to support continuous assessment in Science teaching include: it

1. gives the science teacher a greater involvement in the overall performance of science students;
2. provides a more valid assessment of students' overall knowledge, skills and attitude;
3. enables teachers to be more flexible and innovative in their instruction.
4. provides a basis for more effective guidance of students.
5. provides a basis for the teacher to improve his or her assessment tools.

Formative assessment is of two types-*planned formative* and *interactive formative assessments*.

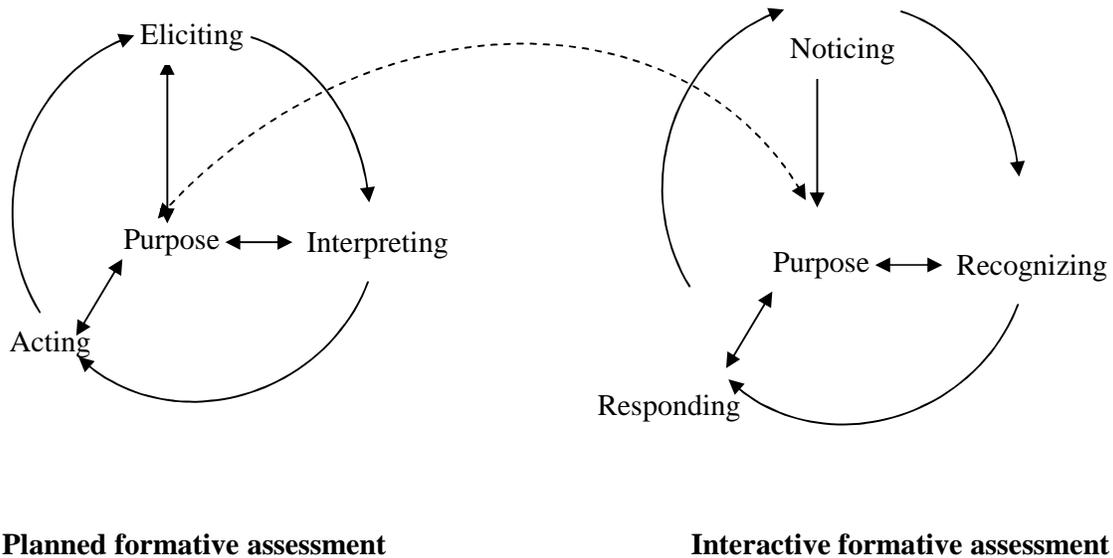


FIG. 1: A model of formative assessment (by Bell B. (2000)).

The **planned formative assessment** is characterized by the teacher eliciting, interpreting and acting on assessment information. It also gives the feedback to the students as to their planning.

The planned formative assessment determines how the information is collected, interpreted and acted upon. So these four (eliciting, interpreting, acting and purpose) are interrelated and mutually determining (Bell 2000). On the other hand, the **interactive formative assessment** usually takes place during student – teacher interactions. It involves the teachers noticing, recognizing and responding to students’ thinking during these interactions. For example, a teacher noticed and recognized that the student misunderstood some concepts from the students’ answers; she/he could respond by calling the class together and initiate a discussion on the concept. In this case, the teacher mediated the learning of the students.

ACTIVITY IV

1. From what you have read so far, what is the difference between the planned and interactive formative assessment?

Interactive formative assessment differs from planned formative assessment in that the specific activity was not planned, it comes out of a learning activity and the teacher mediates the learning of the students (Bell (2000)).

SUMMARY

- In the unit, you learnt about the definition, purpose and importance of evaluation and assessment. The differences between the formative and summative were also highlighted. In the next unit, you will consider types and construction of tests for your various evaluation activities.

ASSIGNMENT

Compare and give examples of instances in the classroom where you could use the planned and interactive formative assessment.

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UNIT 10: EVALUATION IN SCIENCE EDUCATION: TEST TYPES AND CONSTRUCTION

INTRODUCTION

In unit 9, you learnt about the importance and types of evaluation. In this, you will be taught the different types of tests and how to construct teacher-made tests. You should also note that tests and examinations also form an important part of the evaluation process.

OBJECTIVES

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

1. state guidelines to help in the development of tests.
2. describe the various types of Tests.
3. list factors necessary in the construction of a test.

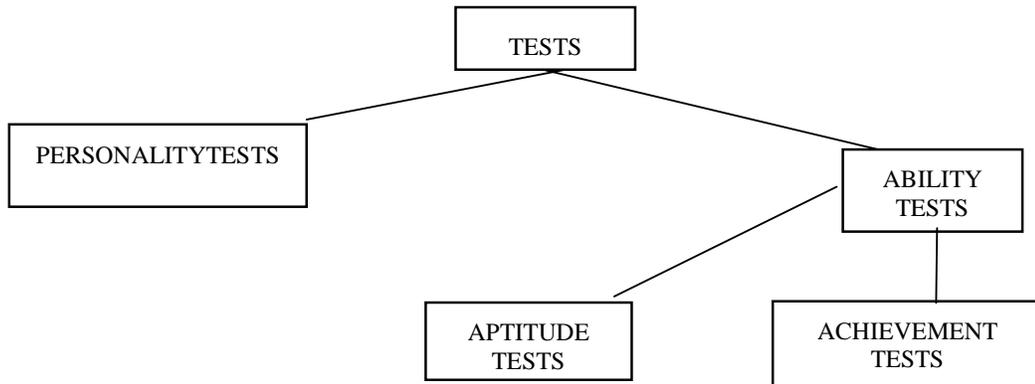
HOW TO STUDY THIS UNIT

1. This unit is directly linked to unit 9 so they are inter-related.
2. It is also the last unit in the modules on science methodology II, so make sure you understand all the concepts taught so far.

STEP 1: DEFINITION OF TESTS AND TEST TYPES

As a science student you must have taken some tests during your school days.

- (i) What are the purposes of these tests?
- (ii) What types of test are these?



Each type of evaluation discussed in unit 9 employs certain tests and the science teacher should identify the different ways of constructing good tests that advances the purpose of science lessons.

If testing, which is a form of evaluation is seen as a measurement to find out if the specific objective has been achieved, then in order to enhance and improve the learning in the classroom, attention must be given to “tests” being conducted.

In most classrooms, test questions are those that only allow the students to recall what has been memorized. Questions should move from the lower stage of recall to stages where the students could reason, analyse, interpret, connect relationships, think and apply practical skills.

According to Busari (2004) for tests to be conducted, the following should be noted:

- (1) The meaning of various scientific facts, laws and theories.
- (2) The inter-relatedness of certain concepts in science (e.g. the laws of thermodynamics, and diffusion in biology, chemistry and physics).
- (3) The acquisition of practical skills.
- (4) Extrapolation of graphs, analysis and interpretation of data and solution.
- (5) The phases used in attending to problems, trial and error or scientific approach.
- (6) Assessment given should be valid enough to serve not only as an evaluation tool but a diagnostic tool.
- (7) Inference making from scientific statements or observations.
- (8) Instruments having predictive value on future knowledge, skills and attitude of the students.

STEP 2: CONSTRUCTION OF TEACHER-MADE TESTS

There had been several tests that failed to achieve their initial objectives. This might be due to the fact that it was ambiguous, not clear enough, not enough time to comprehend the question and provide an answer, there might have been a misinterpretation of the questions or invalidity of the set questions. So it is necessary that:

1. The teacher must first determine what type of test and or evaluation technique to use.
2. The specific content areas should be listed out, including the corresponding topics.

3. Prepare the test blue print or specification tables. This table shows the number of items that will be asked under each topic of the content and the process objective.

**BLUE PRINT FOR MID-TERM CONTINUOUS ASSESSMENT TEST
(OBJECTIVES ITEMS)**

CONTENT	PROCESS OBJECTIVES						NUMBER OF ITEMS
	KNOWLEDGE	COMPREHENSION	ANALYSIS	SYNTHESIS	APPLICATION	EVALUATION	
	Recognizes Terms & Voca ITEMS Bularies 30%	Identifies Facts, Principles Concepts and Generalizations 30%	Break ideal into its parts 10%	Put elements together to form new matter 10%	Applies knowledge in new situation 10%	Judge the worth of information 10%	
A SOIL 25%	4	4	1	1	1	1	12%
B WATER 20%	3	3	1	1	1	1	10
C WEATHER 30%	4	4	2	1	1	2	15
D FOOD 25%	4	4	1	2	2	2	13
Number of Item	15	15	5	5	5	5	50

4. The items in the test must be worded in a clear language to avoid misinterpretation of what is solicited.
5. A consideration of adequate time for answering questions should be the teachers' watchword.
6. A marking scheme must be prepared by the teacher to assess the limitations of such items and should exhaust all possible answers to the items, though translated in different ways.
7. The test items can be validated by specialists outside the immediate school environment.

STEP 3: TEACHER MADE TEST

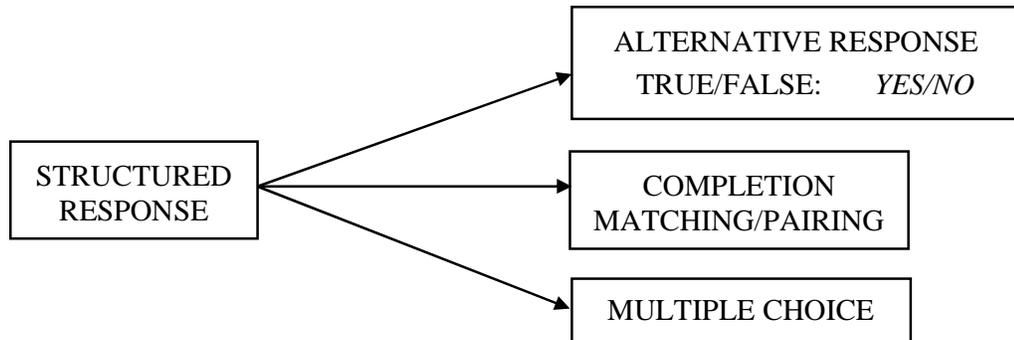
The teacher made test could be categorized as follows:

- (i) Paper and pencil test.
- (ii) Oral assessment.

ACTIVITY I

1. Could you try and distinguish between the two? Give personal examples of test you have taken.

Although the paper and pencil test is used worldwide, the objectives and criteria for the award of scores are different from the oral assessment. Most tests or interviews in our schools are conducted by having a blend of the two. For instance, while personality, composure, and intelligence count so much for the oral assessment, intelligence only could carry the learner through the paper and pencil test.



Emphasis here will be on the paper and pencil test which can be seen in form of the following,

- (i) Fixed response- These are varieties of objective test as follows:
- Multiple choice test (selection item type).
 - True or False (selection).
 - Matching questions (rank – order type).
 - Completion (supply item type).

In the first three listed above, a question is usually asked and options are provided. But for the supply item type the learner supplies the answers.

ACTIVITY II

1. State the selection and supply items types. Give five examples of each.

Free Response

This is an open-ended test in which the learner is given the freedom to express the points but could be restricted by the number of pages.

An example of this is the essay test. The guidelines for responding to free – response test include appropriate selection of evidence, logical development of argument on the basis of evidence etc.

Example: Draw and describe the functions of the human eye.

According to Busari (2004), although the inadequate numbers of trained teachers in test construction and marking have affected the objectivity of this technique, essay test limitations can be highly reduced by:

1. wording the question in a clear language to avoid misinterpretation of what is solicited
2. limiting the items of objectives that are best achieved by an essay test
3. preparing in advance a marking scheme
4. scoring one question at a time for all the students
5. allowing sufficient time for students to answer the question
6. marking students’ essay when you are physically sound and mentally alert

ACTIVITY III

1. Compose two essay questions in your discipline and supply the marking scheme.

SHORT ANSWER AND STRUCTURED TESTS

This type of test stands in-between the essay and the objective test.

As the learner is asked to give a short answer to series of questions.

In fact, the learners are usually limited to the specific space to be used for the short answer.

Example: One advantage of friction to humankind is

The guideline for writing short answer test include: (Busari (2004).

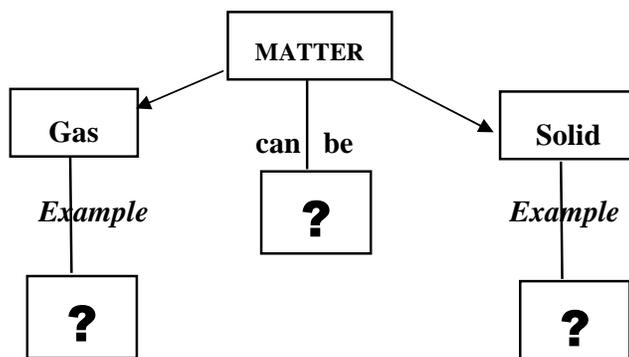
1. The stem should involve information on what questions are set. This may be in form of graphs, diagrams, charts, description of experiment, passages, tabulated data, etc.
2. The questions should be in sequence which may have linear or branched structure. By a linear structure each question depends on the proceeding one while the questions are independent but related to a common stem in a branched structure.
3. The test constructor needs to predetermine all possible answers expected to a question.

4. The space between questions should be moderate as to contain the anticipated answer
 e.g. one advantage of friction to humankind is

Concept Mapping Test

Although this technique could be traced to the cognitive learning theory of Ausubell, Novak & Gowin (1984) claimed it could be used as a powerful evaluation tool. It can also be used as a diagnostic test designed purposely towards finding out the nature of learning, difficulties and possible causes.

Examples:



The following should be noted when using concept mapping as a testing tool in evaluation:

- (i) Use each concept provided once.
- (ii) Highlight each concept provided by enclosing it in a box.
- (iii) Connect concepts that are related by means of a line.
- (iv) Carefully describe the nature of the relationship for each line drawn.

SUMMARY

- In this unit you have gone through the various types of test and their construction. It is important that the science teacher should choose appropriately and give a blend of all these test types to achieve the desired learning outcomes.

ASSIGNMENT

1. As a secondary school teacher, select some topics for SSII 2nd term examination and develop the examination questions – giving a blend of the various test types.

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