NATIONAL OPEN UNIVERSITY OF NIGERIA

FACULTY OF EDUCATION

COURSE CODE: EDU 252

COURSE TITLE: CHEMISTRY METHODS

EDU 252

CHEMISTRY METHODS

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INTRODUCTION

EDU 252 – Chemistry Methods acquaint you with some issues and methods in the teaching of chemistry as a school subject.

What you will learn from this Course

You will learn of the methods of teaching chemistry subject.

Course Aims

The aim of this course is to acquaint you with some issues and methods in the teaching of chemistry as a school subject.

Course Objectives

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

(i) define science;
(ii) discuss the myths surrounding the teaching of science;
(iii) provide lucid explanations on the difficulties of teaching science subjects in Nigeria;
(iv) write an acceptable lesson plan;
(v) discuss the strengths and weaknesses of some methods of teaching science subjects / chemistry.

WORKING THROUGH THE COURSE

To complete this course, you are expected to read the study units, and other relevant books and materials provided by the National Open University of Nigeria at the end of each unit of work.

Each unit contains self assessment exercises and at certain points in the course, you are required to submit assignments for assessment purpose. At the end of the course, there is a final examination. This course is expected to last for a period of one semester. Below, you will find listed, all the components of the course, what you have to do, and how you should allocate your time to each unit in order that you may complete the course successfully and on time.

Assignment File

There are fourteen (14) assignments in this course, covering all the units studied.

This file will be available at your study centre. You are expected to submit completed assignments in them. The marks you obtain for these assignments will count towards the final mark you obtain for this course. Further information on assignments will be found in the Assignment File itself and also in this Course Guide in the section on assessment.

The Course Materials

National OpenUniversityof Nigeriawillprovideyouwiththe following:

The Course Guide: This consists of three Modules, each having up to five units of work as listed hereunder.

Also at the end of each unit are lists of books – References and For Further Reading. While you may not procure or read all of them; they are essential supplements to the course materials.

Remember also that you must submit answers to the TMAs as and at when due.

Study Units

The study units are:

Module 1

Unit 1: Definition of science

Unit 2: Myths and Dogmas about science

Unit 3: Philosophers' view and aim of science education
The aims and historical context of science

Unit 4: The challenge of science teaching

Unit 5:

Module 2 The social dimensions of science and barriers to effective communication in teaching Science

Unit1:

Unit 2: Application of some teaching methods

Unit 3 Lesson Plans and its preparation

Unit 4: Effective Teaching of Science

Unit 5: The use of chemistry laboratory
LaboratoryOrganisation and Managementt

Module 3

Unit 1 Teaching Science in the Face of Scarcity of Chemicals/Equipments
Unit 2The Language of Science, Science Teaching and Textbooks
Unit 3 Learning Theories
Unit 4 Piaget's Theory and Application of Learning Theories to Science Teaching

ASSESSMENTS

There are three aspects of the assessments. First are Self AssessmentExercises(SAEs), second is the Tutor – Marked Assignments (TMAs) and the third is the Final Examination.

SELF ASSESSMENT EXERCISES

You are advised to be sincere in attending to the exercise.You are expected toapply knowledge, information andskills that youhaveacquired during the course. The assignment must be submitted to your tutor for formal assessments in accordance with the deadline stated in your schedule of presentation.

TUTOR MARKED ASSIGNMNT

There are fourteen Tutor Marked Assignments in this course, and you are advised to attempt all.

Aside from your course material provided, you are advised to read and research widely using other references which will give you a broader viewpoint and may provide a deeper understanding of the subject.

Ensure all completed assignments are submitted on schedule before set deadlines. If for any reasons, you cannot complete your work on time, contact your tutor before the assignment is due to discuss the possibility of an extension. Except in exceptional circumstances, extensions may not be granted after the due date.

FINAL EXAMINATION

The final examination for this course will be of three hours duration and have a value marked of 70% of the total course grade. All areas of the course will be assessed and the examination will consist of questions whichreflect the type of self-testing, practice exercise and tutor assignments you have previously encountered. Utilise the time between the conclusion of the last study unit and sitting the examination to revise the entire course. You may find it useful to review your self assessment exercises, tutor marked assignments comments on them before the examination.

Course Marking Scheme
The work you submit will count for 30% of your total course mark. At the end of the course however, you will be required to sit for a final examination, which will also count for 70% of your total marks.

How to get the most from this Course
In distance learning, the study materials are specially developed and designed to replace the lecturer. Hence, you can work through these materials at your pace, and at a time and place that suits you best.

Visualise it as reading the lecture instead of listening to a lecturer.

Each of the study unit follows a common format. The first item is an introduction to the subject matter of the unit and how a particular unit is integrated with the other units and the course as a whole. Next is a set of learning objectives. These objectives let you know what you should be able to do by the time you have completed the unit. Use these objectives to guide your study.

On finishing a unit, go back and check whether you have achieved the objectives. If made a habit, this will further enhance your chances of completing the course successfully.

The following is a practical strategy for working through the course:

- Read this course guide thoroughly.
- Organise a study schedule, which you must adhere to religiously. The major reason students fail is that they get behind in their course work. If you encounter difficulties with your schedule, please let your tutor know promptly.
- Turn to each unit and read the introduction and the objectives for the unit.
- Work through the unit.The content of the unit itself has been arranged to provide a sequence for you to follow.
- Review the objectives of each study unit to confirm that you have achieved them. If you feel unsure about any of the objectives, review the study material or consult with your tutor.
- When you are confident that you have achieved a unit's objectives, you can then start on the next unit. Proceed unit by unit through the course and try to pace your study so that you keep yourself on schedule.
- After submitting an assignment to your tutor for grading, do not wait for its return before starting on the next unit. Keep to your schedule. When the assignment is returned, pay particular attention to your tutor's comments.
- After completing the last unit, review the course and prepare yourself for final examination. Check that you have achieved the units objectives (listed at the beginning of each unit) and the course objectives listed in this course guide.

FACILITATORS/TUTOR AND TUTORIALS

Therewillbe specific timemadeavailable for tutorial sessions, in support of this course. You will be notified of the dates, time and location of these tutorials, together with the name andphone number of your tutor, as soon as you are allocated a tutorial group.

Your tutor will mark and comment on your assignments, keep a close watch on your progress and on any difficulties you might encounter and provide assistance to you during the course. You must mail your tutor marked assignments to your tutor well before the due date. They will be marked by your tutor and returned to you as soon as possible.

Do not hesitate to contact your tutor by telephone, e-mail or your discussion group (board) if you need help.

The following might be circumstances in which you would find help necessary. Contact your tutor if:
You do not understand any part of the study unit or the assigned readings.

You have difficulty with the self – tests or exercises.

You have a question or problem with an assignment, withyour tutor's comments on an assignment or with the grading of an assignment.

You should try your best to attend the tutorials. This is the only chance to have face-to-face contact with your tutor and to ask questions which are answered instantly. You can raise any problem encountered in the course of your study. To gain the maximum benefit fromcourse tutorials, prepare a question list before attending them. You will learn a lot from participating in discussions actively.

SUMMARY

This course is designed to give to you some teaching skills that would help you improve your teaching techniques and thus produce students who pass chemistry methods

We, therefore, sincerely wish you the best and that you enjoy the course.

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MODULE 1NATURE OF SCIENCE

UNIT 1 DEFINITIONS OF SCIENCE

CONTENTS

1.0 INTRODUCTION

Chemistry is part of science and it could be seen as an anchor that unified all the other areas of science. The unit considers some definitions of science together with some basic scientific assumptions.

2.0 OBJECTIVES

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

- Define science in terms of its processes
- Statethree assumptions of science

3.0 MAIN CONTENT

3.1 Definitions of Science

Definitions of Science vary from scientist to scientist. As early as the 1940's and 1950's it was regarded as a body of classified organized and systematized knowledge. Some defined science as "a group of exact demonstrable facts and proven theories". However, when defined in termsofitscontentsor products, scienceis anordered

bodyofknowledge in form of laws, theories and concepts. Also, when defined in terms of its processes, science is a method of investigating about the universe.

Anyoneofthesedefinitionswouldbe inadequateandmisleadingbecause to see science as merely an accumulation of facts or as a body of knowledge is to hold a static view of sciences, and to hold this view is to suggest that science could flourish without laboratories. Neither the processes of science which include, statingproblems, hypothesizing, designing experiments, interpreting data,and synthesizing theories typify the scientific enterprise. The science manpower project (1960) provides a definition of science that is most credible as it emphasizes the dual nature of science. Science is a cumulative and endless series of empirical observations, which results in the formulation of concepts, laws and theories with both laws and theories being subject to further empirical observations. Science is both a body of knowledge and the process of acquiring and refining knowledge. This process requires a number of mental transformations. These include induction, deduction, intuition and logicalreasoning. Thisisknownasthemethods of enquiry.

According to Fitpatric (1960), science is a cumulative and endless series of empirical observations, which result in the formation of concepts and theories, with both concepts and theories being subject to modification in the light of further empirical observation.Thus, science is both a bodyofknowledge and theprocess of acquiring andrefining knowledge, and one of its principal characteristics is its dynamic nature. Stollbery (1961) also defined science as a human enterprise including the ongoing process of seeking explanations and understanding of the natural world,and also including thatwhich the process produces– mans store house of knowledge. Science is process and product. These latter two definitions are quite broad in scope and they suggest the open- ended and dynamic aspects of an ever-growing human enterprise.It is perhaps, in this regard that Anaekwe et al (2017), stated that to fully appreciate the nature and structure of science it must be seen as a set of attitudes and processes on one hand and products on the other hand. The scientific enterprise therefore, comprises of the peculiar disposition of the scientist (attitudes), the way he/she engages in investigating the environment(the process) and the body of knowledge so obtained (the product).

Scientific Attitudes: Theserefer to the peculiar attitudinal disposition that characterizes the intellectual behaviours of scientists and science students. It is a behaviour that emanates from repeatedly going through the scientific process in the search for knowledge irrespective of one's bias or prejudice. The traits that characterize scientific attitude includes:

- Objectivity –impartiality, reporting it as it is, not as it may be.
- Scientific Honesty-truthfully conducting experiments and reportingoutcomes as obtained.
- Observing accurately- paying attention to minutest details
- Patience and Perseverance –allowing outcomes to proceed at prevailingconditions, no interference with stated procedure.
- Humility –admitting shortcomings and accepting responsibility for actions
- Team-spiritedness/Cooperation- being ready to work as a group
- Open-mindedness-readiness to change opinion in the face of more reliable evidence
- Suspended judgment-deferring conclusion until all reliable evidence are obtained, not being quick to draw conclusion.
- Being skeptical-reasonable doubt, not taking things on its face-value.
- Flexibility of thought-allowing reason not myth or superstition to be cloud one's judgment.

ScienceProcess Skills: These refer to the skills which the scientist brings to bear in the process of conducting his/her investigation. They are the essential ingredientsand tools of mental operations in science. They include:

- Observing- the most primary process skill implying taking in of sense perceptions from environment via the sense organs
- Classifying –grouping of observed phenomena based on established scheme
- Measuring-using measuring devices to describe properties like height, Area, Time etc
- Communicating –we communicate via Figures, language, drawings, graphetc
- Inferring –drawing opinionor conclusion based on observed fact. Recall Tests, Observation and Inference in recording of your practical work.
- Predicting –articulation of expected result based on past experience
- Experimenting-practical investigation ofa phenomena through manipulation of variable(s).
- Formulating Hypotheses –the ability on previous or present observation to release a tentative guess which is subject to surer testing.
- Identifying, Manipulating and Controlling Variables-the ability to hold some factor(s) constant and allowing other(s) to vary in order to determine the outcome on the system.
- Interpreting Data-offering answers/explanations to questions or hypothesis under investigation based on data gathered(Akpan, 2015, Anugwo and Asogwa, 2015). It enables inference to be logically drawn.

Science as Product: This refers to an accumulated body of knowledge and skills encapsulated in the subject boundaries as biology, chemistry, physics etc. In constitutes of entities that can be represented or studied as facts, concepts, principles, theories and laws (Anaekwe et al, 2010).

- **Fact-**a piece of information or statement that is true, a situation that exists, or something that happened. It is a fact for instance that 'matter consists of tiny particles called atoms' unlike, 'matter consists of indivisible particles called atoms'. Similarly, 'healthy plant leaves are green' unlike, 'all plant leaves are green'. Facts are the sole units that constitute concepts.
- **Concepts-**the meaningfulness which we attach to scientific facts (Maduabum 1989). It is an organized information about a category of observations. For instance, by looking at the Concepts of Atomic Theory and Photosynthesis we gain more insight on the two factual statements made earlier about 'Matter' and 'Plant leaves'.
- **Principles-**generalizations arrived at by integrating two or more related concepts. Scientific principles convey factual meaning, certainty or exactitude in generalized statements. For example: water expands whenever it freezes; when strongly heated, metals expand. Principles are usually used to explain natural events. Before conducting experiments to investigate situations, reasonable guesses , called hypotheses are proposed and tested.

Self –Assessment:

i. Can you now explain why a glass cup broke after the water content got frozen?
ii. Again, why do engineers allow some gaps in-between railway lines or bridges?

- **Theories-**When a hypothesis has been tested and found to be correct/true within the limits of available evidence, it becomes a theory..
- **Laws-** A scientific law is established only after the theory has been extensively tested and found to be true without any exception.When the hypothesis proposed gives a negative result after experimenting, the scientist goes back to modify the hypothesis or proposes a new one and conducts further experiments. This method of studying a problem is known as the scientific method and it is the foundation of all scientific research.
- Observation>Patterns(facts, concepts>principles)>.Problem.>Hypothesis>.Experiment>.Theory> Further testing>. Law.

Self AssessmentExercise

Explain why science is a body of knowledge and the process of acquiring theknowledge.

3.1.1 Assumptions about Science

There are several accepted assumptions and basic principles, which a science teacher would find helpful in initiating the thinking and activities of the students.

These are:

Principle of Causality: Scientists believe that every phenomenon results from adiscoverable cause.

Principle of complementarity: All phenomena are incorporated into a single consistent natural scheme by scientists. But contradictory generalizations may be necessary to describe different aspects of certain things as they appear.

Principle of consistency The assumption is that the behaviour of the universe is not subject to change, but is describable in terms of consistent laws such that when two sets of conditions are the same, the same consequence may be expected.

Principle of continuous discovery: It is believed that it will be possible to go on learning more about the material world and the material universe of which it is a part, until a more complete understanding of the world and universe may be attained.

Principle of Dynamism: Nature is expected to show variation and change that is dynamic and not static.

Principle of Intergradations: Scientists think in terms of continual and not sharp boundary lines. They expect to find related classes of natural phenomenon grading imperceptibly into one another

Principle of materiality: Preference is on material and mechanical explanations of phenomenon rather than those that depend and supernatural factors.

Principle of objectivity: Ability to examine facts and to suspend observations, conclusions and activities

Principle of parsimony: Preference for simple and widely applicable explanations of phenomena

Principle of practicality: The expectation is that in any situation involving competition among units of varying potentialities, those that work best under existing circumstances will tend to survive and perpetuate themselves.

Principle of probability: Many scientists operate on the premise that certainty is impossible, but they have faith in inductive inference based on probability as guides to explanation of natural phenomena.

Principle of Relativeness:The world and the things in it are thought of as sets of relationships established in certain frame of reference. As frames of reference change, many observed relationships also change.

Principle of social limitation: The social framework of operation may determine and limit both the kinds of problems on which he works and the data which a scientist collects and may also influence his conclusion

Principleoftentativeness: Scientists donotregardtheirgeneralization as final, but they are willing to modify them if they are contradicted by new evidence.

Principleofuniformity:Itisbelievedthattheforcesnow operating in the world and the universe we see are as a result of the continuous operation of these forces. The most interesting aspects of scientific functions is the discovery of valid relationships between events and changes. This is usually don bymaking careful observations, records an analyses; from such analyses, theycan make predictions regarding other events or changes. It is only when

predictions are verifiable by further observations or experiments that scientists can propose generalizations, theoriesorlawswhicheventually serve as basis for other predictions. The predictive function of science is the most important contribution to the human community. In the study of natural phenomena, scientists operate within therealmofpossibilities, probabilities andinevitabilities, none of which can be predicted with absolute certainty. In this case, the language of scientists and science teachers do not include terms suchas absolute, exact, always, never, impossible, and incontrovertible. It is advised that teachers do not forget the above factors when teaching their science classes. Consideration of each of these factors will no doubt enhance the learning of science.

4.0 CONCLUSION

It could be observed that science has its own peculiar culture and it is foreign to our culture. This is reflected in some assumptions of science.

5.0 SUMMARY

In this unit we have learnt that:

(i) Science is both a body of knowledge and the process of acquiring and refining knowledge.

(ii) There are universally accepted assumptions and basic principles, which are helpful to science teachers

6.0 TUTOR MARKED ASSIGNMENT (TMA)

1. Give a universally accepted definition of science and explain why it is universal.

7.0 REFERENCES/FURTHER READINGS

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UNIT 2 MYTHS AND DOGMAS ABOUT SCIENCE

CONTENT

1.0INTRODUCTION

The philosophical context of science gives us another way of looking at science as a way of thinking. Science is also seen as an institution.

2.0 OBJECTIVES

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

- Explain myths and dogmas about science
- Explain the philosophical context of science

3.0 MAIN CONTENT

3.1 Myths and Dogmas about Science

The interpretation of any phenomenon in African society will depend solely on the culture. The African culture has been interpreted to meanwaysandideasofthe pastandit is supposed to be evidenced in language, dress, entertainment (singing and dancing) and beliefs. The introductionof scienceintowesterneducation has, nodoubt, brought about conflict of African culture and science. In a handbook published in Ghana by the Science Education Programmefor Africa (SEPA), reference was made to the conflict of science and culture. It stated that: “A tragedy of science education in Africa, which adults and childrenhave shared, is atit hasnotalwayspaidattention tothe culture of the African. In the recent past there was a lack of adequate knowledgeof thelocalcultural environmentwhichwasin any case dismissed as wholly inimical to the development of science concepts”.

A predominant conflict in science education in Africa is an academicdiscipline, which is facing an uphill task because most African studentsandteachersstill holdfirmlyto superstitions, which eventuallycontradict and buffer any modern approach to science. Professor S.O Awokoya wrote about the conflict of science and superstition in Nigeria “There is a big difference between the position of science in Africa and in the Western world. In Africa we have products of science presented tous.

Weneedthesearchlight ofscience to illuminatethedarkcorridors in our knowledge and it will seem that the first job of science teachers is to eliminate a great deal of superstition to explain natural phenomena in terms of the natural as distinct from the supernatural." For example, according to him, most African children beliefs are that the rainbow is the excreta of the Boa Constrictor. The superstition states that if you are able to find out where the rainbow torches the ground, you will get the excreta of the Boa and if you can manipulate it properly, you can become the richest person in the world. These superstitious beliefs cut across all aspects of science.Chemistry is a subject that could be used to explain most natural phenomena including the food we eat and how they are processed in our body. Most students are likely to see the colour changes in volumetric inorganic analysis as magic.It would therefore be better if teachers could introduce science in such a way that students would be able to apply the methods of science in distinguishing between what is science and what is not science since science is based on facts, which are verifiable. The dogmatic view of an African child about what science is will create in him a type of cultural ambivalence.

Fafunwa once said that "it is due to the fact that the African is a man of two worlds. hat of African culture and that of the other world where science has already become a dominant cultural factor. The African is operating in both of worlds as best he can. The problem is that the African child comes to the school with a load of mysteries that plague his mind.

If care is nottaken, these mysteries usually tagged "superstitions" are capable causing blockage to any scientific knowledge the child might acquire as a result of schooling. In order to bail the child from these problems, explanations to scientific problems are better demonstrated by laboratory experiments. The materials to be used for such experiments must be relevant to the material world of the child. In this case, the concept of improvisation in teaching science is of necessity.

Exercise

Explain briefly why science is foreign to an African child.

3.1.1 Philosophical Context of Science.

Philosophizing about science is primarily concerned with the critical examination of the processes and products of science. Philosophy of science therefore ispreoccupied with posing questions, and seeking rational answers relating to the nature of science, the validity of the scientific knowledge, knowing how knowledge is acquired and how it progresses. It thus seeks answers to questions like, what is science and how does it differ from and relate to other disciplines? What are facts, concepts, laws, principles and theories in science and how are these related? What are paradigms and how do this influence the development of the scientific knowledge?What is the scientific method and what kind of values underlie the scientific enterprise? Answers to these questions and the like help to clarify the nature of science, what the scientist does, and help him to takebetter decisions to improve what he does. They also suggest what kinds of scientific knowledge should beincluded in the curriculum and also howthese shouldbe implemented in the classroom. The philosophicalanalysis and explanations of the nature of science have led people to believe that science is not only a body of systematized knowledge, a method, a way of investigating, but it is also a way of thinking. These analysis and explanations seem to present the scientific enterprise as being inductive. The inductive thinking tends to proceed from the specific to the general, making generalizations from raw and specific data. It attempts to logically mould raw and incoherent data into a comprehensible whole.

Science reaches out for new ideas and facts, which it contributes to the ever growing stock of knowledge. This is unlike religion, which is more concerned with the preservation of "external truth". Science is used to denote a set of characteristic methods by means of which knowledge is certified. It is also a stock of accumulated knowledge stemming from the application of these methods. Science is therefore a process and a product of investigation. Another perspective proposed for science is that it is an institution.A community of scientists identified and accepts certain procedures, certain explanations of natural phenomena. Science therefore includes a set of cultural values and norms of scientific community that govern the activities termed scientific. Scientists believe and accept that an agreed body of fact and theory is the bedrock upon which scientific programmes are developed. Non-science has no such agreed body. Rather, it is characterised by schools of thought.

The scientific reasoning is characterised in terms of inductive and deductive logic. Induction is a scheme of reasoning that permits us to generalize, proceeding from singular statement to universal ones, for example, craziness is hereditary. Thus, from particular facts or examples, a general law is obtained or discovered.Deduction on the other hand, involves the formulation of hypothesis or speculation based on one's previous experiences; the hypotheses are tested before a theory is advanced; the theory is then held tentatively since further tests could falsify it. The exact manner of formulating a hypothesis leading to the putting up of a theory is not clear, but it is believed to involve intuition, creativity and ingenuity. Therefore, theories are propositions which vary in credibility.

4.0 CONCLUSION

Scientificfactsandprinciplescouldbe saidtobe hingedonsomephilosophical benefits. However, scientific reasoning is characterized in terms of inductive and deductive logic.

5.0 SUMMARY

In this unit we have learnt that:

- **(i)** African child comes into a science classroom with his mind loaded with superstitious beliefs.
- **(ii)** Philosophy could be used to explain the processes and products of science.

6.0TUTOR MARKED ASSIGNMENT/TMA

1. How would you make the teaching of Chemistry reflect the culture of the students you intend to teach.

7.0REFERENCES/FURTHER READINGS

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Urevba, A. (1990) Methodology of Science Teaching Benin City JulandPublishers.

UNIT 3: PHILOSOPHERS' VIEW AND AIMS OF SCIENCE EDUCATION

CONTENTS

1.0 INTRODUCTION

The views of philosophers and aims of science are essential ingredients for the dissemination of scientific facts and principle in a logical fashion that is expected to give room for comprehension and application of the facts. They would also go a long way in aiding the development of scientific attitude.

2.0 OBJECTIVES

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

- Explain the views of philosophers on what science is
- State five general aims of science

3.0 MAIN CONTENT

3.1 Philosophers' View of Science

Karl Popper, a philosopher of science, rejects the inductive method as theprocess by which science advances. He said that it is not logical to infer universal statements fromsingularones.Induction believes that there arestatements in science which we have to accept as true because it is not possible to test them. Karl Popper substituted induction with hypothetico-inductive model as a description of the process by which science advances. Hypotheses are formulated and tested; hypotheses are compared with one another and with any other relevant statements so as to find what logical relations exist between them. Hypothetico- deductive model also examines the consequences of varying the hypothesis.It then acceptsthe view that scientific change does not always proceed in the direction it started. According to Popper, hypothesis cannotbe established conclusively evenbyextensive testingwith favourableresultssincefurther tests could falsify it. A single negative instance is sufficient to establish the falsification of a hypothesis.Thus, hypothetico-deductive model is able to provide satisfactory criterion of demarcation between empirical science and non-science since it permits the revision as well as the refutation of theories. So a scientist should approach a theory from the viewpoint of whether it exposes itself to criticism of all kinds and whether it is able to stand up to it.

However, **ThomasKuhn**,another philosopherofscience criticized hypothetico-deductive interpretation of the growth of science. He was notsatisfied with the implication ofthe term falsifiability. The suggestion of Popper about rejection of an experimentally falsified theory was said to be drastic. Kuhn said that it will not be in our interest to rejectatheory,whichhas had

considerable pastsuccessand reputation until a real alternative one is in sight. According to him, it isby challenging observations and adjusting theories that scientific knowledge grows.Tests need not necessarily lead to the replacement of a theory. Kuhn is concerned with the analysis of how scientists behave normally and not how they ought to behave. He used the term "Normal Science". Kuhn attacks the belief that measurement in science is just establishing the "fact". His normative view of science sees that the success of a measure lies in the explicit demonstration of a previously implicit agreement between theory and the world. In some experiments, for example, the experimenter assumes that his experimental results would represent a straight line graph.

In the Normal Science proposed by Kuhn, members of the scientific community are governedby tradition; a strong and dominant theory(paradigm) is accepted and used as a reference point for all tests. These tests are conducted all the time mainly to test individual member scientist's puzzle-solving skills and only occasionally to test the paradigm. Testing of the paradigmis toremove anomalies ordiscrepancies. In fact, the occasional revolutions that occur at the time of paradigm change (or when a paradigm stages a come-back) are often, irrational and subjective. There is no clear basis for choice at the time of paradigm change.It is here that the scientist must turn to the wider notion of acceptability than those exclusive to science. At the time of paradigm change, science is more of a philosophy than it is like a normal science.

According to Kuhn, scientific community is a chosen society and this explains the considerable stability and continuity in science. This negates Popper's view which regarded scientific community as an open society in which no theory, however dominant and successful, is eversacred.

Popper supports the view that error will be systematicallyeliminated by the operation of critical debates in science, those social interests, which produce error will be vanquished by those social interests which produce truth.

The question of which method to use by a Chemistry teacher in the implementation of science curriculumisamatterofchoiceandconvenience. It is advisable for teachers to mix all the proposed methods in order to achieve their desired objectives. Teachers should adopt an eclectic approach to the use of instructional methods and techniques.

The philosophical and cultural context of science is a way of going deep into whatconstitutes scienceand what it entails to bea member of science community. The community must have acceptable principles, which must be used to explain the concept of science.The members must however, realize the limitations of scientific laws and theories.

Self AssessmentExercise

Differentiate between inductive and deductive reasoning.

3.1.1 The Aims of Science Education

In order to keep Nigeria secured among the nations of the world, it is necessary for the citizens to acquire scientific literacy since this will lead the countrytowards technological advancement. Itisnecessaryto realize the fact that science is a creation of man and its future, both theoretical and

technical advancement, will depend upon the quality and numberofourfuturescientists.The needfor scientifically trained manpower increases progressively in a developing country like Nigeria. In order for the citizens to realize the great opportunities, which the development of science has made in the world, identification of a useful set of values that underlie science becomes an increasingly crucial first step in building appropriate curriculum structures toachievethis dimension of scientific literacy. The values of science that must be taught are:

- Longing to know and understand: A conviction that knowledge is desirable and that inquiry directed toward its generation is a worthy investment of time and other resources.
- Questioning of all things: A belief that all things includingauthoritarian statements and "self *evident*" truths are open to question. All questions are prized although some are of greater value than others because they lead to further understanding through scientific inquiry.
- Search for data and their meaning:Prizing of the acquisition and ordering ofdata because they are the basis for theories, which, in turn, areworthwhile because theycan beused toexplain many things and events. Insome cases,thesedatahave immediatepractical applications of value to mankind as in cases in which data enables one to assess accurately the severity of a problem in society and/or the effects of policies directed to improve such situations.
- Demand for verification: A high regard for requests that supporting data bemade public and that new empirical tests be invented and/or conducted to assess the validity or accuracy of a finding or assertion.
- Respect for logic: An esteem for those chains of inference that lead from raw data to conclusion according to some logical scheme and an insistence that conclusions on action, not based on such chains be subject to doubt.
- Consideration of premises: A prizing of frequent review of the basic external and internal assumptions from which a line of inquiry hasarisen, especially when they are used as a basis for determining further action.
- Consideration of consequence: A belief that frequent and thoughtful review of both the direct and indirect effects resulting from pursuing a given line of inquiry or action is worthwhile and that a decision to continue or abort the inquiry or action will be made in terms of the consequences.

Self-Assessment Exercise

Explain briefly two values that must be taught in science.

4.0 CONCLUSION

The changing nature of science drives home the point that science is a philosophy. Scientific communitycannot beregarded as anopen society. This is because of the peculiar nature of scientific culture.He was not satisfied with the implication of the term falsifiability. Thesuggestion of Popper about rejection of an experimentally falsified theory was said to be drastic. Kuhn said that it will not be in our interest to reject a theory, which has had considered past success and reputationuntil

a realalternative one is in sight.Accordingto him, it is bychallenging observations and adjusting theories that scientific knowledge grows. Tests used may not necessarily lead to replacement of a theory. Kuhn is concerned with the analysis of how scientists behave normally and not how they ought to behave. He used the term "normal science".Kuhn attacks the belief that measurement in science is just establishing the "fact". His normative view of science sees thatthe successofa measure lies in the explicit demonstration ofapreviously implicit agreement between theory and the world. In some experiments, for example, the experimenter assumes that his experimental results would represent a straight line graph.

In the Normal Science proposed by Kuhn, members of the scientific community are governed bytradition,a strong and dominanttheory(paradigm) is accepted and used as a reference point for all tests. These testsareconductedallthetimemainlyto testindividual members. Scientists' use puzzle-solving skills occasionally to test the paradigm. Testing of the paradigm is to remove anomalies or discrepancies.In fact, theoccasionalrevolutions that occur atthetimeof paradigm change (or when a paradigm stages a come-back) are often, irrational and subjective. There is no clear basis for choice at the time of paradigm change.

5.0 SUMMARY

In this unit we have learnt that:

(i) Philosophers hold different views about science

(ii) One of the aims of science education is for the citizens to realize the confirmation of science to technological development of the world over.

6.0 TUTOR MARKED ASSIGNMENT (TMA)

1. Explain briefly the scientific views of Karl Popper and Thomas Kuhn

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UNIT 4 THE AIMS AND HISTORICAL CONTEXT OF SCIENCE

CONTENT

1.0 INTRODUCTION

When students learn and their perception of science have to do with the understanding of scientific values.One could enhance the students' interest with the knowledge of specific values which are peculiar toscience. The knowledgeofthehistory ofscience in Nigeria would enable students to appreciate the learning of science at this stage of our development.

2.0 OBJECTIVES

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

- Discuss the aims of science as inculcation of scientific values in the minds of the citizens.
- Identify some values, which are to be taught in order to enhance scientific literacy.
- Explain the necessity of science education as ability to solve problems.
- Trace the history of science in Nigeria.

3.0 MAIN BODY

3.1The Aims and Historical Context of Science

The aims of science education therefore will be the development of scientific literacy and inculcation of scientific values in the minds of the citizens. These aims could be simply put as the acquisition of scientificliteracy, development of scientific attitude and the acquisition of scientific skills. This is in line with the Bloom's taxonomy of educational objectives that is, cognitive, affective and psychomotor domains. The aims are also in line with the national objectives of education.Some authorities strongly believe that the aims of scienceeducation in schools include, scientific literacy – to inculcate the power ofcarefulobservation, classification andinterpretation ofobserved phenomena in young ones. Scientific literacy consists of the relation of science to culture, understanding of the concepts of science and knowledge of how scientific ideas are developed. A scientifically literate person therefore, isone with anunderstanding of thebasic concepts in science, the nature, the ethics that control the scientists in his work, the relationship of science and the humanities and the difference between science and technology. Fafunwa once

advocated for an education that trains the child to adopt a scientific attitude to problem solving, develops aptitude for vocational pursuits that enables the child and the adult to manipulate simple gadgets through with the hands and eyes, which should supplement the mind and the heart.

Scientific skillsshouldinvolvesolvingproblemsituationswhere apparatus has to be selected,takingreadings andmaking scientific observations (Ogunleye, & Babajide , 2011).

The five general aims of science teaching are:

- To make pupils have interest in science
- To develop inquiring mind
- To help pupils to see science in relation to the rest of culture
- To prepare some pupils for careers in science
- To help pupils to solve problems.

These generalaimspose a bigchallengetothescience teacher. A teacher of science should develop in his students, the critical mind and the ability to solve problems in addition to arousing their interest in the subject. If the knowledge imparted into students could not be used to solve their problems and that of their immediate environment, such knowledge is useless.

The goalsof sciencetherefore, should describe what we mean by a scientifically literate person. Such a person should know something about the role of science in society; appreciate the cultural conditions under which science thrives, its conceptual inventions and investigative procedures. From the aims of science education stated above, it should be noted that for this education to be meaningful, room should be givenforcomprehensionandapplication of the scientific facts,which aredisseminated. The development of scientific attitude is also paramount in any science education.

Self-Assessment Exercise

Explain theimportanceofknowledge and itsapplicationinscience teaching.

3.1.1 Historical Context of Science.

Science was introduced into the curriculum of secondary schools in Nigeria in 1859. This was when the first secondary school was established. Before 1859, all educational institutions in the countrytaught primary school subjects, language, writing, geography, drawing, hygiene,singingandhistory to the exclusionofscience.Withthe establishment of CMS Grammar school, Lagos in 1859, some rudiments of science education were injected into the school curriculum. Some attention was given to Arithmetic, Algebra, geometry and Physiology. In1878,theMethodistMissionofferedtoteachTrigonometry, Astronomy, Chemistry, Physiology, Geology and Botany to the students of Methodist Boy's High school Lagos, founded in 1878. These were to be similarly taught at the Methodist Girls' High School, Lagos, founded in 1879. The same set of subjects was offered to students of Baptist Boys' High School, founded in Lagos in 1885.

The HopeWaddellInstitutefoundedinCalabarin1895;theCMSsponsored Teachers' College St. Andrew's CollegeOyo,founded in1876;the Baptist Training College, Ogbomoso, founded in 1897; the Methodist Teachers' College, Wesleyan Training Institute founded in 1905 and the CMS owned Oron Training Institute founded in the same year had science subjects in their curriculum.

Science subjects also featured in the school's curriculum of Abeokuta Grammar School founded in 1908; King's College, Lagos, founded in 1909; Eko Boys' High School,Lagos, foundedin1913;Ibadan Grammar School, also founded in 1913; and the Ijebu-Ode Grammar School also founded in 1913. Both Denis Memorial School founded in 1928 at Onitsha and the two Colonial College Established in Ibadan and Umuahia in 1925 also made provision for the teaching of science.

In spite of the efforts made by the Christian missionaries and colonial officials to promote science education in schools, very little success was recorded. Science education was by no means popular in schools, very few students offered science subjects at the external examinations. And most of those who attempted examinations in science failed. However, the African Education Commission sponsored by the Phelps-stokes Fund of America recommended that science subjects should be included in the curriculum of all secondary schools in 1920.

The colonial government was most reluctant to encourage the teaching of science in the school in the Northern provinces of Nigeria. The belief was that the teaching of Biology could offend "Moslem susceptibilities". Of course, the first reaction of the people to the teaching of science was that of hostility.

The slow pace of the development of science in Nigeria is understandable. This was because the motive for colonization was essentially trade, another reason was that Africans generally were thoughtto be inferior human beings and as such not capable of understanding science. Only Biology related subjects such as Nature Study, Botany and Physiology were taught between 1875 and 1920. The teaching ofother subjectsbeganat about 1920 as a resultofthe recommendation of an African Education Commission, which toured the British West African Colonies under the sponsorship of the Phelps- stokes fund of America.

It was in fact the monetary reward added to the grants made by the British Government to schools which taught science that influenced the introduction of scienceteaching into allschools.The scienceand mathematics curricula in Nigeria schools were modified by the West AfricanExaminationsCouncilafter independence in 1960. The realization of the importance of science teaching in the 60s culminated into the teaching of many science subjects in all secondary schools and Teacher Training Colleges in Nigeria. Integrated science was introduced into the Junior classes as a result of the Aiyetoro Basic Science scheme and the Nigerian Integrated Science Project of the Science Teachers Association of Nigeria (STAN). The first set of the STAN books were introduced into Nigeria schools in 1972. With the adoptions of the New National Policy on Education (revised 1983), the 6-3-3-4 system of education was adopted in September 1982. Integrated science is now being taught in the first three years of Junior Secondary School while physics, chemistry, biology and agricultural science are now taught in the senior secondary school.

Self-Assessment Exercise

Give reasons whytheteachingofsciencewasdelayedinNigerianschools?

4.0 CONCLUSION

A vital aim of education is the understanding of scientific values. The development in the students the scientific attitude and the acquisition of scientific skills are very important to students' understanding of science. The historical trend of science development reveals the disparity in the development of science in the north and southern parts of Nigeria.

5.0 SUMMARY

In this unit, we have learnt that:

(i) One of the aims of science is to inculcate in the students the development of scientific values and skills.

(ii) The aims of science education are in line with the national objectives of education.

(iii) Science entered the curriculum of secondary schools in Nigeria in 1859.

(iv) The financial reward added to the grants made by the BritishGovernment to schools influenced the introduction of science teaching into all schools.

6.0TUTOR MARKED ASSIGNMENT (TMA)

1. Whatarethecontributions ofthecolonialmastersandmissionaries to the introduction of science teaching in Nigerian secondary schools?

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UNIT 5 THE CHALLENGES OF SCIENCE TEACHING

CONTENTS

1.0 INTRODUCTION

There are some concepts, which are peculiar to the teaching of science which needs to be explained. Beside, the language of science is different from the language of other subjects; this is why the social dimension of science needs to be discussed.

2.0 OBJECTIVES

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

- Explain your role as a science teacher
- Discuss the language of science, particularly, Chemistry.
- Differentiate among hypothesis, law and theory.

3.0 MAIN CONTENT

3.1 The Science Teacher

Thethreebasicfunctions of thescience teacher are:to instruct, to supervise and to managethe learning resources or facilities. However, the primary function of a science teacher is the transmission of selected experiences in science to his students. For this to happen effectively, the modern professional teacher should know a great deal about his pupils – how they grow, how they learn their needs and how to satisfy such needs at school, their capabilities or their individual differences, and a variety of methods to use in order to help the children learn easily. He should realize that children are learning directly from his teaching as wellas

indirectlyfrom their surrounding environments. Whatteacher has to offer and what the environment teaches indirectly are of equal importance to the growth and development of the child. In effect, modern teaching must be child centered that is, the interest and needs of the children at their various stages of development must determine what the teacher is to teach.

Some of the teacher-based factors which influence the quality of learning are:

(i) The quality of training given to and acquired by the teacher.
(ii) The adequacy of instructional methods and materials used in a particular lesson.
(iii) The teacher's grasp of the subject matter
(iv) The teacher's degree of attachment to textbooks
(v) The teacher's level of motivation relative to the atmosphere surrounding his job.
(vi) The teacher's capacity to take initiative.
(vii) The teacher's level of self-confidence.

3.1.1 The Learner

The learner is the teacher's audience. The teacher's work depends on who the learner is. He has to plan the lesson with the nature of the learner at the back of his mind. The learner brings into the classroom certain factors; some of which the teacher can control and some he cannot control. Some of the factors are: innate characteristics, his attitude to the subject and level of discipline, his capacity for cognitive adjustment and readiness to persevere at learning tasks, the level of supervision given to him at home, his social orientation, motivation and background in the subject among others. However, Onyegegbu (2018) outlined some barriers of female students to pursuit of Science, Technology, Engineering and Mathematics (STEM) to include paucity of visible role models, stereotypes, Bias of teachers and parents to some careers, cultural factors, poor perception of girls' ability in STEM. Effective instructional delivery is needed to overcome these challenges. The quality of learning is determined by the student's performance in an assessment task.

3.1.2 The Subject Matter

The knowledge of the subject matter by the teacher is very important. Without the subject matter, teacher cannot plan his lesson and effective teaching –learning can not take place. The interest of the students in the subject matter will depend on how interesting the teacher's teaching is.

Self-AssessmentExercise

What do you think makes a good teacher?
List and discuss five avenues of breaking girls' gender barriers to STEM careers?

The Language of Science

Science subjects have their own peculiar languages. The language of Chemistry is different from the language of physicsfor example. This is because science is operating on a different culture.

The language of science consists wholly of declarative sentences. By means of them, the scientist talks about the world. It is therefore the duty of the science teacher to translate this highly codified language into a language that his students can understand.

Most science educators have recognized the central role of language in thought and learning processes. Often the science teacher as an adult, speaks a language completely alien to the students. This is obvious of background experiences thatis, within hisframeofreference. The student, having no such frame of reference, see's him as a foreigner with a strange language. More often than not, the four languages which tend to conflict in the learning of chemistry are: the language of the subject, language of mathematics, English Language and indigenous language. English is the language of instruction.

3.2 Hypothesis, Theories and Law of Science

3.2.1 Hypothesis

A verygoodexample ofa hypothesis is Gay-Lussac's hypothesis, which states that "When gases react, they do so in volumes which bear simple ratio to one another and to the volume of the products if gaseous temperature and pressure are constant.

3.2.2 Laws

A law is a statement, which summarizes the behaviour of substances or some of their characteristics. For example, it is found from experiments that when the temperature of a gas is kept constant, the volume varies inversely with pressure. This is thesituation with all gases.This explained Boyles law, which states that "the volume of a given mass of gas in inversely proportional to its pressure if the temperature is kept constant. Some related laws are Graham's law of diffusion. Chemical lawsdescribe theways inwhichchemical changestake place.

For example, when elements combine together to form compounds, they do so in fixed proportions by weight. This is the law of definite proportion.

Lawsarealsocommontootherareasof science like physicsandbiology. We have Hook's law in Physics and also the law of Osmosis in Biology. Many laws in Physics and chemistry are not strictly true. For example, neither the law of definite proportion nor Boyle's law holds in all cases. However, a law must be approximately true if it is to be of any use. In science, laws are accepted only when experiment show that they are 100 percent accurate or tending towards 100 percent. If law refuses to hold for certain situation, further research into such a circumstance is stimulated and further clarification is made.

3.2.3 Theories

When a question is raised in science, the explanation we advance for scientific laws are called theories. For example, when we start by giving explanation for the question "why are the volumes of different gases affected in the same way by changes of pressure?

Theories emerge. The theory could be that "Gases take the shape of the container. Occasionally, a possible explanation has to be provisionally accepted without experimental testing because the statement of the theory made is not testable. This explanation is called hypothesis. Actually, scientist test theories by finding whether predictions based on them work out in practice. Thus, in the example given above, if gases are kept in the same sized container and it is found out that their volumes are affected in the same way by pressure change, it means that the theory advanced is confirmed within the available evidence. A theory can never be proved, because some unknown facts many affect the situation. For example, in the above explanation, effect of pressure, on the volume of gases may be influenced by other factors other than the shape of the container. Theories are usually tested by making models. Theories are modified based on additional information. For example, atoms were first regarded as indivisible units until the discovery of the fundamental particles of atoms.

Exercise

Write out one in each case; hypothesis, law and theory.

4.0 CONCLUSION

A teacher must know what is expected of him before opting to be one. The knowledge of the students and that of the environment, the subject matter are very important. This is what would make a teacher perform his duties creditably.

5.0 SUMMARY

In this unit you have learnt that:

(i) Teacher has to instruct, supervise and also manage resources.

(ii) Some factors influence the quality of learning.

(iii) There are differences among hypothesis, law and theory.

6.0 TUTOR MARKED ASSIGNMENT (TMA)

1. What are you supposed to know in order to make your work as a teacher a successful one?

2. Give a concise explanation of the factors that could influence the quality of learning.

3. Distinguish among, hypothesis, law and theory.

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MODULE 2

Unit 1: The Social Dimensions of Science and Barriers
Unit 2: To Effective Communication in Teaching
Unit 3: Application of Some Teaching Methods
Lesson Plans and its Preparation
Effective Teaching of Science
The use of Chemistry Laboratory
Unit 4 Laboratory Organisation and Management
Unit 5:

The Social Dimensions of Science and Barriers to Effective Communication in Teaching Science

UNIT 1

CONTENT

1.0 INTRODUCTIO

Science operates in the society, which occupies living and non-living organisms. The effects of science and technology could be felt by the society. Beside, science has both positive and negative effects on the living andnon-living occupantsin the society. Man himself is a scientific being whose operations within the social system could have adverse effect on the entire society set-up. The teaching-learning encounter involves communication and there could be barriers, which could include sex of students and their background (Okafor,2018).

2.0 OBJECTIVES

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

- Explain the social relevance of science
- Differentiate among science, engineering and technology.
- Discuss the contribution of science to overall development of man.

3.0 MAIN CONTENT

3.1The Social Dimensions of Science

Theteachingof scienceshouldnot only involve getting outusefulinformationto the learners, it should also take care of the social relevance of science. Basically, what is required in science education is the teaching of science, technologyand societyand interactionbetweenthem. Science can therefore be regarded as the creation of man and its future is in the realms of both theoretical and technical advancement.

The developmentofscientificliteracyworld-wide has initiatedtheProduction of essential materials needed in allfields of human endeavour. The products of scientific technology include sophisticated weapons, supersonic aircrafts,micro-computers, test tubebabiesand improved medical care. The question of whether these achievements of science are beneficial or destructive to man is debatable.

Science is now regarded as a very important aspect of education in all countries of the world because of its socio-political values. This was in line withwhatFrancisBaconsaidinthe12th centurythatscience should beused for the merit andemolument of man; for thisto be meaningful, the language of science should be blended with those of our people, andthiswillfacilitate understanding ofmanyscientific concepts.

Science, engineering and technology are related but distinct enterprises. In the public mind, however, they are generally lumped together under the broad heading of "Science". Part of the problem of scientific literacy can probably be traced to the fact that the overall enterprise generally known as "Science" begins in the real sense, with observation and in the end returns to the world in the form of technology. Simply, put, wherescience seeks an ultimate understanding of the natural world, engineering seeks to apply such knowledge to practical needs, technology deals with the tools and techniques – the methods of producing the endproducts for a modern industrialsociety. Theadvantage of technology over pure science is that of keeping the student in touch with the "real" world.

Self-Assessment Exercises

1. Distinguish among Science, engineering and technology

2. Explain why science and society are related?

3.1.1 Barriers to Communication in Science Teaching

Sex is another barrier to inter-personal communication in science class. There are things that girls will never disclose to male teachers, but will tell to female teachers. The same holds true withmalestudentsandtheirteachers.Because ofcultural demands, girls are not interested in such professions as auto mechanics, as an example, how then can we then, get them interested? Perhaps laboratory experiences, which is again a matter of proper selection of methods and materials.

Background is another barrier to inter-communication. Most teachers come from the level of middle-class background which prevents a good understanding of students from other backgrounds. Most of our students also come from non-scientific backgrounds. We must, therefore, choose experiences that will give the flavour of science to their lives.

All these barriers of time and space may not be overcomed, but with proper selection of meaningful experiences, we may overcome some of them. Before we can select a particular method, we must ask ourselves certain questions about the materials or techniques that we are going to use.

- Will this method give an accurate picture of what students should learn? For example, if we are demonstrating capillarity with pieces of sugar dipped in a pool of ink and concludes "This proves that water is drawn up". What this demonstration shows is that ink will be drawn up through a piece of sugar.
- Will this method impart desirable information to students? The use of unrelated analogy during a lesson or reference to unrelated experiments will be meaningless to students.
- Is this method appropriate to students? This would depend on the age of students and the topic we are treating.
- Will this method help students to think?
  If any material or method will not get students to think, to probe or to investigate, it may well be that it is a waste of time. Forexample,ifweuseaskeletontoassiststudent in the memorization of the bones of human body and do no more with it than that what thinking can occur?
- Is this method worth the expenses and effort?
  The job of the teacher is to estimate the amount of time amethod a laboratory period, for example, will take. If the results of the time spent are notworth it,the teacher must veto the activity.

3.1.2 Scientific Development and Science Teaching

For a country to be secured among the nations of the world, she needs to embark on scientific literacy of her citizenry. The standard of living and health status of the people will also be improved through the knowledge of science. It is also an important fact that what we know as scientific development today may have questionable value today and may become obsolete tomorrow; the question of what constitutes abuse of drug will be brought to limelight through science education. The technological

breakthrough of any nation will also depend on those members scientifically trained manpower she could produce. Unfortunately, fewerstudents embark onthe learning ofscience inNigeria. Improved science programme must play an important part in solving this problem. A scientifically literate citizenry is also needed inmaking some vital decisions in a democratic system. This is responsibility of the schools and primarily a function of science programme in the schools science education also aims at preparingpeople for adjustment within their environment. Human beings, through infancy, childhood, adolescence, adulthood and old age. They change as functioning biologically organism. The ways that feel about themselves and other people change.

The manner in which society deals with them also changes. At each developmental stage. There are certain needs the individual must meet if he is to work out satisfying adjustments to himself, other people, and his environment. Identification of these needs no doubt, is a function of scientific literacy.

Self AssessmentExercise

Why is the development of man linked with scientific literacy?

4.0 CONCLUSION

There is no doubting the fact that science has social implication and that man is a scientific object. The social contributions of man therefore be enhanced through scientific literacy.

5.0 SUMMARY

In this unit we have, learnt that:

(i) Sciencecontributesimmenselytothedevelopment of the society.
(ii) The theoretical and technical advancement of man depend on hisknowledge of science.
(iii) Science technology and engineering are somehow related.
(iv) Gender of students and their barriers, could be barriers to communication in science. We need to ask question about materials and technique that we are going to use

(vi) The living standard and healthy status of man are through improved the knowledge of science.
(vii) A scientifically literate citizenry is needed to make some vital decisions in a democratic society.

6.0TUTOR MARKED ASSIGNMENT (TMA)

1. Explainwhyascientificallyliteratepersonisneededina democratic setting like Nigeria.

7.0REFERENCES/FURTHER READINGS

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UNIT 2 APPLICATION OF SOMECONVENTIONAL AND INNOVATIVE TEACHING METHODS

CONTENTS

1.0 INTRODUCTION

The teachers need to have a good knowledge of methods of teaching so that he would understand which one to use in different classroom situation. It is the classroom situation that determines method to be used by the teacher. The implication of this is that no method of instruction is superior to the other. Whenever occasion arises, lecture method could be used as the most appropriate.

2.0 OBJECTIVES

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

- Outline three methods of teaching science.
- State three advantages and disadvantages of the teaching methods.
- Apply some of the methods to the teaching of chemistry.

3.0 MAIN CONTENT

3.1 Conventional Teaching Methods

3.1.1 Lecture

The teacher would come to the class fully armed with a mass of facts probably gathered from books and would start to pour out the facts, perhaps pausing at intervals to ask few questions, or if he liked, he could leave the questions to the end of his lecture. . The teacher does most of the talking while the pupil's remain passive listeners for most of the period

Advantages

- Allows the teachers to cover enough ground within a short time.
- Little time is spent on teaching aids
- It could be delivered through radio thus minimizes the cost of employing teachers
- It encourages the art of note taking
- It encourages independent study

3.1.2 Excursion

Excursion to places already mentioned.

3.1.3 Problem Centered

A problem within the reach or understanding of the children is posed, and the children are left to find solutions to it. It is necessary to teach students the normal steps that areinvolved in the solving of any problem: -

- Understand the problem
- Collect relevant information
- Marry the information together
- Solve and evaluate.

3.1.4 Role Playing:

This is the process of assuming the nature, manner, behaviour, attitude, responsibility or authority of a post, persons or objects in a given situation.

Role playing is used in a variety of ways and for various purposes, it is used to resolve conflicts and settle problems as well as teach certain feelings of emotions which might be difficult for a teacher to express or demonstrate by himself.

3.1.5 Dramatization

This method is used by children in schools to convert facts or skills to be learnt into drama in order to make the learning of such facts or skills more interesting and realistic.

Dramatization enables the teachers to learn about the various maturity levels of the pupils in terms of their emotional, physical, intellectual and social development. Some problems inherent in this method are: those of planning, time, costumes and relevant materials needed to enrich the play.

Some of the advantages are:

(i) It affords pupils the opportunity to express themselves freely and happily
(ii) It develops in them a sense of respect for the opinion of others
(iii) It develops in them the attitude of cooperation in a group.

3.1.6 Team Teaching

This takes place when two or more teachers jointly share the responsibility for directing and evaluating of the learning experiences of a common group of students. The goal is improvement of instruction though a better utilization of personnel. The collective effort often yields success. The presence of several professionally competent teachers ensures that one teacher does not assume total responsibility for every lesson.

Self-Assessment Exercise

Explain briefly why a teacher cannot rely on a particular method of instruction.

3.1.7 Inquiry Method

By the simple fact that children are curious and inquisitive they are always exploring, trying to find out why some things occur. Thus, they are always trying to understand aspects of the universe and their immediate environment.

Inquiry method of teaching is teaching in which learners try to find out things for themselves. In order to do this, the learner is led by skillful, thought provoking questions by the teacher in order for them to discover facts for themselves. The learner is given the opportunities to gather information, facts, and ideas and to process them by himself in order to find solution and draw conclusion from them.

The curricula of science subjects, including chemistry in Nigeria focus on inquiry method of teaching. The method makes the science teaching to be student centered, instead of teacher centered because the students are made to find out things or possibly discover knowledge by themselves. Inquiry method also involves high level of mental processes such as asking insightful questions, formulating problems, formulating hypotheses, describing inquiry experiments and so on. Some of the guidelines for inquiry method are:

- The teachercreatesa freeandopenclassroom climate forthe learners.
- The teacher thinks of a problem to stimulate the learners to think by themselves.
- The teacher asks thought provoking questions from the learners.

- The teacher supports correct answers and asks other questions to draw out more facts from the students.
- Once the learners are stimulated and probing begins, the learns can continue their search for the right answer through their performance of certain mental processes such as observation, identifying problems, exploration, measuring hypothesizing, predicting, describing, conducting experiment, collecting data, organizing and analysis data, reporting, and making generalization.
- Probing can be in groups of four or six or in large groups depending on the teachers choice, the class size, age and maturity of the learners
- Sift the information collected and remove those elements that are not relevant
- Ask morequestions which will lead to the final answer of presented question or the solution to the problem.
- Draw final conclusion from the relevant sifted information.

The method enables students to:

a. Participate actively in the class
b. Practice and process certain scientific attitudes suchas objectivity, curiosity, open mindedness and perseverance.
c. Engage in formulating problems for investigation
d. Engage in formulating hypothesis to guide investigation.
e. Engage in designing experiments to collect data.
f. Aid studentsinsynthesizing knowledge in form of generalization or finding solution to a problem.

Self-Assessment Exercise

Why is teaching methods important in the teaching-learning.

3.1.8Demonstration

This is a process of presenting or establishing facts or principle. It is a procedure of doing or performing something in the presence of others either as a means of showing them how to do it themselves or illustrate a principle. Stoll berg (1955) asserts that demonstrations help to:

- Illustrate a fact or principle;
- Visualize processes ;
- Show materials or specimen;
- Portray methods or teaching techniques; create a problem situation;
- Stimulate interest;
- Find solution ;
- Evaluate pupil's achievement

Also, demonstrations could serve as a review or a climax to end a unit. Demonstrations serve as excellent motivational tools. Demonstrations could be done either by the teacher or pupils. It is not always the case that a teacher demonstrates. Pupils' demonstration should be encouraged especially when the materials are safe to use.

Advantages

According to Schilling (1960), a demonstration:

- Allows pupilstoconfrontanatureitself i.e. observenatural processes
- Facilitates spectator experience;
- Allows pupils to observe how a scientist thinks and proceeds;
- Allows the repetition of classical experiments too difficult or dangerous for pupils etc and we could gold that;
- Demonstrations permit pupils to observe raid scientific processes, which otherwise they would have missed.

Disadvantages

Like individual laboratory exercises demonstrations have a number of limitations viz:

- Visibility problems;
- Pupils have a limited opportunity to become familiar with the learning materials
- Not all-scientific information can be grasped by sight and sound alone. Odours and texture require close observation and touch respectively;
- Often only a few students are able to follow the demonstrations
- It is rather to insure maximum mental participation while the body remains inactive;
- Teacherdemonstrationtendstobetoomostconvincing-professionallysophisticated apparatus adds a note of authority and makes results difficult to question.

3.2 Innovative Teaching Methods:

Innovative teaching and learning techniques according to Anaekwe et al (2010), entails structuring Science instructional processes in such a way that the learner is the focal point of the interaction. It is all about creating a learner-centered classroom environment where the teacher serves as a facilitator of learning rather than the ultimate authority for learning to take place. Here learners are encouraged to be curious about the learning environment, proactive and creatively engaged in both hands-on and minds-on activities.

3.2. 1Cooperative Learning Strategy:

Cooperative learning strategy is an innovative teaching and learning approach in which small groups (about 3 to 5) of learners each, of different academic ability groups (high, medium and low) use a variety of learning ativities to improve the mastery of a topic or subject matter among the group members. Each group works as a team and strives to out-performothers. It enhances intra-group cooperation and inter-group competition. The group chooses its leader. The score for each group is the average of group members. The teacher serves as a facilitator. Teacher may use
learners in the upper 30%, middle 30% and bottom 30% (say from end of session result) in classifying the learners into mixed-ability grouping(Nnaka and Anaekwe, 2006).He/she may as well adopt any other approach that would ensure heterogeneous ability grouping.

Some additional benefits of cooperative learning include:

- When students are working toward a common goal, academic work becomes an activity valued by peers.
- Students are motivated to help one another learn.
- Students are able to translate the teacher's language into "student language" for one another.
- Students who explain to one another strengthen their own learning.
- When students need to organize their thoughts in order to explain them to teammates, they must engage in thinking that builds on other ideas (cognitive elaboration) which greatly enhances their own understanding.
- Teammates can provide individual attention and assistance to one another.
- Regular and constructive collaborative study groups can assist you with mastery of material, exam preparation, and better performance on tests

What are the possible disadvantages of this type of instructional strategy?

3.2.2 Concept Mapping

A concept map is a diagram showing the relationship between concepts. It is a diagrammatic visualization of relationships between concepts. Concepts are connected with labeled arrows in a downward branching hierarchical structure. Concept Maps can be used before, during or after a learning activity to assess development of understanding, particularly in terms of inter-relationship between super and minor concepts (Novak and Golwin, 1996) . It is a powerful tool for identifying learner's correct scientific ideas and misconceptions. It enhances meaningful learning.

3.2.3 Computer Assisted Instruction (CAI)

CAI is an outgrowth of the application of programmed learning instruction.When the computer is used in instruction/learning, that type of instruction/learning is termed Computer Assisted Instruction(CAI) or ComputerAssisted Learning (CAL).In each case, there must be a program being studied. CAI is directed towards developing a selective instruction based on individualability. CAI has great potential for individualizing instruction in which the learner works at his/her pace. However it has little or no merit in promoting inter-personal relationship.

Types of Computer Assisted Instruction

1. **Drill-and-practice** Drill and practice provide opportunities or students to repeatedly practice the skills that have previously been presented and that further practice is necessary for mastery.
2. **Tutorial** Tutorial activity includes both the presentation of information and its extension into different forms of work, including drill and practice, games and simulation.
3. **Games** Game software often creates a contest to achieve the highest score and either beat others or beat the computer.
4. **Simulation** Simulation software can provide an approximation of reality that does not require the expense of real life or its risks.

5. **Discovery** Discovery approach provides a large database of information specific to a course or content area and challenges the learner to analyze, compare, infer and evaluate based on their explorations of the data.
6. **Problem Solving** This approach helps children develop specific problem solving skills and strategies.

Advantages of CAI

- One-to-one interaction
- Great motivator (Chieke & Anaekwe, 2019)
- Freedom to experiment with different options
- Instantaneous response/immediate feedback to the answers elicited
- Self pacing - allow students to proceed at their own pace
- Helps teacher can devote more time to individual students
- Privacy helps the shy and slow learner to learn
- Individual attention
- Learn more and more rapidly
- Multimedia helps to understand difficult concepts through multi sensory approach
- Self-directed learning – students can decide when, where, and what to learn

Limitations of CAI

- May feel overwhelmed by the information and resources available
- Over use of multimedia may divert the attention from the content
- Learning becomes too mechanical
- Non availability of good CAI packages
- Lack of infrastructure

What are the possible demerits of computer usage in education?

4.0 CONCLUSION

The method of teaching adopted by the teacher is what determines the success of such teaching. There are many methods from which a teacher could choose from but none of the methods could be regarded as the best. In some cases, a teacher would need to combine two or three methods in order to achieve the objective of the lesson.

5.0 SUMMARY

In this unit, we have learnt that:

(i) Teachers need to have adequate knowledge of the different method of teaching.

(ii) No method is superior to the other

(iii) Any method of instruction has its advantages and disadvantages.

(iv) The situation in the classroom determines which methods to the teacher would use.

6.0 TUTOR MARKED ASSIGNMENT (TMA)

What are the factors to be considered by the teacher in the selection of methodology of teaching?

7.0 REFERENCES/FURTHER READINGS

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UNIT 3 LESSON PLANAND ITS PREPARATION

CONTENT

1.0 INTRODUCTION

Lesson Plan is a teaching guide which a teacher could easily refer to during teaching.A lesson is prepared in such a way thatany other teacher in the same area of specialization could make use of the plan ifthe usual teacher is not available for the teaching.A lesson plan is to a teacher what a building plan is to a Builder. It contains all the actual parts of the lesson but the detail unfolds in course of the instructional delivery. Lesson plan differs from lesson note. Lesson note refers to the chalk-board summary often written by the teacher at the end of the lesson for learners to copy in theirnotebook.

2.0 OBJECTIVES

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

- State the importance of note of lesson
- State the different parts that make up a lesson plan
- Write a good lesson plan on any chosen topic in chemistry

3.0 MAIN CONTENT

3.1 Requirements for Lesson Preparation

The last stage of lesson preparation is lesson plan. When a teacher setsout to prepare a lesson, he must first ask himself questions such as:
(a) Who is to be taught ?
(b) What is to be taught ?
(c) How is it to be taught?

The question of what to be taught require that the lesson must have an aim and the material for the lesson will be selected in order to achieve the aim. Sources of materials are not limited to textbooks.

The question of how is it to be taught will determine the method. Teachersoften developed multitudes of methods based on their knowledge of child development and the psychology of learning. The secret of teaching is to vary methods from time to time.

In order to address the question of who's to be taught, it is obvious that a lesson prepared for children of twelve would not be suitable for children of six, the content and approach would be different in each case. Beside, the varying abilities of students should be taken into consideration.

3.1.1 Lesson Plan – Its Composition

The main function of the lesson is to aid the memory of the teacher and consequently facilitate teaching. In a situation whereby a teacher has to teach eight subjects a day, it would be difficult to commit every fact that has to be taught to memory and teach without any plan of the lessons.Lesson plan constitute the final stage of a lesson preparation.

Lesson plan need not be too long but neither should they be too short. The rule seems to be that lesson plan should be long enough to indicate clearly what is going to happen during the course of a lesson, but not so detailed as to run into many pages. Frequent references to lesson notes portray the teachers as nervous and lacking in confidence as well as lacking assurance in the mastery of subject matter. An advantage of teachers writing fairly detailed lesson plans is that if the normal teacher, for one reason or another, cannotteach theparticular lesson he has written plans for a different teacher can take his place follow the plan made and teach the topic on his behalf. Lesson may be of two forms namely, the Prose and the Tabular formats. The form used in writing lesson plans depends on the nature of the subject. However, the Science teachers Associatio of Nigeria (STAN) has been consistent in advocating for the use of tabular format. The reasons include that it is consistent with the goals of learner-centered advocacy. It spells out clearly the activities of the learner at every stage of the instructional delivery as well as the instructional strategy adopted(Nnaka and Anaekwe, 2004). A good lesson planshould contain the following:

(i) General information
(ii) Aim/objective
(iii) Previous knowledge
(iv) Introduction
(v) Presentation
(vi) Pupils activities;
(vii) Conclusion and evaluation.

3.1.2 General Information

This include the personal details of the Teaching Practice candidate, the date, the time of the day, the lesson to be taught, the class, the topic to be treated.

3.1.3 Behavioral Objectives

The objectives set out to be attained by the learners by the end of the lesson isreferred to as instructional objectives. Because they are stated in terms of demonstrable behavior of the learners, it is also known as behavioural objectives.

A more fruitful way to state instructional objectives is in terms of the types of outcomes we expect from our teaching. That is after getting through our lessons successfully, what do we expect our students to be able to do, or say, or master? They are stated using action verbs like state, define, mention, draw and label, calculate, differentiate, discuss, evaluate, etc.The opening statement would read thus: By the end of the lesson (not at the end of the lesson), the learners should be able to: The use of 'By' instead of 'At' recognizes individual differences in learning and guarantees a wider time frame as to when learning (behavior change) will take place unlike the later which is more point-blank as at the time learning will occur.

Considering a topic like Ocean Currents, the student may be expected to do the following:

- Identify the various currents of the Atlantic Ocean.
- Describe in their own words the causes of the flow of the current;
- Differentiate between warm and cold currents;
- Advance reasons for the currents being warm or cold.

When aims/objectives ofa lesson are stated in this manner, attention is shifted from the teacher to the learners and what they are expected to be able to do as a result of the learning experience. Thus, the focus is shifted from the teacher to the pupil and from the **learning process tothe learning outcome.** This is referred to as behaviouralobjective. It is so called because each specific learning outcome starts with a verb that indicates behaviour that can be watched by an outside observer, and thus the observer is in a position to evaluate whether the pupil has learnt something or not. It is always better for teachers to indicate in the objectives of their lessons what behavior or actions they should expect from the pupils at the end of the lesson in order to judge whether the lesson has been a success or a failure.

3.1.4 Instructional Materials

Instructional Materials are very important in teaching science subjects. This is because they help to concretize abstract concepts and aids multi-sensory perception of concepts. Instructional materials selected for a lesson must be intimately related to the topic. They are topic-specific since it is a material needed to concretize the master of the stated objectives. It is erroneous to state general classroom resources like Chalk-board, textbooks, chairs, pen etc, as instructional materials. These items are not topic specific. Such examples points to the laxity or shallowness of the teacher in preparing his/her lesson. Providing appropriate instructional materials is as important as the appropriate utilization of the material in course of lesson delivery.

3.1.4Previous Knowledge

We need to state the knowledge the learners have acquired previously. This is not the knowledge of just the last lesson,. But knowledge that appears relevant to the topic to be taught and which will help the children to learn the present topic more successfully if reminded of it. This stage is also called entry behavior.

3.1.5. Introduction

A teacher could start by asking simple questions which are relevant; he could pose a problem to solve or set a short physical task for them to do.This stage is often called set-induction.The introduction must have the following qualities:

- Relevant to the topic
- Stimulating to arouse the interest and curiosity of the children.
- Must be brief – lasting about 3 - 5 minutes.

3.1.6Presentation and Procedure

This is a clear statement of what is to be taught in the lesson and how it is to be taught. It should be logical and sequential. It could be divided into **steps** for the PROSE format or **stages of Content Development** forthe TABULAR format, but ground is usually prepared for the achievement of the objectives of the lesson at this stage of presentation. If for instance, there are three instructional objectives for the lesson, it is expected that there will be three steps in the presentation or three stages of content development, with each level corresponding to each of the stated instructional objectives.

3.1.7Evaluation

At this stage, the teacher determines the extent the stated instructional or behavioral objectives have been attained. The evaluation questions are tied to the instructional objectives. There is a relationship between instructional objectives , presentation stages and evaluation questions. If for instance, there are three objectives, we expect three steps/stages of content development in presentation and three evaluation questions or more depending on the scope of the content, granted that a minimum of one question should be asked per instructional objective.

This serves as a test of whether the objectives of the lesson are achieved or not. If the children are able to do the given exercises in this section successfully, this means that the teacher's objectives in his presentation are on the road to being achieved. The questions posed could help to build up blackboard summary which the students can later copy (Note for learners to copy).

4.0 Conclusion

Here the aim is finally tested and realized. It may be brief; it may take the form of activities for the children to perform or questions for them to answer.

Self-Assessment Exercise

Why is a lesson plan important for the teacher?

3.2 Specimen Lesson Plan(PROSE)

Name of Student Teacher:……..
MatriculationNo:…
Degree in view:…….
Teachingpractice school:……..
Subject:…….
Topic: Atomic Structure
Class taught: JSS 1
Time: 40 minutes (9.00am – 9.40am)

Behavioral Objectives:

By the end of the lesson, students should be able to:

(i) Identify the components of an atom
(ii) Write out the different components in words
(iii) Draw the structure of an atom
(iv) Draw structure for different atoms

Instructional Material(s)

(i) A chart showing structures of different atoms

Entry behaviour(Relevant Previous knowledge)
Students have gotten the knowledge of elements from hydrogen to calcium.

Introduction: Teacher asks simple questions such as

(i) What is an atom (ii) Name the first twenty elements in the periodic table.

Presentation of the lesson

Step 1:

Teacher gives the students the: i. Definition of atom.
Step 2:

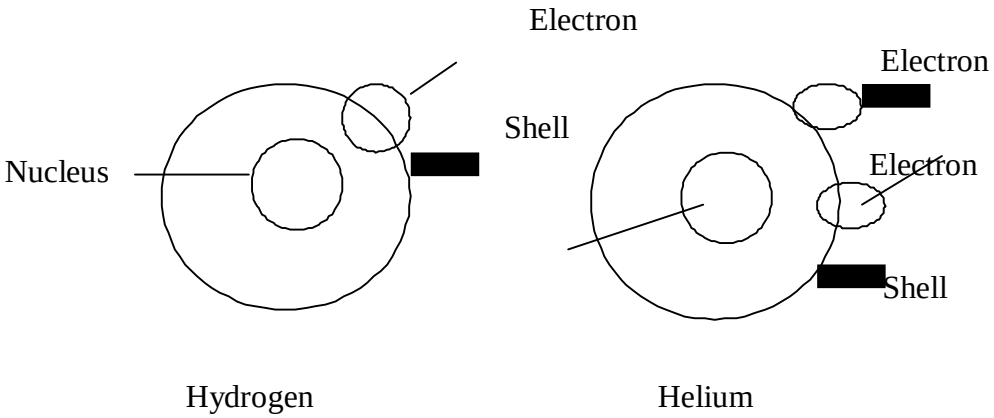
ii. Writes the names of the first twenty elements on the chalkboard

Step 3:

iii. Mention the component parts of atom (Nucleus, Proton, Neutrons); electro

Step 4:

iv. Draws the structure of the first element on the chalkboard. This is following by those of other elements.



Evaluation

Ask students the following questions:

i. Name the component parts of atom
ii. Name atoms with atomic numbers 3, 8, 12, 14 and 20.
iii. Which of the atoms are having their outermost shell completed?
IvDraw the structures of atoms with atomic numbers 8, 15, 18, 19.
v. Arrange the atomic order of their atomic numbers and show when and how the new shells are to be introduced in their structures.

Conclusion(chalkboard summary)

Let students ask their questions if any. Then let them copy the blackboard summary into their notebooks. Also refer them to theappropriate chapter in the recommended textbook.

Assignment:

Read about electronic configuration of atoms.

TABULAR FORMAT
Topic:
Instructional Objectives:
Instructional Materials
Entry Behaviour:(all as in Prose Format)
Presentation and Procedure:

Content Development	**Teacher's Activities**	**Students' Activities**	**Strategies**
Definition	**Defines an atom**	**Note the definition and explain**	**Verbal communication**

		nations	
Names of First 20 Elements	Introduces a mnemonic for students to name an	“He has large brain but can not offer full ni	Verbalization; Problem solving

	d recall 1st 20 Elements, thus: H e: H: Hydrogen H as: H	nes subjects, many art students proves science courses s	

	e: Heium L arge: Li: Lithium :: P oor: K: Potassium C areer	as poor career” where the words stand respectively	

	: Ca: Calcium	for elements: H, He, Li, Be, B, C, N, O, F, Ne, Na,	

		Mg, Al, Si, P, S, Cl, Ar, K, Ca.	
Component Parts of a	three basic component	Proton; positive E=	Demonstration

n Atoms	t parts are represented as PEN ie: proton, electron	electron; negative N = neutron; neutral	

	E x p l a i n t h e f e a t u r e s a n d l o c a t i o n s o f e a n d n e u t r o n .		

	chcomponent part		
S tructure of some named Atoms	P resent Chart of some named atoms	- Observe the chart; - Note the explan	P roblem solving

	and their structures. R equest some students to draw t	ations; - Respond to questions posed.	

	he structure of some named atoms.		

Evaluation:
Conclusion(Chalk board summary):
Assignment: (all as in Prose format)

Self AssessmentExercise

Why is it necessary to introduce a lesson?

4.0CONCLUSION

The central focus of any teaching-learning encounter is the lesson plan.
Thus, its preparation is very paramount to the teacher. In order to do this all the essential parts of the Plan must be fully comprehended by the teacher.

5.0SUMMARY

In this unit, we have learnt that,

(i) Note of lesson is a guide to the teacher
(ii) The plan must give essential ingredients of the lesson
(iii) Other teachers in the same area of specialization should be able to use the lesson plan in the absence of the usual teacher.
(iv) A specimen lesson plan could be written by making use of theessential component parts.

6.0TUTOR MARKED ASSIGNMENT (TMA)

1. Write acomprehensive note oflessonbased onatopicin chemistry.

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UNIT 4 EFFECTIVE TEACHING OF SCIENCE

CONTENT

1.0 INTRODUCTION

If students are not attentive in the class, the teacher may end up wasting time. Teacher can only capture the students' attention if he is able to present his teaching in a logical fashion by using appropriate materials and also ability to manage the class effectively.

2.0 OBJECTIVES

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

- Understand the technicalities involved in the dissemination of information to students
- Show how you can ensure students participation in the lesson
- Demonstrate how you can manage the class effectively.

3.0 MAIN CONTENT

3.1Teacher in the Classroom

As earlier said, students are the teachers audience. There are bound to be multifarious international patterns among the teacher, the students and the learning environment. Ability of a teacher to control the interactions with the view to filter out desirable ones will make the teaching to be effective. It should be noted that some of the students' interactions are undesirable. There could be; students – students interactions,student- teacher interaction; students-environment interaction.

Presentation of the lesson is the giving out of the contents sequentially and in a logical fashion. This has nothing to do with the mastering of the subject matter by the teacher; and his ability to use instructional materials appropriately. Every point should be complete, introduced, brought to its climax and concluded. Activities recommended in the chemistry curriculum must be provided for the students even if it means improvising the materials/equipment inthe absence of the real apparatus. Childrenlearnbest from concrete objects.Inproviding activities for students, explain the role of each student in clear terms.

In the use of chalkboard, always maintain distinction between major and minor points. The practice, whereby teachers give notes to students after teaching a lesson should be discouraged. Good teaching includes ability of the teacher to write out the summary of what he or she is teaching, just as teaching progresses. If the teaching strategies are effective, then just a chalkboard summary will suffice for students to:

1. Acquire a skill in adjusting the rates at which new ideas are covered and learned
2. Possess the ability to ask thought provoking questions. Socrates would want to ask people questions in order to get rid of misconception in their minds.

Always throw questions to the whole class and not to a particular student Ask questions,wait, and look around,before you call ona student to answer. If students volunteer to answer, the questions better results are obtained. Avoid a rhetoric question that simply requires 'Yes' or 'No' e.g. "Isn't it" "do you understand'? and the like .

Possess good spelling skills. Most lessons are ruined by the inability of the teacher to spell well and speak loud.

A chemistry teacher and any teacher for that matter should not cultivate the habit of reading to students from textbooks. Also, do not try to solve a problem, which you are not sure of the answer on the chalkboard for students otherwise, you stand the chance of mortgaging your credibility.

Agoodteacher wouldhavepracticed the problemat homebefore bringing it to the class. Similar one could also be brought to the class by the students.

In concluding a lesson, the teacher should summarize the lesson. Allow students to ask questions and perhaps complete the chalkboard summary. In order to test the effectiveness of his teaching strategies for a particular lesson, questions based on the stated objectives are asked.

The responses from students will show whether the objectives had been achieved or not.

A chemistry teacher should endeavour to give assignment, which would enable them to prepare for the next lesson.

Self-Assessment Exercise

Write-out two activities of a teacher that are necessary in his teaching.

3.1.1 Classroom Dynamics

The classroom climate that exists between pupil and pupil, and between pupils and teacher is a function of the physical, social and psychological environment of the classroom. The physical environment of the class will affect the state of mind of the pupils while this in return will affect the sociological make up of the learners. An attractive class will develop in the minds of the learners, positive psychological effect. Students in a good classroom environment will possibly learn better and would be more responsive to teaching. Classroom socio-interaction between the pupils and between the pupils and the teachers will influence to a great extent a teachers leadership, classroom morale, conduct and discipline.

3.1.2 Classroom Discipline

Most of the classroom rules are based on moral, personal, legal, safety and educational considerations. In the realsense of it, lists ofrules should be minimal, relevant, meaningful and positive. The aim of good classroom discipline is to maintain an environment that will optimize.

Through **sound preparation**, a teacher can establish control since he will enter the classroom with confidence. Confidence helps to generate a good atmosphere. The lesson will proceed smoothly. The lesson will be interesting and the pupils will be kept usefully occupied.

3.2. Teacher's own Personality

The way a teacher dresses, speaks, conducts himself in front of his class will go a long way in helping him to control the class effectively. A teacher who cannot control his temperament and emotions, especially hisanger, is likely to findclass control difficult. A teacherwho is authoritarian in his classroom is likely to kill the initiative of his pupils because most of the students would refuse to participate in his lessons for fear of punishment. It is therefore necessary for a teacher to be fairly democratic, and permit his students to act in a normal manner. A teachershould be friendly with his pupils but not too familiar with them because the students would then not take him seriously.

3.2.1 Cooperation

Cooperation betweenteacher and taught can be introduced into the classroom without endangering control. At the primary level, cooperation in the routine physical tasks involved in running the class, such as distributing books, cleaning the chalkboard, making a list of late comers and absentee, keeping cupboards tidy is possible. Class officers are better selected by election.

3.2.2 Good Organization

There should be sufficient supply of the necessary materials ready in the classroom. On the other hand, students should be made to share material in a reasonable fashion.

3.2.3 Teacher's Technique for Proper Classroom ManagementSimple, Clear Instructions

Provisionofsimple,clearinstruction will minimizeconfusion and disturbances that could arise when students ask.

Order before Teaching or Making Announcements

It is not advisable to start teaching while studentsare still moving around and talking. Insist on silence before lesson commences.

Learning the pupils' Names

Knowing the pupils by names as soon as possible helps to createa friendly atmosphere. "You" or "that boy sitting near the window" would not augur well for effective participation of the students.

Being Positive, not Negative

Try as much as possible to put emphasis on the positive side of the pupils' conduct. Avoid too many "don'ts"

Noise Level in the Class

Absolutesilenceinnotpossibleunlessthey arewriting examination. Noise maybe due to classroom activities. Avoid reckless and excessive noise.

Cultivation of Voice

Never you adopt a militant way of talking in the classroom. Talk in a natural way, this will create a relaxed atmosphere in the classroom and this will encourage learning. Speaking sharply would
Lead to a tensed atmosphere and governed by fear. The class would be .....

Always consider individual difference

Students would not behave in the same way since they are different, they cannot work at the same rate and also cannot understand facts and concepts in the same way. Ample opportunities for participation must be given to all pupils. Both weak and good students must be encouraged.

Dealing with Class Misdemeanors

Teachers should not take all acts of indiscipline to the headmaster. If they do, students will no longer respect the teachers. Classroom crisis should be effectively managed by the teacher.

Self-Assessment Exercise

How can a teacher make his lesson interesting?

4.0 CONCLUSION

Teacher must know his job very well in order for him to deliver his job satisfactorily. He must strivevery hard to achieveobjectivesfor his lessons and ensure success of his students. In order to achieve this he must be able to filter all the international patterns in the class and control for the ones that are not favorable.

5.0 SUMMARY

In this unit we have learnt that;

(i) Teacher must have effective control of the lesson before he could be successful.
(ii) Lesson must be presented logically and sequentially
(iii) Ask questions and allow students to answer the question, preferably on their own.
(iv) A good chalkboard summary is necessary for effective teaching.

6.0 TUTOR MARKED ASSIGNMENT (TMA)

Summarize briefly the behaviour you expect from a teacher of chemistry when he gets to the classroom.

7.0 REFERENCES/FURTHER READINGS

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UNIT 5 THE USE OF CHEMISTRY LABORATORY: LABORATORY ORGANIZATIONAND MANAGEMENT

1.0 INTRODUCTION

Laboratory plays an important function in the teaching of chemistry. This is because practical exercises take their positions in the curriculum of the subject. All areas of the curriculum are

loaded with activities which are expected to be demonstrated by the teachers. For the teachers to be able to make effective use of the laboratory, he has to maintain both human and material resources of the laboratory very well.

2.0 OBJECTIVES

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

- Explain the meaning of laboratory
- Explain how to store chemicals and equipment
- Discusshow tomanage both human andmaterial resources in the laboratory successfully.

3.0 MAIN BODY

3.1The Science Laboratory

The Science laboratory is that school building or block specifically designed to carryout experiments. Safety is the watch word, when setting up a science laboratory, hence it must be well sited to facilitate movement of human and material resources and safety gadgets must be provided. For example a laboratory should be far from places used for sports or food. A laboratory should be large enough to allow students have no difficulty in seeking the chalkboard, as well as what is happening on the demonstration desk, otherwise the students will be restless, in the process of which they may cause preventable accident. For the same reason, the teacher should be on a raised platform so as to see whatthestudentsaredoingon theirvariousdesks. Normallaboratory must have at least two doors one on either side. There should be windows on opposite sides and the windows should not be burglary proofed to ensure easy escape of students in case of explosion, fire etc.

The facilities provided must include:

- **Storage Room**

In an ideal situation, a laboratory should be provided with two stores. One for flammables and the other for corrosive materials. In storing materials, chemicals that can react with each other must never be stored close together. Substances that are poisonous should be kept in cabinets that can be locked and only the teacher should have a key. Acidsor corrosivematerials should be placed on the ground or in cabinets and not on the top of constructed shells.

- **Preparatory Room**

This is a room used by the teacher to try out experiments before a demonstration or can actual laboratory session. The prep-room is a mini- lab. Hence, it should be provided with sinks, gas, electricity, water supply, etc.

- **Darkroom**

This is a room where light experiments are carried out.

- **Balance Room**

Balances are very sensitive. The movement of air can affect readings while using chemical balance. Hence, the need for a room to keep the balances. The balance room should be provided with concrete or heavy wooden benches. The room should be provided with good lighting. If possible it should be air conditioned.

- **Fume Cupboard**

A fume cupboard reduces the risk of exposing laboratory users to a high risk or dosage of poisonous gases e.g. H_2S, NH_3 and Cl_2 etc.

- **Benches and Stools**

The bench tops depend on the type of laboratory. Concreteare preferable in chemistry. The stools should be four legged with flat seats and smooth edges.

- **Other facilities**

These include chalkboard, electricity, water supply, sinks and good draining system. Water shower must be provided to wash off corrosive materials in case of spillage. There must be fire extinguishers, and buckets and blankets.

3.1.1 Laboratory Management

The science laboratory is usually a center of scientific activities where staff, students and materials are always in a dynamic interaction. The science teacher, as the sole administrator of a science laboratory has the responsibility of managing these interacting factors, in such a way that accidents are reduced to the barest minimum level. The science teacher must make sure that all those who use the laboratory perform their work efficiently andthosewhohave nothing doing shouldnotbein the laboratory.

3.1.2 Management of Laboratory Staff

Involving staff in laboratory management is very easy. Not only can staff, though consultation, have a hand in planning safety policy for a particular laboratory but their involvement can be on-going through staff meetings where everybody is reminded of his or her responsibilities. In other words, it is part of an efficient management technique for science teachers to hold regular science staff meetings with all those who work in the laboratory.

3.1.3 Laboratory Technicians/Attendants

Theprimarydutyoftechnicians istomaintainandrepairdamaged equipment. Apart from this, they also perform the following tasks, in the maintenance process;

- Keeping the apparatus clean and tidy
- Setting up or dismantling demonstration apparatus
- Ordering of apparatus
- Storing of apparatus in accordance to a regular order
- Preparing dilutedsolutionsfromstocksolutions,stains or mount specimen.
- Keeping adequate records of purchases and damages.
- Improvising apparatus
- Make minor repairs
- Experienced technicians or attendants also serve as resource person to students.

The work of the laboratory technicians/attendants reduces to that of errand boys when they are not well trained.

Self-Assessment Exercise

Explain why it is necessary to have fume cupboard and balance room in the laboratory.

3.1.4 Management of Students

Involving students in a meaningful way is not so easy. One way of doing this is tofamiliarize students with the apparatus in the laboratory. Another way is to develop laboratory rules that will ensure safety.

3.1.5 Rules

Every laboratory should have few but strict rules to be followed. Students should be made to be aware of possible consequences of their actions in the laboratory. For instance, students should be told that they will pay for any apparatus they damage. Other rules may include:

- Laboratory materials are to be used only in the laboratory.
- Laboratory materials must be used for only the purposes sanctioned by the teacher.
- Students should do only experiments assigned or approved by the teacher.
- There should be no horse play in the laboratory. Walk around. Do not run.
- Nothing should be tasted or eaten in the laboratory. Anything accidentally taken into the mouth must be washed with water.
- Bottles should never be held by the neck.

- Keep the floor and the bench clean and dry always.

These rules and some others, depending on the situation at hand, could be pasted in conspicuous places for students to see. However, there is a world of difference between pasting a list of laboratory rules and seeing that they are obeyed. Workingsafely in the science laboratory is a serious business. It requires a lot of ingenuity on the part of the teacher as well as other laboratory staff.

3.1.6 The Use of Posters

Another way of involving students meaningfully in the efforts to ensure safety is to ask them to design safety posters. Such poster are aimed at drawing people's attention to unsafe practices inthe laboratory. However, most teachers frequently misuse posters. If you are lucky to have a set of such posters, do not make the mistake exhibiting them all at once. Instead, show only a few at a time. Change them regularly and also change their position. If a poster remains fixed in one place for too long a time, students soon 'look but do not see'.

3.1.7 Management of Materials

Science materials are in terms of chemicals and apparatus chemicals Science laboratories house a lot of chemicals that could endanger life of laboratory users. Working in a laboratory therefore, involves a lot of risk. Safety in the laboratory is a coefficient of common sense, knowledge of physical and chemical effects of substances and knowledge of human behaviour.

3.2 Nature of Chemicals

It is important for the science teacher to understand the nature of chemicals he or she is working with. Some chemicals, if not properly handled could constitute a source of hazard,

For example, fire could result from

- Uncontrolled chemical reactions
- Storing hot places with flammables
- Storing in the same place chemicals that violently react together e.g. alkali metals and their peroxides.

3.3 Handling of Chemicals

In order to prevent self poisoning, it is advisable to handle chemicals with care. Most bottle labels have warning about possible hazards of the chemical they contain. It is advisable to read these label before you handle them or give such chemicals out to students.

Certain chemicals which are handled carelessly could cause permanent damages which could even be transferred to the next generation. For example. All barium salts are

poisonous.Benzene, carbon tetrachloride chloroforms, phosphine are not only carcinogenic but some like phosphine can attack the kidney and nervous system.

Bromine, chlorine and iodinecan damage the skin, eyes respiratory system.H2Sparalysis olfactory organ Mercury vapors is a cumulative poison to all tissues, it is a mutagent. Even the so called common salt (NaCl) in large quantity becomes toxic. Perhaps we can conclude that when chemicals are improperly handled, they could be hazardous.

3.4 Apparatus

Since science apparatus are generally delicate and expensive, it is the duty of the science teacher to see that:

- The apparatus that are bought are actually needed
- That the teacher should consult good laboratory manuals and catalogues in order to identify the address of suppliers and their condition of sale.
- The teacher makes direct contact with suppliers so as to reduce cost.
- When ordering equipment, the science teacher should give a clear and specific description of desired apparatus.

Maintenance of Apparatus

It is one thing to purchase an apparatus, it is another thing to be able to maintain the apparatus. The way we handle or set up an apparatus, to a large extent determine how long the apparatus will last. It will suffice to say that good laboratory maintenance depend, above all on great care and a demonstrationof responsiblebehaviour by those who use the laboratory.

3.5 Laboratory Book keeping

Another important dimension of management of laboratory materials and equipment has to do with Laboratory book-keeping. This involves keeping accurate records concerning stocking of materials and equipments and transactions involving them in the laboratory (Anaekwe, 2019). For effective management of laboratory materials, four essential records, are kept namely:

i. Stock or Inventory book: This is for keeping records of all items supplied or purchased in the laboratory, indicating the date and quantity procured.

ii. Borrower's or Loan book:This is for keeping records of any item(s) loaned to another department, for instance Biology mar decide to borrow thermometer from chemistry laboratory, indicating the name of borrower, item(s) borrowed, quantity borrowed, signature of borrower with date, Signature and date returned.

iii. Breakage or Damage book: This record book is for items broken or damaged in the laboratory, indicating name of item broken/damaged, By who, date, Cost of item, date replaced

Iv. Accident or First Aid books: This is for recording accident occurrences in the

laboratory, no matter how minor it may appear, as well as the date and first aid treatment given to the victim.

3.6 Supervision

Another aspect of laboratory management is thorough supervision. This means direct inspection of laboratory materials. From our discussion so far, it is clear that the responsibility of laboratory safety rests solely on the teacher. It is his duty to see that laboratory activities are carried out smoothly and with minimum risks. Without carefully planned and coordinated supervisory activities, the laboratory becomes an unsafe place to work in. It is the duty of a science teacher to see that faults are corrected and that necessary repairs are carried out to enhance safety in the laboratory.

4.0 CONCLUSION

The laboratory is an essential facility for effective science teaching. A teacher must ensure effective management of both human and material resources in the laboratory before the objectives of the lesson could be achieved.

5.0 SUMMARY

In this unit we have learnt that:

(i) The science laboratory is that school building or block specifically designed to carry out experiments.

(ii) Staff students and materials are always in a dynamic interaction in the science laboratory.

(iii) The three components in it must be properly managed by the teacher.

(iv) Chemicals must be handled carefully in the laboratory.

6.0 TUTOR MARKED ASSIGNMENT (TMA)

What are the things, which the teachers are expected to do in order to make the effective use of the laboratory?

7.0 REFERENCES/FURTHER READINGS

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Abdullahi, A (1982) Science Teaching in Nigeria Ilorin Atoto Press.

Ogunniyi, M.B. (1986) Secondary School Science Teaching in Africa Ibadan University Press Plc.

MODULE 3

UNIT 1 TEACHINGSCIENCEINTHE FACE OF SCARCITY OFCHEMICALS/EQUIPMENT

CONTENT

1.0 INTRODUCTION

Science teaching in Nigeria poses a great challenge to the teacher particularly in a situation where money is not available to buy chemicals and equipment which would enable us practicalise the recommended demonstration inthelaboratory. In this case,teacher wouldneedtohave theknowledgeofhowtoputalternative chemicals and equipment in places this is referred to as improvisation.

2.0 OBJECTIVES

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

- Explain what to do when facilities are not available for teaching chemistry.
- Discuss the method of improvisation in the teaching of chemistry

3.0 MAIN CONTENT

3.1 Selecting materials for chemistry teaching

It is at the lesson plan stage that equipment and the learning materials are selected. The course of the lesson dependsn the material chosen. The teacher should not only specifythe materials needed but also make arrangement to procure them before then.

3.1.1 Improvisation in Teaching

The term improvisation refers to the process by which science equipment and materials are produced from locally available materials. Improvisation is a child of necessity. This is because, it only arises when the industrially manufactured science equipmentareno whereto be found, especially when practical activities are supposed to be carried out in the laboratory. Since the introduction of the economic principle of Structural Adjustment Programme (SAP) and the resultant austerity measure, it has become increasingly difficult for government at all levels to procure all the science equipment required for effective teaching and learning of science. Resulting from this, science education felt the need to keep the teaching of science in a continuous stead, and to effect this meaningfully within the frameworkof limited resourcesavailableat their disposal. Hence, the campaign to go into improvisation began. A number of advantages are derivable from the acceptance of improvisation as means of attaining the national goal of science education. Advantages derivable from improvisation are:

(i) It saves money
(ii) Itsaves time of waitingindefinitelyfororderedorimportedmaterials and funds
(iii) It encourages innovation and creativity in science teaching
(iv) Itcreatesopportunity forlearnersto participatefullyintheconstruction and use of apparatus;
and
(v) It induceslearner'sinterestandunderstandingofscience generally.

From the foregoing, two aspects of improvisation are identifiable. They are:

As a means of providing for a need, necessity due to non-availability of synthesized or manufactured equipments. That is a substitute for science equipment and materials.

As an activity-oriented approach of teaching science in both primary and secondary levels of education in Nigeria.
The two aspects of improvisation are:

Import substitution

A critical look at what obtains in our laboratories at the secondary and tertiarylevels of Nigerian educationsystemrevealsthatagreaterpercentage of the materials and equipment selected are imported from oversea countries. Purchases areusually made after going through aset of catalogues through which they are advertised. Typical of these media of advertisement is thefact that there is no direction as to its use andadaptability to local climate and conditions. The result is that most of these equipments are left unused, misused, damaged or simply left to accumulate dust. Evenwhentheequipmentsareputtouse,lackofproper maintenance and adequate repair make the cost of replacement out of reach.

It therefore looks as if buying science equipment for schools constitutes a major source of revenue wastage. This situation will remain until such a time when we have learnt to make use of locally available materials to replace these imported ones. Meanwhile, it will be worthwhile if science teacher andindigenousscientists canimbibeandembracetheopportunity being provided byimprovisation. Thisis inspite ofitslimitations of which some are, crudity and inaccuracy. If more attention is paid to improvisation, with time, all the limitations will be a thing of the past.

Embracing the spirit of improvisation will provide the benefit of reducing the cost of science education on the part of the government.Besides, Balogun (1982) once noted that the major reason from improvisation stems from the fact that the economics of education is generally the economics of scarcity namely that no matter how generous and rich educational authorities might be, they are generally not always in a position to provide schools with all their needs.

Improvisation asActivity-Oriented ApproachtoScienceTeaching

The major aim of science education programme does not only include producing more scientists or science teachers, but to prepare individuals to become scientifically literate. This is not limited only to volume of scientific knowledge acquired, but the gaining of good understanding of both thepowersand limitations of science and its fundamental principles.

These laudable objectives are attainable through a number of means. These include:

Introducing the learner to science by presenting him with a variety of materials to investigate; and

Desiring exercise, that could develop pupils skills in using the processes of science.

The essence of the second approach is that a scientist's behaviour and disposition as he embarks on sciencing constitute a complex set of skills and intellectual activities. In addition, the individuals' ability to use these various processes can be developed by a systematic manner, stating from the early years of schooling. If properly pursued, the complex skills and intellectual activities could lead the pupils and teacher as well to fundamental inventions.

This systematic acquisition of skills could result into the production of some materials and equipment made from locally available materials (improvisation),which willcompetefavorably withimported andindustrially manufactured ones. According to Balogun (1982) history of science has revealed several incidents of producing locally made apparatus from local raw materials.

3.1.2 Assessing Improvisations

If and when we improvise or encounter an improvisation, it seems necessary that we should be able to assess its relative worth from the view-point of science teaching. I suggest the following questions:

(a) What scientific questions/principledoesthedeviseseekto answer/illustrate?
(b) Does the devise provide a valid answer/ illustration?.
(c) What is the monetary worth of the devise?
(d) Would the devise further the interest/curiosity of the learner?
(e) Would the devise promote the desirable skills in the learner?
(f) Is the devise readily replicable?
(g) Is the devise durable, rugged for storage?
(h) What is the accuracy range of the devise and?
(i) What is the aesthetic rating of the improvisation
(j) What precautionary measures are needed?

4.0 CONCLUSION

Teaching science successfully in Nigeria would require that the science teachers (including those of chemistry) should be prepared to look for alternatives to the original recommended apparatus/chemicals because of lack of fund.

5.0 SUMMARY

This unit has been able to acquaint you with the fact that, in the face of scarcity and non availability of materials, certain concepts can still be effectively taught, and set objectives met. This is possible if the teacher can put into use, effective skills and knowledge about improvisation.

6.0 TUTOR MARKED ASSIGNMENT

Describe how you can proceed with a chemistry practical class, if you are faced with the lack of the followings:

i. beakers
ii. test tube holders iii. stirring rods

7.0 REFERENCES

Abdullahi, A. (1982) Science Teaching in Nigeria. Ilorin Atoto Press.

Oguniyi, M. B. (1986) Secondary School Science Teaching in African. Ibadan University Press Plc.

UNIT 2 THE LANGUAGE OF SCIENCE AND SCIENCE TEACHING

CONTENT

1.0 INTRODUCTION

It is the duty of the teacher to translate the highly codified language of science into a language that his students can understand. However, the learning situation is such that students have input and it is the duty of the teacher to put all resources together to ensure success of the lesson.

2.0 OBJECTIVES

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

- Explain the relevance of the language of science
- Explain the learning situation
- Discuss that ability to learn science is not based on undefinable variables but specific influencing the learners.

3.0 MAIN CONTENT

3.1 The Language of Science and Science Teaching

Thesystemofexplanations referredtointhepreceding paragraph, constitutes the language of science. As Brodbeck (1963) puts it "the language of science consists wholly of declarative sentences. By means of them, the scientist talks about the world". Therefore, it is is the duty of the science teacher to translate this highly codified language that his students can understand.

Most science educators have recognised the central role of language in thought and learning process. Often the science teacher, as adult speaks a language completely alien to the students. This is obvious because he thinks and speaks on the basis of background experiences i.e. within his frame of reference. The students having no such frame of reference, see's him as a foreigner with a strange language. The problem recognizesthepedagogical implications of the language he used during science and instruction; be knowledge of the socio-economic background of his students. be able to identify appropriate techniques for communicating the language of the science subject he teaches; recognizes that science contains a lot of abstract terms which refer to things, to events quite remote to direct sensations; beacquaintedwithrole of language inthinkingand learning processes; be efficient in the use of questioning as a means of soliciting information and/or appraising students' understanding of what is taught; be aware of how distractive mannerisms and idiosyncrasies exhibitedduring a lesson ca affect learning; be acquainted with interactions strategies and so on.

3.1.1 Written Materials

It is a well known fact that most teachers and their students depend solely on the textbook as the major source of scientific information. As Piltx (1961) and Ogunniyi (1982) pointed out, many teachers mainly on the text to shape theirrely instruction in science. This situation is perhaps more serious in the developing countries where laboratory facilities are scarce, teaching is confined to a given syllabus of a centralized examination and where teacher have not learned to explore theirimmediate environment intheteaching of science. Inspiterecent efforts to write simpler reading materials especially for students, it must still be recognized that the communicational strategies employed by majority of the texts are too sophisticated for an average student. Worse still, is that many science teachers copy materials verbatim for their students to memorise

3.1.2 The learning Situation

A well coordinated instruction is indispensable to learning. Learning as an activity takes place in a context and not in a vacuum. When a student comes into the classroom or the laboratory to learn science he does not have a blank mind. He has some form of 'library' of knowledge (though rather rudimentary, incomplete and sometimes faulty) to be developed refined and/or consolidated. As stated earlier, students learn at different rates and use varied learning strategies. Also in the context of learning are such variables as the teacher or the teaching agent, the learningmaterials and of course, the objective(s) to be achieved. Let us see how those cluster are related.

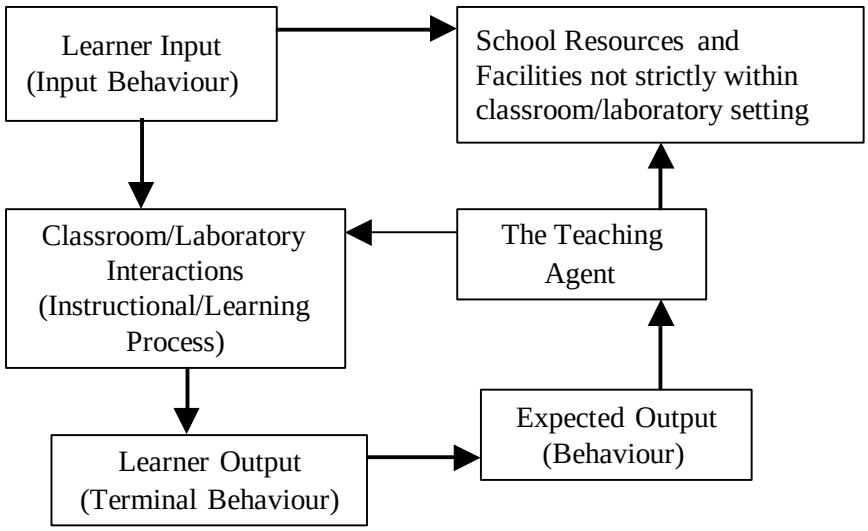

Figure 4: A Paradigm of classroom Interactions

In figure 4, the learner interacts with the teacher and learningmaterials and the result of these interactions is the behavioral outputs of the learner. This is why learning issometimes defined as relatively permanent behavioral changes, which result from new experiences(Carin and Sund, 1967). This behavioral output may or may not measure up to expectation. For instance, the teacher on realizing that a student has not been able to demonstrate an expected behaviour might organize a special tutorial, select and apply other remedial measures or re teach the whole lesson. Alternatively, he may ask other students to help the weak students or may instruct the latter to go into the library or see specialists in the area in question and to find the relevant information by him. This approach is called diagnostic-prescriptive teaching strategy.

Diagnosisistheprocessofdetermining the statusofalearner's orlearners'readiness while prescription deals with the course of action taken by the teacher on the basis of diagnostic information. Remedial instruction is usually reserved for learners with extreme achievementdeficit a highly intensive individualized attention (Otto, et al 1973). The teaching-learning-material interactions form thecontext underwhich learning takes place. Hence, the learning strategies in science must be related to the structures and conditions existing within the context of classroomor laboratoryinteractions.Goodplanningisthereforeindispensable for successful learning of science. This may not be readily apparent when one isobserving class room interactions between an experiencedscience teacher andmature students. But as the lesson progresses, it becomes obvious that learning is taking place in a rational and well-organized manner (Victor and Lerner, 1975).

The ability to learn science is not based on undefinable variables but on specific factors differently and jointly influencing the learner e.g. the student's inherent capacity, interest motivation, background knowledge, valuesystem, belief, theconditions under which he istaught;theteaching methods; the audio-visual and learning materials used, etc. are allcriticaltothelearningprocess. Inthelight ofthesefactors,psychologist have developed various learning theories. Let us consider some of them.

Science/Chemistry Textbooks

MeaningA science text-book is an indispensable resource material which enables a science teacher to make effective preparation for his lesson. Being a resource material, it contains scientific information –knowledge of facts, theories, principles and laws; practical activities which guides the development of science process skills- observing, measuring, classifying, experimenting etc, as well as attitudinal qualities that characterize scientific investigations-honesty, perseverance, skepticism etc.

Importance In science teaching and learning, the importance of the text-book cannot be over-emphasized.It is a primary reference point for instructional preparation. A conscientious science teacher in a bid to prepare for his/her lesson is expected to be guided by the recommended textbook as well as other reference text-books. The teacher should consult a variety of text-books in order to have a repertoire of knowledge to facilitate learning. The textbook also predisposes the science teacher to instill in the learners some manipulative skills. Through practical activities, the learners imbibe these skills which enable them to adjust effectively in the society. A good text-book can even replace class-room teaching. The science text-book also has great potentials for the development of the affective attributes of learning. This implies that it aids the learners in the development of their personalities, in developing open mindedness, developing appreciation and understanding of nature and not merely stuffing their minds with facts. A good science text-book should enable the teacher to motivate the learners towardsdifferent career prospects in science as well as the academic and personality attributes needed for such careers.The contents of science text-books should contain not only the established facts and theories but also the problems/challenges which are confronting the society, thereby arousing the interest in the learner in these problems. It should help in linking up science with life and practice. The learners should be equipped with the 'know-how' of utilizing scientific knowledge in solving human problems in everyday life.

Qualities of a good science text-book

i. **Authorship**: A good science text-book is judged, at face value, by the author, his academic and professional qualification. Since one cannot give what he/she has not, it is very important to ascertain the extent of expertise possessed by the author of a particular science text-book. This is also an important criterion for recommending a science text-book.

ii. **Subject matter/Content**: The subject-matter or content should be presented in a logical sequence to enhance mastery. In other words, there should be sequential presentation of contents from known to unknown, from simple ideas to complex ones and from concrete to abstract terms. Care must be taken of the mental growth and interest of pupils.

iii. **Specificity of Subject Matter**: There should be consistency of the subject-mattertreatment in reference to the curriculum of a particular discipline and level of the learner. The text-book should satisfy the objectives of teaching a particular science discipline.For instance a text-book meant for Basic Science and Technology at Junior secondary school class one level, should dutifully cover the contents of the subject matter as spelt out in the appropriate curriculum.

iv. **Opening and Closure:**Each chapter should begin with a brief introduction and a highlight of the chapter content and end up with evaluation questions and assignments.

iv. **Comprehensiveness of Subject Matter:**Subject-matter should be comprehensive in scope. This means that it will lead to the inculcation of cognitive, psychomotor and

affective attributes of learning. The importance of including practical activities is very crucial in this respect.

v. **Illustrations:**In the treatment of the subject-matter, proper illustrations including numerical spatial, graphical, diagrammatic examples should be used where necessary.

vi. **Important Preliminary Information**: Each text-book should contain important preliminary information including Table of Contents, List of Tables List of Figures, References and an Index.

vii. **Clarity of Language:**The language of the book should be simple, clear, lucid, scientific and precise. The English equivalents of the terms should be always given in brackets.

viii. **Use of Local Examples**:Since examples serve to enhance proper understanding of scientific concepts and fosters transfer of learning, there is need to use examples from the immediate environment of the learner.

ix. **Legibility of the Print:** The printing should be legible and appetizing to read.

x. **Quality of Print and Paper**: The quality of print and paper used should be attractive.

xi. **Quality of Binding**:The quality of binding the text-book should be such as to be durable.

Evaluating a Good Science Textbook:

In evaluating the qualities of a science text-book for personal or institutional use, a number of features are considered, Some of them are:

iii. Authorship
iv. Clarity of Language
v. Affordability
vi. Diagram/Sketches/Illustrations
vii. Use of Examples from the local Environment
viii. Gender balance in presentations and illustrations
ix. Comprehensiveness of subject matter
x. Appropriateness to the level of the learner
xi. Quality of paper, print and binding

Self-Assessment Exercise

How can you take students existing knowledge into consideration in your teaching?

4.0 CONCLUSION

The learning of science is hinged on how a teacher can use the language of the subject to the benefit of the learner in the classroom.

5.0 SUMMARY

In this unit you have learnt that:

(i) The teacher must understand the language the subject he is to teach.

(ii) The teacher mustinterpret thelanguagetothestudents'advantage
(iii) Learning is defined as permanent behavioral changes.
(iv) Ability to learn science is not based on undefinable variables.

6.0TUTOR MARKED ASSIGNMENT (TMA)

1.Describe briefly the learning situation in a chemistry lesson

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UNIT 3 LEARNING THEORIES

CONTENT

1.0 INTRODUCTION

The teaching-learning situation, no matter the method adopted is backed upon with learning theories(Ndirika, 2018, Jibrin, and Amina, 2019). Understanding of these theories would go a long way in the success of a lesson.

2.0 OBJECTIVES

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

- Explain learning theories
- Discuss theimportanceoflearningtheoriesinateachinglearning process.
- Explain the learning theories of Gagne and Ausubel.

3.0 MAIN CONTENT

3.1 Robert M. Gagne – Learning Hierarchies

Gagne's theory of hierarchy of principles stipulates that the learning of a concept or skill depends upon the mastery of prerequisite concepts or skills. Gagne begins with a task analysis of the instructional objectives. He asks the question, 'what is it you want the learner to be able to do? This capabilityhe maintains mustbestatedspecificallyand behaviourally. He defines capability as the ability to do what one was originally unable to do before a learning situation; i.e. the ability toperform certainspecifictasks under specificsituation. A capability could be to focus a microscope, to operate a telescope or solve problems on simultaneous equations. This capability can be construed in terms of a terminal behaviour and placed at the top of a pyramid as shown below.

To Gagne, learning a task necessitates the mastery ofprerequisiteintellectual operations or skills. Thus, the desired concept or skill, C is dependent on an understanding of a and b, which in turn are dependent on lower level concepts or skills c, d, e and f and so on.

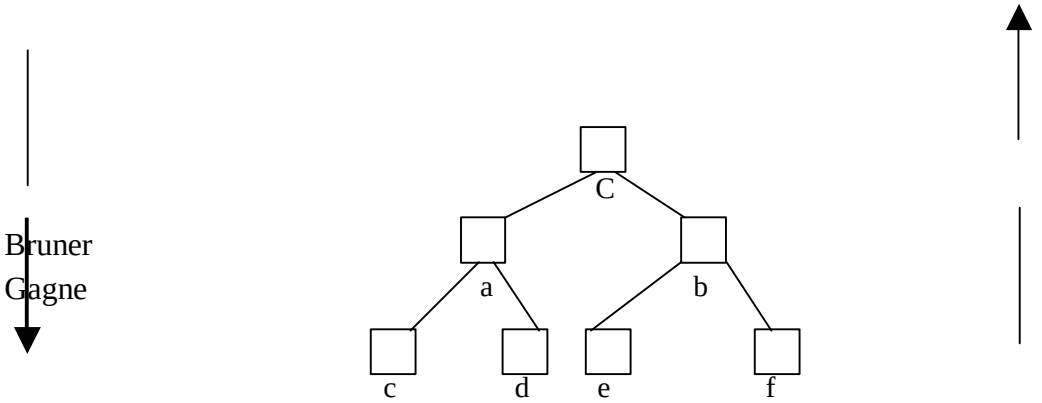


Figure 5: Pyramid of Learning

3.1.1 Jerome S. Bruner – Learning By Discovery

Bruner takes a different approach to learning. To Bruner, learning is a process of discovery, the student is confronted with problems which may take the form of:

Goals for achieved in the absence of readily discernible means of achieving such goals;

Apparent contractions among sources of information of relatively equal status; or

The quest for structure or symmetry in situations where such order in not reality apparent.

The first step of discovery is a sensed disparity or contrast with what one already knows. The learner then attempts to bring some order out of this confusion.This mayrequirean internal re-organizationor "cognitive restructuring" of previously known ideasinorder to accommodate the new experience. To Bruner, the essence of discovery issomething, which takesplacewithin the learner through the assimilation of new relations and the creation of new structures.

Bruner's main emphasis is on the production and the manipulation of learning materials. Borrowing hisideasfrom Piaget'stheoryof cognitive development, Bruner contends that a childmoves through three successive stage of mental development: the enactive, the ionic and the symbolic. At the enactive stage, the child manipulates learning materials directly. At the ionic stage, he deals with mental images of objects but does not manipulate them directly. Lastly, at the symbolic stage he is able to manipulate symbols and no longer mental images of objects. Bruner synthesized this theory with the Socraticnotionof learning asaninternal re-organization into what isnow known as learning-by-discoveryapproach. To Bruner, learningby discoveryin which an "old" knowledge gives way to the new is consistent with the nature of science (Shulman and Tamir, 1973). Shulman (1968) contrasting the theories of Gagne and Bruner's assertions.

Thus for Gagne, instruction is a smoothly guided tour up a carefully constructed hierarchy of objectives; for Bruner, instruction is a roller- coaster ride of successive disequilibria and equilibra until the desired cognitive state is reached or discovered. Although the same diagram of learning hierarchies (Fig. 3) is appropriate for Bruner, the direction of the arrowisintheopposite of Gagne's. ForBruner, learningby discovery begins with problem solving: a process analogous to teaching someone to swim bythrowing him intoa deeppool of water. The assumption is that he will learn the necessary skills because the needs them. The basis for this assumption is rather tenuous. Any wonder why a large number of "casualties" have occurred under many of the new science and mathematics programmes. Many students were literally "drowned" by the very programmes designed to help them learn science or mathematics. For Gagne, the sequence of instruction is from simple to

complex; for Bruner, the learner start with the complex and learns the simple mechanisms in the context of working with the complex (Shulman, 1968).

Self AssessmentExercise

Briefly explain Gagne's learning theory?

3.1.2 David P. Ausubel – Meaningful Verbal Learning

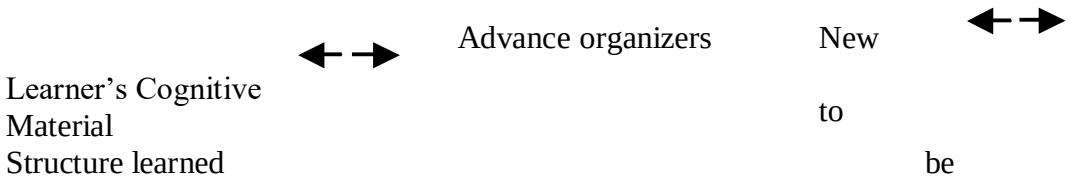
Ausubel, like Gagne, emphasizes the essence of systematically guided exposition in the teaching-learning process. The key isthecarefulsequencing of experiences so that any unit taught is related to previous experiences. It is the continuity or ratability between thelearners existing cognitive structure and the material to be learned that makes the new material meaningful to him. It is his contention that learning through reception is not necessarily by note.

UnlikeBruner, Ausubeldoes notsee any justifiablereasonfor introducing alearnertoaproblem-solving situation before he has internalized the new learning material. If thematerialcan be meaningfully organized by the teacher, then the need for the student to discover is removed and the process of learning is greatly facilitated. To Ausubel, learning by discovery is time wasting and inefficient.

For Ausubel, those parts of the learner's cognitive structure (i.e. organized knowledge), which provides the necessary interactions necessaryfor meaningful meaning, are called "subsumers". Ausubel defines a subsumer as a generalized body of knowledge possessed by the learner for anchoring new knowledge. By means of such subsumers the learner is able to relate the new material with what is already known. Where relevant subsumers do not exist he advocates the use of "advance organizers".

Ausubelbeginsthe instructional sequence with a setofbroadbutcomprehensive statements at a higher level of abstraction to what is to be learned. He calls such statements "advance organizers." These organizing statements are learned already; i.e. his cognitive structure.

This can be represented thus:



Thus, advance organizers are useful alternatives to sub-sumers. For example, you may begin a lesson with the statement "seeds germinate under special conditions which include water, optimum temperature and oxygen." The students may have learned about these factors without seeing their relationship to seed germination. But from their study of the implications of this statement (advance organizer) they can be lead to understand how the three factors are connected to seed germination i.e. by associating the new material with previous knowledge(Akpan, 2015).

For many years it was generally believed that Gagne and Ausubel were agreed in their views about the process of learning. As stated above, Gagne's view of this process is that meaningful learning occurs through movement of simple to complex, which is from concrete to abstract.

Ausubel on the other hand, construes meaningfulness intermofembedding specific into the already assimilated context of complex generalization. Gagne's assertion in recent years that learning of processes and skills is more important and more fundamental than thatof context mastery and has made the twopositions fardistinctive. One way of relating the two theories perhaps is by regarding Gagne's theory of learning hierarchies as a useful description of how best low intellectual skills are best acquired while treating Ausubel'ssubsumption theory or meaningful verbal learning as a graphic and tersedescription of how an organized body of knowledge can best be acquired (Shulman and Tamir, 1973).

4.0 CONCLUSION

The centralfocus of learning theories arethatlearning followsaparticular sequence. This is to saythatlearning concepts,thereareparticular steps or sequence of arrangements, which have to be followed in order to learn the whole concepts.

5.0 SUMMARY

In this unit, you have learnt that:

(i) Gagne's theory stipulates that the learning of a concept or skill depends upon the mastery of prerequisite concepts;

(ii) Ausubel's theory emphasizes systematically guided exposition the teaching learning process.

6.0 TUTOR MARKED ASSIGNMENT (TMA)

1. Give a brief summary of the theories of Gagne and Ausubel.

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UNIT 4 PIAGET'S THEORY AND APPLICATION OF LEARNING THEORIES TO SCIENCE TEACHINGCONTENT

1.0 INTRODUCTION

The Piaget theory of intellectual development is important to theteaching-learning process. It is also important to note that, all the learning theories have application to the teaching-learning encounter.

2.0 OBJECTIVES

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

- Explain Piaget's theory of intellectual development.
- Demonstrate the highest level of learning in problem solving.
- Discuss that Science could be taught according to fundamental structures or 'big ideas'.

3.0 MAIN BODY

3.1 Jean Piaget – Theory of Intellectual Development

The emphasis of this theory is that learning ability correspond to levels of cognitive development. Basically, Piaget sees four stages of mental development:

Sensory-motor (between birth to around two years of age). Pre-operational or representational stage (between two to about six years of age); Concrete operational stage (from about 7 to about 11 years); Formal operational stage (from about 12 years upwards).

Inthisbookwe shall beconcerned only with the last three stages. Detailed characteristics of all the stages can be found in virtually all educational psychology books. At the second stage, the learner'

interacts with objects rather intuitively operational stage is that a learner relies on concrete referents in his representation of reality. As mentioned earlier, a learner gains new experiences through his interaction with things in his environment. The last stage or formal operational stage, the learner can think in abstraction and can deal with concepts that do not have concrete referents.

Application of Learning Theories to Science Teaching

For Gagne, an instructional programme should be carefully guided in a step wise manner from simple to complex until the desired objective is achieved. Although, thelearneris activelyinvolvedinthelearningprocess, the sequence of activities in which he is engaged is determined entirely by the programme. To Gagne, the highest level of learning is problem-solving, lower level involve facts, concepts, generalizations, etc. As far as Gagne is concerned, the appropriate sequence in learning is, in terms of figure 5 from the bottom to the top. That is, one begins with simple prerequisites and works up, pyramid-wise, to the complex capability to be attained.

For Bruner, on the other hand, much less order is necessary for the programme, although such order is not precluded. Bruner insist on the learner manipulating materials and dealing with contrasts or discrepancies. Bruner deliberately builds potential incongruities into the learning materials, which will cause disequilibrium in the learner. As the learner tries to resolve such disequilibrium, he eventually makes somediscoverythroughtheprocessofwhatweearlier referred"cognitive restructuring." Like Piaget, Bruner sees learning as a process of successive disequilibria and equilibra. The learner, confronted with a novel situation, is at first confused or unstable and must accommodate the new experience to his cognitive structure if he is to achieve a new position of cognitive stability. Like Gagne, Piaget advocated that learning should go from simple to complex. For Piaget, learners should deal withconcrete materialsbeforethey are asked to learn abstract concepts and generalization. Before learners can deal meaningfully with numbers and computations they must comprehend what numbers mean.

They mustunderstandsymbolsbeforethemanipulationofsuchsymbols. Sincemostof the pupils at the primary and thelower secondary school are still at the concrete operational stage. Piaget would recommend theuseofrealmaterialsor modelsindealingwiththeoretical concepts and generalizations. From experience, we know that many of the pupils attheupper secondary school levelhavenotcompletely outgrown the need for concrete referents in their study of science. In reality, even adult resist to concrete operational behaviours from time to time especially when confronted with unfamiliar items or when there is need to recall some information. It seems therefore, that we never outgrow concrete operational behaviour to the extent that out intellectual activities are solely and strictly controlled operational behaviours.

It must be pointed out at this stage that great strides have been made with respect to learning theories. Despite this, we still have not understood completely how learning takes place. This is no point of despair: it provides a fertile ground for further inquiries. It is certain, however, that theories oflearning which at the moment are mainly descriptive will develop to the explanatory and predictivestages reminiscent of the theories of science, when theories of knowledge and pedagogy become more comprehensible than they are now.

Teaching Science According To Fundamental Structures or Big Ideas

As basic issue of which all learning psychologists are agreed, as the importance of structuring the context of science for effective learning. Although Bruner introduced the concept of structure to the educational community, it was Schwab who has explicated this concept specifically to science education (Shulman and Tamir, 1973). According to Schwab (1962). The structure of the discipline consists in part, of a body of imposed conceptions, which defines the investigated subject no matter of a discipline and controls its enquiries.

Bruner (1960) contends that an understanding of the fundamental structures of science will help students to:

> learn how things are related; learn that one concept reinforces a another;be aware of the fact that patterns in nature are more comprehensible than bits and pieces of information; learn that conceptual development broadens over time; know that science has identifiable structure rather than being collocation of multitude of information items; remember things learned better; Similarly, the fundamental structure of science: cater for individual differences since the students could be assigned to different levels of concepts; gives stability to the curriculum because they represent structures of high credibility in the scientific literature; helps the students to conceptualize the dynamic nature of science in terms of constant interplay between the product and process of science.

A number of science andmathematic curricula have been developed to reflect around the so-called "fundamental structures" "big ideas", or conceptual schemes." These programmes are based on the premises that: big ideas or schemes, represent conceptions in science that have been firmly established by the scientific community and are basic to the progress of science teaching and research: each scheme represents a system of facts, concepts and generalizations which hopefully can be organized into a sound learning sequence from simple to complex (Akpan, 2015).

It should be realized, however, that mastery of the "big ideas" of a given field involves more than the mere acquisition of the facts, concepts and generalizations; italso includes the development of desirable manipulative skills and attitudes necessary for solving problems that may emerge.

To instill scientific attitudes by teaching requires much more than the presentation of the "big ideas" of science. It also entails hard work on the teacher. It involves a thorough grasp of the subject matter and the ability to communicate such understanding to students in an interesting manner. There are several ways of making a topic interesting viz:

Asking thought provoking questions;
Telling a short story;
Giving abrief history relating to discoveryofthesubjectin questions;
Performing a short demonstration, etc. Whatever method is used, the teacher should be patient, enthusiastic and resourceful.

A big idea or scheme will remain in students' mind only if they contain "critical concepts" or what Bruner (1960) refers to as"regenerative concepts.' A scientist does not remember all the details of a topic but rather here member thecritical orregenerative components of topic. Such critical concepts are useful in processing given scientific information. For example, after observing an animal for a few minutes a scientist is ableto saywhether the animal is a vertebrate invertebrate; whether a plant is an angiosperm or gymnosperm; whether a chemical is an acid of base; whether a piece of metal is magnetic or not; whether a given soil is sandy and clayey, etc.

The ability of the scientist to process information quickly and correctly is not based on the recall of a catalogue of detailed scientific information but just on a recall of basic concepts. Sometimes such critical concepts are coined as formulae

e.g. $r \propto \frac{1}{\sqrt{d}}$ where r and d denote rate of diffusion and density of a given gas respectively.

According toBruner(1960)whatunderstanding of "big"ideas"of science does is to ensure that total loss of memory does not occur; that what is left in the learners' mind is sufficient, to reactivate and reconstruct the details of a given subject matter when needed.

4.0 CONCLUSION

A teacher should have indept knowledge of the learning theories and their application to teaching. By doing this, the curriculum implementation would be made easier. However, it is important to structure the content of science for effective learning.

5.0 SUMMARY

In this unit, you have learnt that:

(i) Learning ability corresponds to levels of cognitive development

(ii) Learning theories could be applied to the teaching of science

(iii) Structuring the content of science is important to science teaching

6.0TUTOR MARKED ASSIGNMENT (TMA)

1. How would you apply the following theories in the teaching of Chemistry
   a. Gagne b. Ausubel and c. Piaget

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