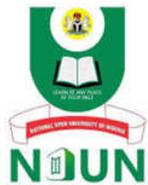




EDU 252
CHEMISTRY METHODS

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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 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.

The Course Materials

National Open University of Nigeria will provide you with the 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.

Study Units

The study units are:

Module 1 Nature of Science

- Unit 1 Definitions of Science
- Unit 2 Myths and Dogmas about Science
- Unit 3 Philosophers View and Aim of Science Education
- Unit 4 The Aims and Historical Context of Science
- Unit 5 The Challenge of Science Teaching

Module 2

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

Module 3

- Unit 1 Teaching Science in the face of Scarcity of Chemicals/Equipment
- Unit 2 The 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-Assessment Exercises (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 to apply knowledge, information and skills that you have

acquired during the course. At the end of the units, you will be provided with probable answers to the SAEs.

Tutor-Marked Assignment

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 of 70% of the total course grade. All areas of the course will be assessed and the examination will consist of questions which reflect 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.

marked

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

There will be specific time made available 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 and phone 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, with your 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 from course 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 1 NATURE OF SCIENCE

Unit 1	Definitions of Science
Unit 2	Myths and Dogmas about Science
Unit 3	Philosophers View and Aim of Science Education
Unit 4	The Aims and Historical Context of Science
Unit 5	The Challenge of Science Teaching

UNIT 1 DEFINITIONS OF SCIENCE

- 1.1 Introduction
- 1.2 Intended Learning Outcomes
- 1.3 Definitions of Science
- 1.4 Scientific Attitude
- 1.5 Science as Process Skills
- 1.6 Science as a Product
- 1.7 Assumptions about Science
- 1.8 Summary
- 1.9 References/Further Readings/Web Resources
- 1.10 Possible Answers to Self-Assessment Exercise(s)



1.1 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.



1.2 Intended Learning Outcomes

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

- Define science in terms of its processes
- State three assumptions of science.



1.3 Definitions of Science

Reflect on your own way of defining science after this class, be calm and let us consider some views about science because they will guide in forming your own definition. The word science is an umbrella term which covers a number of different kinds of activity and this suggests that there are many definitions of science. Definitions of Science vary

from one scientist to the other. As early as the 1940's and 1950's it was regarded as a body of classified organised and systematised knowledge. Some defined science as "a group of exact demonstrable facts and proven theories". it was again defined as the intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment.

<https://www.google.com/search?q=science&oq=science&aqs=chrome.0.69i59j>

However, when defined in terms of its contents or products, science is an ordered body of knowledge in form of laws, theories and concepts. Also, when defined in terms of its processes, science is a method of investigating about the universe. A balanced view about science must consider both the product and process attributes of science.

Anyone of these definitions would be inadequate and misleading because 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, stating problems, hypothesising, designing experiments, interpreting data, and synthesising theories typify the scientific enterprise. The science manpower project (1960) provides a definition of science that is most credible as it emphasises 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 logical reasoning.

This is known as the methods of enquiry. The importance of science can never be over-emphasised as it is the key to understanding of our environment and the natural laws. https://www.google.com/search?q=importance+of+science&ei=JIm4Yq23O_m. You may as well watch the video on the importance of science. <https://www.youtube.com/watch?v=AHHcu5aIcC8>

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 body of knowledge and the process of acquiring and refining 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 that which the process produces—man's 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).

Self-Assessment Exercise 1

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 2 minutes

Give your own view about the definition of science.

1.3.1 Scientific Attitudes

In the last section, we discussed the definition of science. This unit focuses on the behavioural traits that characterises a scientist while carrying out investigations about nature. Scientific attitudes refer to the peculiar attitudinal disposition that characterises the intellectual behaviours of scientists and science students. <https://www.google.com/search?q=scientific+attitudes&oq=scientific+atti&aqs=chrome.0.0i512j69i57j0i512i8.112305j0j7&sourceid=chrome&ie=UTF-8>

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 characterise scientific attitude includes:

- Objectivity –impartiality, reporting it as it is, not as it may be.
- **Scientific Honesty**-truthfully conducting experiments and reporting outcomes as obtained.
- **Observing accurately**- paying attention to minutest details
- **Patience and Perseverance** –allowing outcomes to proceed at prevailing conditions, 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.

Self-Assessment Exercise 2

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 2 minutes

The behavioural trait that enables a chemistry student to push on in spite of obvious difficulties in a practical experiment is(humility, objectivity, flexibility, patience and perseverance)

1.3.2 Science Process Skills

In the last section, we discussed the scientific attitudes which are those behavioural traits that characterises a scientist while carrying out investigations about nature. In this section, we shall consider Science Process Skills. https://www.google.com/search?q=science+process+skills&ei=jgPBYsWKFcCGxc8Pi9ud2AM&oq=science+process&gs_lcp=Cgdnd3Mtd2l6EAEYATIFCAAQkQIyBQgAEJECMgUIABCRAjIFCAAQgAQyBQgAEIAE These refer to the skills which the scientist brings to bear in the process of conducting his/her investigation. They are the essential ingredients and 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, graph etc.

Inferring – drawing opinion or 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 of a phenomenon through the 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.

Self-Assessment Exercise 3

Attempt the following reflective exercise before you move to the next section:
 Estimated time of completion: 2 minutes
 The eye, ear, nose, hand and tongue are the primary organs for the process of

1.3.3 Science as Product

In the last section, we discussed the Science Process Skills which are those behavioural traits that characterises a scientist while carrying out investigations about nature. In this section, we shall consider Science Process Skills which are the skills which the scientist brings to bear in the process of conducting his/her investigation. In this section we will focus on Science as a Product. https://www.google.com/search?q=science+process+skills&ei=jgPBYsWKFcCGxc8Pi9ud2AM&oq=science+process&gs_lcp=Cgdnd3Mtd2l6EAEYATIFCAAQkOIyBOgAEJECMgUIABCRAjIFCAAQgAQyBOgAEIAE Science as a product 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 organised 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-generalisations arrived at by integrating two or more related concepts. Scientific principles convey factual meaning, certainty or exactitude in generalised 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.

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-Assessment Exercises 4

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 5 minutes

1. Can you explain why a glass cup broke after the water content got frozen?

2. Why do engineers allow some gaps in-between railway lines or bridges?

1.3.3 Assumptions about Science

In the last section, we discussed the Science as a product. In this section, we shall consider assumptions and basic principles which are of immense importance in understanding scientific enterprise. They serve very useful purpose in mainstreaming students' understanding of science. <https://www.news24.com/News24/Understanding-science-scientific-assumptions-20140627> 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 a discoverable cause.

Principle of complementarity: All phenomena are incorporated into a single consistent natural scheme by scientists. But contradictory generalisations 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

Principle of tentativeness: Scientists do not regard their generalisation as final, but they are willing to modify them if they are contradicted by new evidence.

Principle of uniformity: It is believed that the forces now 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 done by making careful observations, records and analyses; from such analyses, they can make predictions regarding other events or changes. It is only when predictions are verifiable by further observations or experiments that scientists can propose generalisations, theories or laws which eventually 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 the realm of possibilities, probabilities and inevitabilities, none of which can be predicted with absolute certainty. In this case, the language of scientists and science teachers do not include terms such as 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.

Self-Assessment Exercises 5

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 2 minutes

1. **Principles of**refers to the ability to examine facts and to suspend observations, conclusions and activities
2. The principle of dynamism states that.....



1.4 Summary

Let us quickly go through what we did in this unit. In this unit, you have learnt that science can be variously defined according to the author, of which you may be one. Specifically, this unit looked at Science as both a body of knowledge and the process of acquiring and refining knowledge. It also considered scientific attitudes, Science as a process and a product as well as universally accepted assumptions and basic principles, which are helpful to science teachers.

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



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1.6 Possible Answers to Self-Assessment Exercise(s)

Answers to SAE 1

Science is a body of knowledge and the process of acquiring the knowledge. A balanced view about science should emphasise the process and product dimensions.

Answers to SAE 2

Patience and perseverance

Answers to SAE 3

Observation

Answers to SAEs 4

1. Water expands whenever it freezes, hence the glass cup breaks.
2. When strongly heated, metals expand; hence some gaps are left in-between railway lines or bridges.

Answers to SAEs 5

dynamic and not static.
constantly and always vary.

1. Principles of objectivity
2. In nature there are changes that are
Everything in nature changes

UNIT 2 MYTHS AND DOGMAS ABOUT SCIENCE

Unit Structure

- 2.1 Introduction
- 2.2 Intended Learning Outcomes
- 2.3 Myths and Dogmas about Science
 - 2.3.1 Philosophical Context of Science
- 2.4 Summary
- 2.5 References/Further Readings/Web Resources
- 2.6 Possible Answers to Self-Assessment Exercise(s)



2.1 Introduction

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



2.2 Intended Learning Outcomes

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

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



2.3 Myths and Dogmas about Science

You are once more welcome to another unit of the course EDU252 dealing with myths and dogma. These concepts are usually based on tradition and people's way of life. As such they vary from one society to the other. What is acceptable belief in one community might vary with another community. Any one of such community have their myths and dogma deep-rooted in their culture. For instance, the interpretation of any phenomenon in African society will depend solely on the culture. <https://www.google.com/search?q=myths+and+dogma+about+science+and+technology&oq=myths+and+dogma+about+science&aqs=chrome..69i57j33i160l2.25993j1j7&sourceid=chrome&ie=UTF-8>The African culture has been interpreted to mean ways and ideas of the past and it is supposed to be evidenced in language, dress, entertainment (singing and dancing) and beliefs. The introduction of science into western education has, no doubt, brought about conflict of African culture and science. In a handbook published in Ghana by the Science Education Programme for 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 children have shared, has not always paid attention to the culture of the African. In the recent past there was a lack of adequate knowledge of the local cultural environment which was in any case dismissed as wholly inimical to the development of science concepts”.

A predominant conflict in science education in Africa is an academic discipline, which is facing an uphill task because most African students and teachers still hold firmly to superstitions, which eventually contradict 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 to us.

We need the searchlight of science to illuminate the dark corridors 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 touches 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. That 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 as 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 not taken, these mysteries usually tagged “superstitions” are capable of 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 of 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.

SELF-ASSESSMENT EXERCISES 6

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

- i. Outline four avenues through which a society/community expresses their culture.
- ii. Explain briefly why science is foreign to an African child.

2.3.1 Philosophical Context of Science.

Philosophising about science is primarily concerned with the critical examination of the processes and products of science. Philosophy of science therefore is preoccupied 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 does this influence the development of the scientific knowledge? What is the scientific method and what kind of values underlying 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 take better decisions to improve what he does. They also suggest what kinds of scientific knowledge should be included in the curriculum and also how these should be implemented in the classroom. The philosophical analysis and explanations of the nature of science have led people to believe that science is not only a body of systematised 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 generalisations from raw and specific data. It attempts to logically mould raw and incoherent data into a comprehensible whole. https://www.google.com/search?q=philosophy+of+science+and+technology&ei=KgbBYueJOaeIlwT9mYX4Cw&oq=philosophy+of+science&gs_lcp=Cgdnd3Mtd2l6EAEYATIECAAQQzIECAAQQzIECAAQQzIECAAQQzIFCAAQgAQyBQgAEIAEM

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 generalise, 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.

SELF-ASSESSMENT EXERCISES 7

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. A scheme of reasoning that permits us to generalise, proceeding from singular statement to universal ones is termed
- 2..... is preoccupied 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.
3. How would you make the teaching of Chemistry reflect the culture of the students you intend to teach?



2.4 Summary

In this unit we took a critical look at myths and dogma as well as the philosophical context of science. We have seen that African child comes into a science classroom with his mind loaded with superstitious beliefs.

We have also seen that philosophy could be used to explain the processes and products of science.

Scientific facts and principles could be said to be hinged on some philosophical benefits. However, scientific reasoning is characterised in terms of inductive and deductive logic.



2.5 References/Further Readings/Web Resources

Ogunniyi, M.B. (1986). *Teaching Science in Africa*. Ibadan: Salem Media (Nig.) Ltd.

Urevba, A. (1990). *Methodology of Science Teaching*, Benin City: Juland Publishers.



2.6 Possible Answers to SAEs Possible Answers to SAEs

Answers to SAEs 6

- 1.. Language, dress, entertainment (singing and dancing) and beliefs.
- 2.. African child is intimately tied to his/her culture, have strong belief on superstition which retards quest for scientific literacy.

Answers to SAEs 7

1. Induction
2. Philosophy of science
3. Using examples from local environment, improvisation of instructional materials, encouraging critical/creative thinking skills, embarking on field trips to places of scientific significance in the society.

UNIT 3 PHILOSOPHERS' VIEW AND AIMS OF SCIENCE EDUCATION

Unit Structure

- 3.1 Introduction
- 3.2 Intended Learning Outcomes
- 3.3 Philosophers View of Science
 - 3.3.1 The Aims of Science Education
- 3.4 Summary
- 3.5 References/Further Readings/Web Resources
- 3.6 Possible Answers to Self-Assessment Exercise(s)



3.1 Introduction

From our discussion in the last section of unit 2, we saw that philosophical analysis played an important role in understanding science concepts. In this unit, we shall be looking at the Philosophers' view and aims of science education. 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.



3.2 Intended Learning Outcomes

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

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



3.3 Philosophers' View of Science

In this section, we shall be considering the views of key philosophers whose ideas impacted significantly to the study of science. Karl Popper, a philosopher of science, rejects the inductive method as the process by which science advances. He said that it is not logical to infer universal statements from singular ones. Induction believes that there are statements 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 accepts the view that scientific change does not always proceed in the direction it started. According to Popper, hypothesis cannot be established conclusively even by extensive testing with favourable results since further 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, **Thomas Kuhn**, another philosopher of science criticised hypothetico-deductive interpretation of the growth of science. He was not satisfied with the implication of the 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 reject a theory, which has had considerable past success and reputation until a real alternative one is in sight. According to him, it is by 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 governed by 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 paradigm is to remove anomalies or discrepancies. 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 ever sacred. Popper supports the view that error will be systematically eliminated 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 curriculum is a matter of choice and convenience. 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 what constitutes science and what it entails to be a member of science community. The community must have acceptable principles, which must be used to explain the concept of science. The members must however, realise the limitations of scientific laws and theories.

Self-Assessment Exercises 8

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes.

1. Which is the best method for teaching chemistry curriculum.
2. Differentiate between inductive and deductive reasoning.

3.3.1 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 country towards technological advancement. It is necessary to realise the fact that science is a creation of man and its future, both theoretical and technical advancement, will depend upon the quality and number of our future scientists. The need for scientifically trained manpower increases progressively in a developing country like Nigeria. In order for the citizens to realise 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 to achieve this dimension of scientific literacy.

https://www.google.com/search?q=aims+of+science+education&ei=xgbBYuuFD4q6ae_xkvgJ&ved=0ahUKEwjrgPrM3dv4AhUKXR0KHe-4BJ8Q4dUDCA4&oq=aims+of+science+education&gs_lcp=Cgdnd3

The values of science that must be taught are:

1. **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.
2. **Questioning of all things:** A belief that all things including authoritarian 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 of data because they are the basis for theories, which, in turn, are worthwhile because they can be used to explain many things and events. In some cases, these data have immediate practical 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.
3. **Demand for verification:** A high regard for requests that supporting data be made public and that new empirical tests be invented and/or conducted to assess the validity or accuracy of a finding or assertion.
4. **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.
5. **Consideration of premises:** A prizing of frequent review of the basic external and internal assumptions from which a line of inquiry has arisen, especially when they are used as a basis for determining further action.
6. **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 9

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

Explain briefly any five values that must be taught in science.



3.4 Summary

In this unit we have learnt studied the Philosopher’ view of science as well as the aims of science education. We also considered the essential

values that need to be taught in a science class. We learnt also that Philosophers hold different views about science. One of the aims of science education is for the citizens to realise the significant role of science to technological development of the world over.

The changing nature of science drives home the point that science is a philosophy. Scientific community cannot be regarded as an open society. This is because of the peculiar nature of scientific culture. He was not satisfied with the implication of the 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 reject a theory, which has had considered past success and reputation until a real alternative one is in sight. According to him, it is by challenging 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 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 governed by 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 members. Scientists’ use puzzle-solving skills occasionally to test the paradigm. Testing of the paradigm is to remove anomalies or discrepancies. 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.



3.5 References/Further Readings/Web Resources

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

Conant, J.B. (1951). *Science and Common Sense*. New Haven; Connection Yale University Press.



3.6 Possible Answers to Self-Assessment Exercise(s)

Answers to SAEs 8

1. The method to use by a Chemistry teacher in the implementation of science curriculum is a matter of choice but largely determined by the objective of the lesson and level of the learner among other factors. 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
2. **Inductive and Deductive Reasoning:** Inductive reasoning that permits us to generalise, 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.

Answers to SAEs 9

1. **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.
2. **Questioning of all things:** A belief that all things including authoritarian 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.
3. **Search for data and their meaning:** Prizing of the acquisition and ordering of data because they are the basis for theories, which, in turn, are worthwhile because they can be used to explain many things and events.
4. **Demand for verification:** A high regard for requests that supporting data be made public and that new empirical tests be invented and/or conducted to assess the validity or accuracy of a finding or assertion.
5. **Respect for logic:** Rationality is central in scientific investigations. There is no room for indoctrination in science class. 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.

6. **Consideration of premises:** A prizing of frequent review of the basic external and internal assumptions from which a line of inquiry has arisen, especially when they are used as a basis for determining further action.

7. **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.

UNIT 4 THE AIMS AND HISTORICAL CONTEXT OF SCIENCE

Unit Structure

- 4.1 Introduction
- 4.2 Intended Learning Outcomes
- 4.3 The Aims and Historical Context of Science
 - 4.3.1 Historical Context of Science
- 4.4 Summary
- 4.5 References/Further Readings/Web Resources
- 4.6 Possible Answers to Self-Assessment Exercise(s)



4.1 Introduction

When students learn the 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 to science. The knowledge of the history of science in Nigeria would enable students to appreciate the learning of science at this stage of our development.



4.2 Intended Learning Outcomes

By the end of this unit, you 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.



4.3 The 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 scientific literacy, 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. You may wish to refer to the document; National Policy on Education (FRN, 2013), for detailed treatment on National Educational Objectives. <https://education.gov.ng/wp-content/uploads/2020/06/NATIONAL-POLICY-ON-EDUCATION.pdf>

Some authorities strongly believe that the aims of science education in schools include, scientific literacy – to inculcate the power of careful observation, classification and interpretation of observed 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, is one with an understanding of the basic 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 skills should involve solving problem situations where apparatus has to be selected, taking readings and making 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 general aims pose a big challenge to the science 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 goals of science therefore, 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 given for comprehension and application of the scientific facts, which are

disseminated. The development of scientific attitude is also paramount in any science education.

Self-Assessment Exercises 10

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. What are the key attributes required of a scientifically literate person?
2. Outline the five general aims of science teaching.

4.3.1 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 country taught primary school subjects, language, writing, geography, drawing, hygiene, singing and history to the exclusion of science. With the 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. In 1878, the Methodist Mission offered to teach Trigonometry, 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 Hope Waddell Institute founded in Calabar in 1895; the CMS sponsored Teachers' College St. Andrew's College Oyo, founded in 1876; 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, founded in 1913; 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 colonisation was essentially trade, another reason was that Africans generally were thought to 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 of other subjects began at about 1920 as a result of the 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 science teaching into all schools. The science and mathematics curricula in Nigeria schools were modified by the West African Examinations Council after independence in 1960. The realisation 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 Exercises 11

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. Give two reasons why the teaching of science was delayed in Nigerian schools?

2. What are the contributions of the colonial masters and missionaries to the introduction of science teaching in Nigerian secondary schools?



4.4 Summary

In this unit, we discussed the aims and historical context of science. One of the aims of science is to inculcate in the students the development of scientific values and skills. The relationship between aims of science and national educational objectives were pointed out.

The aims of science education are in line with the national objectives of education as contained in the National Policy on Education. The historical context of science in Nigeria would remain incomplete without discussing the contributions of the Missionaries and British government. British and missionaries influenced the introduction of science teaching into all schools and supported them financially.

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.



4.5 References/Further Readings/Web Resources

- Abdullahi, A. (1982). *Science Teaching in Nigeria*. Ilorin: Atoto Press Limited.
- Fafunwa, B. (1979). *The Purposes of Teacher Education in Adaralegbe*. A.A. Philosophy for Nigerian Education. Ibadan: Heinemann Educational Books Ltd.
- Ogunleye, B.O. & Babajide, V.F.T. (2011). Commitment to Science and Gender as Determinants of Students' Achievement and Practical Skills in Physics. *Journal of Science Teachers Association of Nigeria*. 1(46) 125- 135.



4.6 Possible Answers to Self-Assessment Exercise(s)

Answers to SAEs 10

1. Attributes of scientific literacy: He/she should be knowledgeable about the role of science in society; appreciate the cultural conditions under which science thrives, its conceptual inventions and investigative procedures as well as potentials of science and technology to contribute to economic development of a nation.
2. General aims of science teaching:
 - 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.

Answers to SAEs 11

1. This was because the motive for colonisation was essentially trade/commerce. Another reason was that Africans generally were thought to be inferior human beings and as such not capable of understanding science. Cultural and religious inhibitions was also a factor as well as paucity of curricular and manpower requirements.
2. Providing grants in aid of educational establishments, providing impetus for curricular materials, training of personnel for teaching and interpretation of the local languages to them.

UNIT 5 THE CHALLENGES OF SCIENCE TEACHING

Unit Structure

- 5.1 Introduction
- 5.2 Intended Learning Outcomes
- 5.3 The Science Teacher
 - 5.3.1 The Learner
 - 5.3.2 The Subject Matter
 - 5.3.3 The Language of Science
- 5.4 Hypothesis, Theories and Law of Science
 - 5.4.1 Hypothesis
 - 5.4.2 Laws
 - 5.4.3 Theories
- 5.5 Summary
- 5.6 References/Further Readings/Web Sources
- 5.7 Possible Answers to Self-Assessment Exercise(s)



5.1 Introduction

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



5.2 Intended Learning Outcomes

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.



5.3 The Science Teacher

The three basic functions of the science teacher are: to instruct, to supervise and to manage 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 realise that children are learning directly from his teaching as well as indirectly from their surrounding environments. What teacher 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. <https://theconversation.com/5-characteristics-of-an-effective-science-teacher-from-a-researcher-who-trains-them-165211>

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.

SELF-ASSESSMENT EXERCISES 12

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. The three basic functions of a science teacher are -----, ----- and

Identify any five teacher-based factors that influence the quality of learning

5.3.1 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.

Self-Assessment Exercises 13

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. From your own experience identify any four barriers constraining female students in the pursuit of Science, Technology, Engineering and Mathematics (STEM)
2. Suggest measures to overcoming these constraints.

5.3.2 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 cannot take place. The interest of the students in the subject matter will depend on how interesting the teacher's teaching is.

Self-Assessment Exercise 14

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

Identify five avenues of breaking girls' gender barriers to STEM careers?

5.3.4 The Language of Science

Science subjects have their own peculiar languages. The language of Chemistry is different from the language of physics for 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 recognised 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 that is, within his frame of reference. The student, having no such frame of reference, sees 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. https://www.google.com/search?q=language+barrier+to+communication+in+science&ei=UQnBYtTzIuuGxc8PIZ6y4AY&ved=0ahUKEwiU4MOD4Nv4AhVrQ_EDHRWPDGwQ4dUDCA4&oq=language+barrier+to+communic

SELF-ASSESSMENT EXERCISE 15

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. Identify the four languages which tend to conflict in the learning of chemistry
2. How can we, as chemistry teachers minimise the negative impact of conflicting languages in the learning of chemistry.

5.4 Hypothesis, Theories and Law of Science

5.4.1 Hypothesis

Hypothesis refers to the ability, on previous or present observation to release a tentative guess which is subject to surer testing. It is a tentative guess. A very good example of a 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 remaining constant.

5.4.2 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.

5.4.3 Laws

A law is a statement, which summarises 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 the situation with all gases. This explained Boyles law, which states that “the volume of a given mass of gas is inversely proportional to its pressure if the temperature is kept constant. Some related laws are Graham’s law of diffusion. Chemical laws describe the ways in which chemical changes take 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.

Laws are also common to the areas of science like physics and biology. 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.

Self-Assessment Exercise 16

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

From your knowledge of chemistry distinguish among the concepts of hypothesis, theory and law.



5.5 Summary

In this unit you have studied challenges affecting effective teaching and learning of chemistry at the classroom level. Some of these challenges emanate around the teacher, the learner, the subject matter and the language of instruction. Chemistry has its own technical terms which

learners find difficult to assimilate especially in the midst of mathematical figures, symbols and equations. The resolution of these challenges still imposes some responsibility on the teacher to adequate instructional preparation and delivery. Teacher has to instruct, supervise and also manage resources.

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 is very important. This is what would make a teacher perform his duties creditably.



5.6 References/Further Readings/Web Resources

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- Urevba, A. (1990). *Methodology of Science Teaching*. Benin City: Juland publishe



5.7 Possible Answers to Self-Assessment Exercise(s)

Answers to SAEs 12

1. to instruct,
2. to supervise and
3. to manage learning resources or facilities.

2. Teacher-based factors:

The quality of training given to and acquired by the teacher.

The adequacy of instructional methods and materials used in a particular lesson.

The teacher's grasp of the subject matter

The teacher's degree of attachment to textbooks

The teacher's level of motivation relative to the atmosphere surrounding his job.

The teacher's capacity to take initiative.

The teacher's level of self-confidence.

Answers to SAEs 13

1. Paucity of visible role models, gender stereotypes, Bias of teachers and parents to some careers, cultural factors, poor perception of girls' ability in STEM.
2. Suggestions: Effective instructional delivery is needed to overcome these challenges, Mentorship, Public enlightenment, Guidance and counseling, scholarship awards.

Answers to SAE 14

As in SAE 2, Number 2 above

Answers to SAEs 15

1. Four conflicting languages are the language of the subject, language of mathematics, English Language and the indigenous language of the community from where the learners come.
2. Overcoming impact of conflict of languages; Use of English language in conjunction with the indigenous language of the immediate community, collaboration between chemistry and mathematics teacher in instructional delivery, adopting patience and perseverance as an effective tool while teaching, adopting observe-pair-share strategy among students.

Answers to SAE 16

Hypothesis is a tentative guess which is subject to surer testing. When a hypothesis has been tested and found to be correct/true within the limits of available evidence, it becomes a theory. Thus theories are

explanations we offer to observed natural event. A law is a statement, which summarises 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.

GLOSSARY

Assessment is the action or an instance of making a judgment about something: the act of *assessing* something: appraisal.

Culture is a way of life of a group of people--the behaviors, beliefs, values, and symbols that they accept, generally without thinking about them.

Dogma definition: is a fixed, especially religious, belief or set of beliefs that people are expected to accept

Education is the process of receiving or giving systematic instruction, especially at a school or university.

Myth a traditional story, especially one concerning the early history of a people or explaining a natural or social phenomenon, and typically involving supernatural beings or events.

Philosophy the study of the fundamental nature of knowledge, reality, and existence, especially when considered as an academic discipline.

Science is a systematic enterprise that builds and organises knowledge in the form of testable explanations and predictions about the universe

Society the aggregate of people living together in a more or less ordered community.

Technology the application of scientific knowledge for practical purposes, especially in



1.2 Intended Learning Outcomes

By the end of the unit, you will 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.



1.3 The Social Dimensions of Science

The teaching of science should not only involve getting out useful information to 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, technology and society and interaction between them. Science can therefore be regarded as the creation of man and its future is in the realms of both theoretical and technical advancement.

The development of scientific literacy world-wide has initiated the Production of essential materials needed in all fields of human endeavour. The products of scientific technology include sophisticated weapons, supersonic air crafts, micro-computers, test tube babies and improved medical care. The question of whether these achievements of science are beneficial or destructive to man is debatable. Can you reflect on some destructive contributions of scientific technology?

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 with what Francis Bacon said in the 12th century that science should be used for the merit and emolument of man; for this to be meaningful, the language of science should be blended with those of our people, and this will facilitate understanding of many scientific 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, where science 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 end products for a modern industrial society. The

advantage of technology over pure science is that of keeping the student in touch with the “real” world.

<https://www.google.com/search?q=positive+and+negative+contributions+of+science+and+technology+in+society+science&ei=rArBYrzdDJb0a-L6trgB&ved=0ahUKEwi84-io4dv4AhUW-hoKHWK9DRcQ4dUD>

Self-Assessment Exercise 17

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. is credited with the statement that in the 12th century, science should be used for the merit and emolument of man.
2. State two ways by which the products of scientific technology are destructive to man.

1.3.1 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 with male students and their teachers. Because of cultural demands, girls are not interested in such professions as auto mechanics, as an example, how then can we 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. https://www.google.com/search?q=language+barrier+to+communication+in+science&ei=UQnBYtTzIuuGxc8PIZ6y4AY&ved=0ahUKEwiU4MOD4Nv4AhVrQ_EDHRWPDGwQ4dUDCA4&oq=language+barrier+to+communic

All these barriers of time and space may not be overcome, 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. For example, if we use a skeleton to assist student in the memorisation 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 a method a laboratory period, for example, will take. If the results of the time spent are not worth it, the teacher must veto the activity.

SELF-ASSESSMENT EXERCISES 18

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. andare barriers to inter-personal communication in science class.
2. List any three considerations that should guide the selection of method/instructional materials for teaching chemistry.

1.3.2 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, fewer students embark on the learning of science in Nigeria. Improved science programme must play an important part in solving this problem. A scientifically literate citizenry is also needed in making some vital decisions in a democratic system. <https://www.google.com/search?q=positive+and+negative+contributions+of+science+and+technology+in+society+science&ei=rArBYrzdDJb0a-L6trgB&ved=0ahUKewi84-io4dv4AhUW-hoKHWK9DRcQ4dUD> This is responsibility of the schools and primarily a function of science programme in the schools. Science education also aims at preparing people for adjustment within their environment as human beings, through infancy, childhood, adolescence, adulthood and old age and their changing roles. They change as functioning biologically organism. The ways they 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-Assessment Exercises 19

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

Why is the development of man linked with scientific literacy?



1.4 Summary

In this unit we have discussed the social dimensions of science with attendant barriers.

- The interplay of scientific development and science teaching was also discussed.
- Science contributes immensely to the development of the society. The theoretical and technical
- advancement of man depends on his knowledge of science. Science technology and engineering are somehow related. 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.
- There is no doubting the fact that science has social implication and that man is a scientific object
- reacting at various stages of development to the changing events in the society.
- The social contributions of man could therefore be enhanced through scientific literacy. There is no gainsaying that the contributions of science and technology to society has both positive and negative consequences.



1.5 References/Further Readings/Web Resources

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**1.6 Possible Answers to Self-Assessment Exercise(s)****Answers to SAEs 17**

1. Francis Bacon
2. Production of objects of mass destruction, armament race, pollution of the environment, euthanasia, etc.

Answers to SAEs 18

1. **Gender, students' background, cultural demands.,**
2.
 - Appropriateness of the method in delivering the objective of the lesson,
 - appropriateness to the age of students and the topic we are treating,
 - ability of the material/method to help students to think, to probe or to investigate,
 - the cost implication of the method/material

Answers to SAEs 19

1. The technological breakthrough of any nation will also depend on those members scientifically trained manpower she could produce.
2. A scientifically literate citizenry is also needed in making some vital decisions in a democratic system and this is responsibility of the schools and primarily a function of science programme.
3. Science education also aims at preparing people for adjustment within their environment as human beings, through infancy, childhood, adolescence, adulthood and old age and their changing roles/needs must be provided for through scientific literacy.

UNIT 2 APPLICATION OF SOME CONVENTIONAL AND INNOVATIVE TEACHING METHODS

Unit Structure

- 2.1 Introduction
- 2.2 Intended Learning Outcomes
- 2.3 Conventional Teaching Methods
 - 2.3.1 Lecture
 - 2.3.2 Excursion /Field Trip
 - 2.3.3 Project Method
 - 2.3.4 Experimentation
 - 2.3.5 Dramatisation
 - 2.3.6 Team Teaching
 - 2.3.7 Inquiry Method
 - 2.3.8 Demonstration
- 2.4 Innovative Teaching Methods
 - 2.4.1 Cooperative Learning Strategy
 - 2.4.2 Concept Mapping
 - 2.4.3 Computer Assisted Instruction
 - 2.4.4 Focus Group Discussion
- 2.5 Summary
- 2.6 References/Further Readings/Web Sources
- 2.7 Possible Answers to Self-Assessment Exercise(s)



2.1 Introduction

In unit 1, we dealt with the social dimensions of science. In this unit 2, we are going to go properly into the business of different methods of teaching and learning chemistry in the classroom. Very importantly, we shall also explore the strengths and weaknesses of each method. 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.



2.2 Intended Learning Outcomes

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

- Outline three methods of teaching science
- State two advantages and disadvantages for any named teaching method
- Apply some of the methods to the teaching of chemistry.



2.3 Conventional Teaching Methods

In this section, we shall consider those teaching methods that are traditionally used in teaching and learning different school subjects. Some of them are teacher-centred, but the current trend is to adopt learner-friendly methods of teaching.

https://www.researchgate.net/publication/350487211_Innovative_Methods_and_Practices_In_Conventional_Teaching_Methods

2.3.1 Lecture

In lecture method of teaching, 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 pupils remain passive listeners for most of the period. At last, the teacher copies notes for the students or gives one of the students to copy for the class.

Advantages

- Allows the teachers to cover enough ground within a short time.
- Little time or no time is spent on teaching aids
- It could be delivered through radio thus minimises the cost of employing teachers
- It encourages the art of note taking
- It encourages independent study

Dis advantages:

Largely teacher centered, does not encourage acquisition of process skills and creativity, encourages passivity and rote learning on the part of the learners.

Suggestions for the Use of Lecture Method

1. Lecture method should be used in junction with other methods of teaching. This will help to enhance students' participation in the lesson.
2. As much as possible, avoid coverage of too many topics, which may lead to boredom and tend to confuse the students.
3. Encourage active participation of students in class through asking questions and giving them opportunity to make comments.
4. At the end of each lesson period, the teacher should summarise the key points

2.3.2 Excursion /Field Trip

Field trip is one of the methods of teaching chemistry which involves taking students outside the classroom setting to have first-hand experiences of what happens in our environment or real-life situations. The method enables the students to make useful observations and collect information, which cannot be obtained within the classroom. Experiences acquired during field trip are usually long lasting and cannot easily be forgotten by the students. Examples of areas where students can undertake field trip include brewery, industries, oil spillage sites, refinery, hospitals etc. A study of these phenomena will be more meaningful when students visit the affected sites than when discussed under the classroom setting (Nzewi et al 2009). Field trip is highly rewarding if it is well planned and executed. It affords the students the opportunity of observing, collecting, classifying and having an in-depth study of certain concepts and phenomena.

Advantages of Field Trip

1. Field trip provides the students with the opportunity of having first-hand knowledge of certain phenomena that occur in our environment.
2. It helps to generate and sustain students' interest in the subject.
3. With field trip, motivation to work is usually very high.
4. It aids retention of information since the experiences are long lasting.
5. Field trip can help students to develop interest in certain professions e.g. engineering, medicine etc.
6. It helps to channel student's experiences towards one direction.
7. Field trip helps students to understand man's relationship with his environment

Disadvantages of Field Trip

- (1) If it is not well planned, it becomes a waste of time and resources.
- (2) It is extremely tedious to carry out field trip especially when it involves long distance trip.
- (3) In some situations, accident may occur in the course of a field trip.
- (4) In most cases, field trip time encroaches into other lesson periods. This would likely result in conflict between the teachers involved if it is not properly handled.
- (5) Field trip results in extra financial expenditure on the part of the school and students.

Suggestion for the Effective Use of Field Trip

1. The chemistry teacher should first discuss the idea of taking students on a field trip with the school authority for approval.
2. Subsequently, she should write to the managing director (MD) if it involves an industry for permission to visit, time of the visit as

- well as the date of the visit. Finally request for any written rules guiding the place.
3. Before the trip the teacher should then discuss with the students concerning the trip, the aim of the visit, materials to take along ego pen, pencil, exercise book, ruler etc.
 4. Furthermore, the teacher should inform the students about the rules guiding the place, possible dangers, things to look out for as well as method of reporting their observations.
 5. The teacher should make sure that the field experience fits properly into the instructional sequence.
 6. The teacher should carry first aid kit along in case of any accidents involving students.
 7. Ensure adequate arrangement for transportation in the case of trips involving long distances.
 8. After the trip, examine the students on the specimens and information collected from the trip. This has to be in connection with the report of the trip in order to facilitate retention of the experiences from the trip.

Self-Assessment Exercises 20

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. The method of teaching characterised by Chalk-and-talk is calledmethod
2. Why is it important to provide a first aid kit while embarking on a field trip?
3. List three important components of the first aid kit/box.

2.3.3 Project Method

Projects are organised or planned activities in which students are allowed to investigate or research on their own. Project method can be used to individualise instruction or it can be used on a group of students. For example, five students, ten students or a whole class can be asked to execute a project. Projects usually are given for a period of time for instance 3 days, one week or even months. They may be carried out during or outside class work.

Teachers may assign project topics to the students while in some cases, students are allowed to choose any topic that might be consistent to their interest. Project method provides opportunities for greater understanding among students. It requires a bit of originality and creativity. It can be used by teachers to solve the problem of individual differences among students.

Some examples of project topics in Chemistry include:

- (1) Reading of Scientific Journals.
- (2) Production of Soap, Pomade, Sanitizer, Disinfectant etc

(3) Constructing/drawing the complete periodic table

Advantages of Project Method

1. Project method helps to solve the problem of individual differences since each student can carry out their own work at his/her own pace.
1. The emphasis on project is “doing” so students are given the opportunity to develop their initiative.
2. Motivation to work is usually very high since it is based on student’s interest particularly for students with special talents.
3. Group projects afford opportunities for developing leadership qualities.
4. Project helps students to have an in-depth study of the topic under investigation.

Disadvantages of Project Method

1. Project method is time consuming since it will surely be more than a day.
2. Project methods are mostly beneficial to students who have the potentials of independent work.
3. It is also very difficult to ascertain the extent to which a particular Student has gone with the work since they may invite other people to do the work for them.
4. It is difficult to get a topic that will interest all the students.

Suggestions for the Effective Use of Project Method

1. Provide students with the entire necessary guide that will help them carry out the project effectively.
2. Spread the project over a long period of time to enable them have an in-depth study of the topic.
3. Ensure that the purpose of the project fits properly into the instructional sequence.
4. Ensure that there is objectivity in marking and scoring of the project by developing a marking procedure.

2.3.4 Experimentation

Experimentation is a method of learning science concepts not through what the teacher told the students, but through what is involved in the process of investigation, carrying out experiments as well as other practical activities. Experimentation involves activity-oriented learning. In this case, the emphasis is on doing. Most times, the activities are carried out in the laboratory. A laboratory is a room or building set aside for scientific investigations. Experimentation is a means of acquiring science process skills such as observation, measuring, classifying objects or things, defining variable operationally, designing

experiments, interpreting data, hypothesising, predicting etc. Experiments in chemistry can be carried out by individual students or group of students working together. The latter is used when the equipment and materials needed for the experimentation cannot go round to individual students.

Experimentation is a means by which students acquire meaningful learning of science concepts to the point of achieving transfer and application of knowledge. Hence it exposes them to acquire attitudes and skills of a scientist. This method of teaching science has proved to be one of the most effective ways of learning (Nzewi, *et al.* 2009) The laboratory work involved in the process of experimentation can be broken down into different phases since it involves whole class activity.

Phase One -Pre-Laboratory Session, Phase Two -Laboratory Session, Phase Three -Post laboratory session

Phase One–Pre–Laboratory Session

For a teacher to carry out effective experimentation in the laboratory, careful planning and proper organisation are necessary. To this effect, he needs to assemble in advance all the equipment and materials for the exercise. Furthermore, he has to ensure that they are also in good working condition. Subsequently, the experiment is trial tested by carrying it out first to ensure that the chemicals to be used are still very active and the procedure carefully followed by the teacher. This pre-laboratory session is very important because it reduces errors which the teacher may have committed in the actual laboratory session. Also, the sitting arrangements of students are put into consideration as well as the time to spend in carrying out the investigation.

Phase Two–Laboratory Session

During the laboratory session, the teacher will first of all interact with the students by telling them what to do, the purpose of the experiment, the procedure to be followed in carrying out the investigation as well as safety measures to be taken to avoid incidence of accident. Thereafter, while students are now working with their equipment and materials, the teacher's duty is to be an overseer. He works round the class to make sure that all the students are following the procedure carefully. The teacher clarifies any doubt or problem arising from the students and by so doing gives them adequate encouragement and support in the learning process.

Phase Three–Post Laboratory Session

In this session, the teacher discusses the result of the investigation in order to clarify students who may be in doubt. He can assign marks to the work done by the students. The teacher can also summarise the

process as well as the result of the investigation in the form of backboard summary. Finally, students are allowed to clean up their tables and wash off equipment before leaving the laboratory. This is very important especially in cases where there is no laboratory assistant.

Advantages of Experimentation

1. Experimentation enables students to have direct sensory experience of scientific knowledge e.g. identification of ions or volumetric analysis, it enables the learner not only to acquire knowledge but also to appreciate chemistry in action.
2. Experimentation fosters opportunities for the acquisition of science process skills e.g. manipulation, measuring, classifying etc.
3. It helps in the retention of information as the students interact with the scientific process.
4. The uses of experiments help students to develop scientific attitude such as enquiry, curiosity, carefulness, objectivity, honesty etc.
5. Experimental works help to stimulate and sustain student's interest in science.
6. It aids students in problem solving and arriving at conclusions.
7. It helps to increase student's ability towards critical thinking and acquisition of better understanding of scientific knowledge.

Disadvantages of Experimentation

1. Experimentation is wasteful in terms of resources to be used in carrying out the investigation unlike demonstration.
2. It is also time consuming in carrying out a single experiment. What the teacher can say in five minutes may take one hour to investigate.
3. It also exposes the teacher's ignorance on those areas he is not competent enough to handle.
4. In experimentation, lack of background knowledge about the activities may make students to dislike the subject.

Suggestions for the Effective Use of Experimentation

1. Experiments should be based on students' background and availability of materials.
2. The teacher should ensure that the time frame for the experimentation will be such that students will be able to achieve results at the end of the time.
3. The language of instruction for any investigation should be very clear and within the child's chronological age.
4. The teacher should make sure that the equipment for students are in good working condition and enough materials are available for all the students.

Self-Assessment Exercises 21

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 4 minutes

1. List any two advantages of project method of teaching
2. Experimentation has three phases namely....., and
3. The topic “Effect of Chemical fertilizer on the yield of Maize” can be carried out by.....method.

(Lecture, Demonstration, Project, Inquiry)

2.3.5 Dramatisation

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.

Dramatisation 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.

2.3.6 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 through a better utilisation 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.

2.3.7 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 teacher creates a free and open classroom climate for the 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 learners can continue their search for the right answer through their performance of certain mental processes such as observation, identifying problems, exploration, measuring hypothesising, predicting, describing, conducting experiment, collecting data, organising and analysis data, reporting, and making generalisation.
- Probing can be in groups of four or six or in large groups depending on the teacher's choice, the class size, age and maturity of the learners
- Sift the information collected and remove those elements that are not relevant
- Ask more questions 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 such as 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 students in synthesising knowledge in form of generalisation or finding solution to problem.

Suggestions for the Effective Use of inquiry Method

1. Provide students with the entire necessary guide that will help them carry out the activity effectively.
2. Spread the project over a long period of time to enable them have an in-depth study of the topic.
3. Ensure that the purpose of the project fits properly into the instructional sequence.
4. Ensure that there is objectivity in marking and scoring of the project by developing a marking procedure.

Self-Assessment Exercises 22

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. enables the teachers to learn about the various maturity levels of the pupils in terms of their emotional, physical, intellectual and social development (Inquiry, Demonstration, Dramatisation, Discussion)
2. When two or more teachers jointly share the responsibility for directing and evaluating of the learning experiences of a common group of students, it is called (group teaching, team teaching, Focus teaching, Cooperative learning strategy)
3. Enumerate five (5) uses of inquiry method of teaching to the students

2.3.8 Demonstration

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;
- Visualise 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 pupils to observe natural 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.
- Demonstrations permit pupils to observe real 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;

Teacher demonstration tends to be too most convincing- professionally sophisticated apparatus adds a note of authority and makes results difficult to question.

Suggestions for the Effective Use of Demonstration

1. Before the lesson commences, the teacher should assemble in advance all the necessary materials and equipment to be used for the demonstration lesson.
2. The teacher should try out the demonstration first to ensure his competence and the workability of the equipment before carrying it out with the students.
3. Students sitting arrangement should be such that smaller ones in front and tall ones behind. This arrangement will enable all the students to observe the demonstration clearly.
4. The teacher's voice is also very important in demonstration; hence he needs to be audible especially in large classes.
5. Few students could be called upon to repeat the demonstration if time permits

6. At the end of the demonstration, the key points or the procedure should be written on the board for students in form of blackboard summary.

Self-Assessment Exercises 23

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. ----- 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.
2. Enumerate three suggestions for effective application of demonstration method in teaching chemistry.

2.4 Innovative Teaching Methods

In the traditional teaching methods, the teacher is mostly at the centre of the learning process. 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. https://www.researchgate.net/publication/350487211_Innovative_Methods_and_Practices_In_Conventional_Teaching_Methods

2.4.1 Cooperative 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 activities to improve the mastery of a topic or subject matter among the group members. Each group works as a team and strives to out-perform others. 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 organise 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

Self-Assessment Exercises 24

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. -----is an innovative teaching and learning approach in which small groups (about 3 to 5) of learners each, of different academic abilities (high, medium and low) use a variety of learning activities to improve the mastery of a topic / subject matter.
2. Mention three distinctive features of Cooperative Learning group, as against ordinary grouping of students in class.
3. Outline three possible disadvantages of working in a cooperative learning group.

2.4.2 Concept Mapping

A concept map is a diagram showing the relationship between concepts. It is a diagrammatic visualisation 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.

Advantages of Concept Mapping

1. Concept mapping helps students to achieve meaningful learning and make teachers to be highly effective in class instruction.

2. It helps them to highlight key concepts in any topic and link them sequentially.
3. Concept mapping helps to represent knowledge in form of a structure or map.
4. Concept mapping helps in understanding of the subject matter better by laying emphasis on the major concepts. (Nzewi *et al*, 2009)
5. Concept mapping makes the students to feel very comfortable and stabilise their emotional state.
6. It has been found to lower student's anxiety in science classrooms.
7. It can be used to teach any subject or any discipline.
8. Concept mapping creates opportunities for students to be highly creative in the learning situation by making new connections and patterns of knowledge structure.
9. Concept maps can be used to suggest further exploration while revealing the extent of knowledge of the individual.

Disadvantages of Concept Mapping

1. In construction of concept maps, previous knowledge of the individual about the topic affects his representation of the maps.
2. Every map reflects the extent of knowledge of the mapper.
3. No map is error free as the accuracy depends on the information available to the mapper.

Suggestions for the Effective Use of Concept Mapping

1. The class teacher should help students to highlight the key concepts of any topic.
2. Concept mapping should be used along with other strategies otherwise students may lose interest in the learning process.
3. Concept mapping should not be employed for students that are still in their lower classes because its application may be too difficult/complex for them.

Self-Assessment Exercises 25

Attempt the following reflective exercise before you move to the next section:

1. Estimated time of completion: 3 minutes
A diagrammatic visualisation/representation of relationships between concepts is called.....
2. Point out any two demerits of concept maps

2.4.3 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 Computer Assisted Learning (CAL). In each case, there must be a program being studied. CAI is directed towards developing a selective instruction based on individuality. 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 analyse, 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

Self-Assessment Exercises 26

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. The full meaning of the acronym CAI is -----
2. . List five advantages of CAI
3. Compared to cooperative learning strategy, one of the demerits of CAL is (enhancing team work, No inter-personal relationship,. promoted good neighbourliness, learning is anti-mechanical)

2.4.4 Focus Group Discussion

Focus group discussion is a tool used for collecting qualitative data or information from members of a group through discussions. Discussion in this case is aimed at eliciting insights and understanding from the group members. The focus group discussion helps in facilitating an organised discussion from members of a group. In focus group discussion, multiple meanings of certain words or concepts in science can be revealed by different groups. The discussion should be able to evolve new ideas or knowledge. Detailed information about a particular topic in science could be obtained through this method. It is also very important on studies that involve attitude and feelings of students. The information of the group can be based on different characteristics such as age, gender, race, ability, parental occupation etc. The members of the group should have a common background. In order words, they should be a homogenous group and also be very comfortable.

Usually, a group may comprise five to eight students. In the formation of the group, the teacher or moderator should ensure that the group of students for which the topic under discussion is meant for is used in order to elicit correct and proper information. (Nzewi *et al.* 2009)

In focus group discussion, the teacher occupies a key position in the discussion. The teacher directs the discussion without being part of it i.e. a facilitator of knowledge and not to dominate the discussion. A good teacher tries to keep the discussion on its track by asking series of open-ended questions. The teacher's guidance helps to acquire in-depth qualitative information concerning the student's feelings attitudes, interest and perceptions on the topic discussed. The teacher tries to encourage every student to participate in the discussion instead of allowing a few to dominate the Discussion or favouring a particular student.

During the discussion, the teacher may ask probing questions such as: “give us an example of what she is saying”, “can you tell us more about that”, “okay go ahead and explain” etc.

In a situation, where the students wander away from the objectives of the discussion, the teacher tries to return the conversation to the topic under discussion. The teacher also records every useful comment made by the group as well as individuals.

The role of the teachers is not only being highly demanding but also very challenging. The teacher must possess an attribute of a good listener, and non-judgmental in character. This will help the students to have open interactive dialogue about the topic under discussion. There are some guidelines that will help the teacher in conducting focus group discussion.

1. At Preparation Level

This involves taking record of all the things that will be used for the discussion, the number of students to be involved, venue for the discussion, developing discussion guide as well as the question to be asked which follow from general questions to specific questions, the amount of time to be used, choice of an appropriate equipment to be used, topic to be discussed which students will understand better, the objectives of the discussion, Benches and tables as well as a closed circuit television may be provided.

2. Members of the Group

This involves selection of the number of students to be involved and the size of each group. The size may range between five to eight students to enable them provide valuable information.

3. At Discussion Level

At this stage, the teacher introduces the topic to be discussed. The teacher moves round each group, standing at the back to watch their discussions. The questions placed on the Discussion table should be in line with the discussion. There may be closed circuit television that records all the activities taking place or the teacher takes notes. The discussion may last between one hour to one and half hours.

4. Moderating the Sessions

This is one of the most difficult tasks since inexperienced teachers may not be able to moderate the session effectively and it becomes a waste of time and resources. It requires having a listening ability to draw information from students.

In the process of moderating the session, the following should guide the teacher.

Keeps the information flowing- The teacher should have firm control of the discussion and allow a situation where students wander away from the topic of discussion. Every student should be given opportunity to express him or herself.

Period of Discussion - This should depend on the topic at hand as well as the objectives to be achieved.

Teacher Role - The teacher should allow students to do the discussion instead of dominating the discussion.

Post Discussion Session- The teacher talks to all the students. Mentioning the useful points of the discussion and using it to form summary of the lesson.

5. Analysis of the Discussion

At this stage, the teacher can review his notes of lesson and highlight key concepts and ideas in greater detail. This can also be accompanied with video tape if available. Ensure that the key points were discussed.

Advantages of Focus Group Discussion

1. Focus group discussion provides insight into what the student knows and those yet to know.
2. It can be used to ascertain student's needs, experiences and aspirations.
3. Students' views and ideas can be tackled with focus group discussion.
4. Helps to provide an in-depth knowledge of a topic which cannot be obtained from the teacher alone.

Disadvantages of Focus Group Discussion

- (1) The data or information generated may be difficult to analyse since it is not structured.
- (2) Few students who are extroverts may dominate the discussion.
- (3) The quality of the discussion depends greatly on the extent of teacher's competence in handling the issues raised in the discussion.
- (4) If the number of students in a group is too small, they may not actually contribute meaningfully in the discussion.
- (5) Although focus group discussion is a powerful strategy in teaching and learning, it may not be used as the only teaching method for students. It is time consuming.

Guidelines for the Effective Use of Focus Group Discussion

1. The teacher should bear in mind the level of the students, language level and their chronological age. This will help the teacher in designing the questions for discussion.
2. The general nature of the student is also important. Is the group homogenous or heterogeneous in their ability levels?
3. Focus group discussion requires highly experienced teachers in order to guide the discussions properly.
4. The size of the group should not be more than eight students. This enables all the students to participate in the discussion.
5. Create so many groups if the number of students in the class large.
6. The video, if any, should cover all comments made by the various groups.

SELF-ASSESSMENT EXERCISES 27

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. ----- is a tool used for collecting qualitative data or information from members of a group through discussions.
2. Focus Group Discussion is very important on studies that involve ----- of students/respondents. (calculations, attitude and feelings, quantitative data, symbols)
3. Enumerate for advantages of focus group discussion.



2.5 Summary

In this unit, we have discussed teaching methods pointing out their merits, demerits and suggestions for improvement of each method. It is expected that teachers need to have adequate knowledge of the different method of teaching. No method is superior to the other. Any method of instruction has its advantages and disadvantages. The situation in the classroom determines which methods is to be used by the teacher.

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.



2.6 References/Further Readings/Web Sources

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2.7 Possible Answers to Self-Assessment Exercise(s)

Answers to SAEs 20

1. Lecture
2. To inter vene in case of accident
3. Constituents of First Aid box: Scissors, Plaster, essential drugs, razor, bandage, ointment, hydrogen peroxide, Gentine violet (GV), Iodine solution etc.

Answers to SAEs 21

1. Advantages of project method:

1. Helps to solve the problem of individual differences since each student can carry out their own work at his/her own pace.
 2. Emphasis is on “doing” so students are given the opportunity to develop their initiative.
 3. Motivation to work is usually very high since it is based on student’s interest particularly for students with special talents.
 4. Group projects afford opportunities for developing leadership qualities.
 5. Project helps students to have an in-depth study of the topic under investigation.
2. Pre-laboratory phase, Laboratory phase and Post-laboratory phase.
 3. Project

Answers to SAEs 22

1. Dramatisation
2. Team teaching
3. Importance of Inquiry to learners:
 - Participate actively in the class
 - Practice and process certain scientific attitudes such as objectivity, curiosity, open mindedness and perseverance.
 - Engage in formulating problems for investigation
 - Engage in formulating hypothesis to guide investigation.
 - Engage in designing experiments to collect data.
 - Aid students in synthesising knowledge in form of generalisation or finding solution to a problem.

Answers to SAEs 23

1. Demonstration method.
2. Suggestions for effective use of demonstration method:
 - the teacher should assemble in advance all the necessary materials and equipment to be used for the demonstration lesson.

- The teacher should try out the demonstration first to ensure his competence and the workability of the equipment before carrying it out with the students.
- Students sitting arrangement should be such that smaller ones in front and tall ones behind. This arrangement will enable all the students to observe the demonstration clearly.
- Teacher needs to be audible especially in large classes.
- Students could be called upon to repeat the demonstration if time permits
- At the end of the demonstration, the key points or the procedure should be written on the board for students in form of blackboard summary.

Answers to SAEs 24

1. Cooperative Learning Strategy
2. Mixed ability grouping, mixed gender in coeducational situation, Assignment of roles to group members, intra group cooperation and inter-group competition, group score is the average of individual members scores on the exercise, minimal teacher interference.
3. A loquacious student may dominate group activity; A bright student may slide back in performance score due to average score for the group; Introverts may suffer unduly in the group work.

Answers to SAEs 25

1. **Concept maps**
2. **Demerits:**
 - In construction of concept maps, previous knowledge of the individual about the topic affects his representation of the maps.
 - Every map reflects the extent of knowledge of the mapper.
 - No map is error free as the accuracy depends on the information available to the mapper.

Answers to SAEs 26

1. **CAI= Computer Assisted Instruction**
2. **Merits of CAI**
 - One-to-one interaction
 - Great motivator
 - 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 guaranteed
- Learning more and more rapidly
- 3. Demerit of CAI= No inter-personal relationship.

Answers to SAEs 27

1. Focus group discussion
2. Attitude and feelings
3. Merits of FGD:
 - Focus group discussion provides insight into what the student knows and those yet to know.
 - It can be used to ascertain student's needs, experiences and aspirations.
 - Students' views and ideas can be tackled with focus group discussion.
 - Helps to provide an in-depth knowledge of a topic which cannot be obtained from the teacher alone.

UNIT 3 LESSON PLAN AND ITS PREPARATION

Unit Structure

- 3.1 Introduction
- 3.2 Intended Learning Outcomes
- 3.3 Requirements for Lesson Preparation
 - 3.3.1 Lesson Plan – Its Composition
 - 3.3.2 General Information
 - 3.3.3 Behavioural Objectives
 - 3.3.4 Instructional Materials
 - 3.3.5 Previous Knowledge
- 3.4 Introduction
 - 3.4.1 Presentation
 - 3.4.2 Evaluation
 - 3.4.3 Specimen Lesson Plans
 - 3.4.3.1 Prose Format
 - 3.4.3.2 Tabular Format
- 3.5 Summary
- 3.6 References/Further Readings/Web Resources
- 3.7 Possible Answers to Self-Assessment Exercise(s)



3.1 Introduction

Lesson Plan is a teaching guide which a teacher could easily refer to during teaching. A lesson is prepared in such a way that any other teacher in the same area of specialisation could make use of the plan if the 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 their notebook. <https://www.google.com/search?q=essentials+of+lesson+planning+in+science&oq=essentials+of+lesson+planning+in+science&qs=chrome..69i57j33i16013j33i22i29i3016.28402j0j7&sourceid=chrome&ie=UTF-8>



3.2 Intended Learning Outcomes

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.



3.3 Requirements for Lesson Preparation

The last stage of lesson preparation is lesson plan. When a teacher sets out 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. Teachers often 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. Besides, the varying abilities of students should be taken into consideration.

SELF-ASSESSMENT EXERCISE28

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

What are the three basic questions that guide a teacher's preparation for a lesson?

3.3.1 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, cannot teach the particular 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 Association 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 plan should contain the following:

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

3.3.2 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.

3.3.3 Behavioural Objectives

The objectives set out to be attained by the learners by the end of the lesson is referred 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' recognises 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 of a 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 to the learning outcome**. This is referred to as behavioural objective. 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.

Self-Assessment Exercises 29

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. Why is the lesson plan important to the teacher?
2. Why is it preferable to use tabular format of lesson plan
3. Justify the use of 'By the end of the lesson', instead of 'At the end of the lesson' in stating instructional objectives?

3.3.4 Instructional Materials

Instructional Materials are very important in teaching science subjects. This is because they help to concretise 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 concretise 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 utilisation of the material in course of lesson delivery.

3.3.55 Previous 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.

Self-Assessment Exercises 30

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. Mention one important feature of an instructional material
2. What do you mean by multi-sensory perception of concepts in the use of instructional materials?
3. Explain the term Entry behaviour or previous knowledge.

3.4 Introduction to Lesson presentation

A teacher could start by asking simple questions which are relevant; he could pose a problem to solve, present a short story 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.

3.4.1 Presentation 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** for the 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.

3.4.2 Evaluation

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).

Self-Assessment Exercises³¹

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. Identify three features of Set Induction
2. In lesson delivery, the stages of content development should be in harmony with the (instructional objectives, teaching aids, evaluation, entry behaviour)
3. At the stage of ----- the teacher determines the extent the stated instructional or behavioral objectives have been attained. (entry behaviour, set induction, evaluation, lesson presentation)

3.4.3 Specimen Lesson Plan:

3.4.3.1 PROSE FORMAT

Name of Student Teacher.....

Matriculation No: ...

Degree in view.....

Teaching practice 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

Conclusion (chalkboard summary)

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

Assignment: Read about electronic configuration of atoms.

3.4.3.2 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 explanations	Verbal communication
Names of First 20 Elements	Introduces a mnemonic for students to name and recall 1 st 20 Elements, thus: He: H: Hydrogen Has: He: Heium Large: Li: Lithium : : Poor: K: Potasium Career: Ca: Calcium	“He has large brain but cannot offer full nine subjects, many art students prove science courses as poor career” where the words stand respectively for elements: H, He, Li, Be, B, C, N, O, F, Ne, Na, Mg, Al, Si, P, S, Cl, Ar, K, Ca.	Verbalization; Problem solving
Component Parts of an Atoms	Three basic component parts are represented as PEN ie: proton, electron and neutron. Explain the features and locations of each component part	P=proton; positive E=electron; negative N=neutron; neutral	Demonstration
Structure of some named Atoms	Present Chart of some named atoms and their structures. Request some students to draw the structure of some named atoms.	-Observe the chart; -Note the explanations; -Respond to questions posed.	Problem solving

Evaluation:**Conclusion (Chalk board summary):****Assignment: (all as in Prose format)****3.5 Summary**

In this unit, we have been exposed to lesson preparation and presentation. It is known that lesson plan is a guide to the teacher. The preliminary features of a lesson plan are as important as the basic features. Care must be taken in preparing a lesson plan to ensure effective delivery by the teacher. Other teachers in the same area of specialisation should be able to use the lesson plan in the absence of the usual teacher.

The central focus of any teaching-learning encounter is the lesson plan. <https://www.google.com/search?q=essentials+of+lesson+planning+in+science&oq=essentials+of+lesson+planning+in+science&aqs=chrome..69i57j33i160l3j33i22i29i30l6.28402j0j7&sourceid=chrome&ie=UTF-8> 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.

**3.6 References/Further Readings/Web Sources**

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3.7 Possible Answers to Self-Assessment Exercise(s)

Answers to SAEs 28

1. Who is to be taught?
2. What is to be taught?
3. How is it to be taught?

Answers to SAEs 29

- 1.
2. **Tabular format is preferred because it emphasises on the activity of the learner.**
3. The use of 'By' instead of 'At' recognises individual differences in learning among learners (fast, moderate and slow) 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.

Answers to SAEs 30

1. It is topic-specific. Every instructional material should be intimately related to the topic being taught.
2. By multi-sensory perception we mean 'that which appeals to multiple senses. For instance, the use of an instructional material like chart appeal to the senses of sight, ear, feeling as we can see them, hear the explanations and touch or feel the object.
3. Entry behaviour or previous knowledge is the 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.

Answers to SAEs 31

1. **Features of set induction:**
 - Relevant to the topic
 - Stimulating to arouse the interest and curiosity of the learners.
 - Must be brief
2. Instructional Objectives
3. Evaluation

UNIT 4 EFFECTIVE TEACHING OF SCIENCE

Unit Structure

- 4.1 Introduction
- 4.2 Intended Learning Outcomes
- 4.3 Teachers in the Classroom
 - 4.3.1 Classroom Dynamic
 - 4.3.2 Classroom Discipline
- 4.4 Teachers Own Personality
 - 4.4.1 Cooperation
 - 4.4.2 Good Organisation
 - 4.4.3 Teacher's Technique for Proper Classroom Management
- 4.5 Summary
- 4.6 References/Further Readings/Web Resources
- 4.7 Possible Answers to Self-Assessment Exercise(s)



4.1 Introduction

Maintenance of discipline in the class is very necessary for effective teaching of chemistry. 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. https://www.google.com/search?q=essentials+of+effective+science+teaching+and+learning&ei=rwzBYvXdGcKLlwTyzbLQAg&oq=essentials+of+effective++science+teaching&gs_lcp=Cgdnd3Mtd2l6EAEYATIFCCEQoAEyBQghEKABMgoIIRAcEA8QF



4.2 Intended Learning Outcomes

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

- Communicate effectively to students in the classroom
- Demonstrate competence in handling disciplinary problems in the class
- Demonstrate how you can manage the class effectively.



4.3 Teacher in the Classroom

As earlier said, students are the teacher's audience. There are bound to be multifarious interaction 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-material 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 in the absence of the real apparatus. Children learn best from concrete objects. In providing 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 on a 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 loudly.

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.

A good teacher would have practiced the problem at home before bringing it to the class. Similar one could also be brought to the class by the students.

In concluding a lesson, the teacher should summarise 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 Exercises 32

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. The responses from students will show whether the ----- had been achieved or not.
2. Outline the three different interaction patterns in a science class

4.3.11 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 teacher's leadership, classroom morale, conduct and discipline.

4.3.2 Classroom Discipline

Most of the classroom rules are based on moral, personal, legal, safety and educational considerations. In the real sense of it, lists of rules should be minimal, relevant, meaningful and positive. The aim of good classroom discipline is to maintain an environment that will optimise. <https://www.boyd.k12.ky.us/userfiles/401/CHETL%20by%20Content/sciencehctl.pdf>

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.

Self-Assessment Exercises 33

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 2 minutes

1. Classroom climate needs to be for effective teaching and learning. (conducive, hot, hostile, dull)
2. Through sound -----, the teacher can maintain effective control of his class (punishment, clapping, preparation, smiling)

4.4 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 his anger, is likely to find class control difficult. A teacher who 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 teacher should be friendly with his pupils but not too familiar with them because the students would then not take him seriously.

4.4.1 Cooperation

Cooperation between teacher 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.

4.4.2 Good Organisation

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.

4.4.3 Teacher's Technique for Proper Classroom Management Simple, Clear Instructions

Provision of simple, clear instruction will minimise confusion and disturbances that could arise when students ask.

Order before Teaching or Making Announcements

It is not advisable to start teaching while students are 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 create a 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

Absolute silence is not possible unless they are writing examination. Noise may be 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 Exercises 34

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. A teacher who is authoritarian in his classroom is likely to kill the ----
-- of his pupils (discipline, friendship, Initiative, attention)
2. Classroom crisis should be effectively managed by the -----
(principal, headmaster, teacher, students)
3. Both weak and good students must be ----- (encouraged,
discouraged, punished, sidelined).



4.5 Summary

In this unit we have been exposed to classroom management techniques that would ensure effective learning. Teacher must have effective control of the lesson before he could be successful. There are basic guidelines that regulate asking of questions in the class. The teacher should be familiar with these principles for effective class control.

Teacher must know his job very well in order for him to deliver his job satisfactorily. He must strive very hard to achieve objectives for 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.

4.6 References/Further Readings/Web Resources

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4.7 Possible Answers to Self-Assessment Exercise(s)

Answers to SAEs 32

1. Objectives
2. **Student-Teacher, Student-Student and Student-Material interactions**

Answers to SAEs 33

1. **Conducive**
2. **Preparation**

Answers to SAEs 34

1. Initiative
2. Teacher.
3. **Encouraged**

UNIT 5 THE USE OF CHEMISTRY LABORATORY: LABORATORY ORGANISATION AND MANAGEMENT

Unit Structure

- 5.1 Introduction
- 5.2 Intended Intended Learning Outcomes
- 5.3 The Science Laboratory
 - 5.3.1 Laboratory Management
 - 5.3.2 Management of Laboratory Staff
 - 5.3.3 Laboratory Technicians/Attendants
 - 5.3.4 Management of Students
 - 5.3.5 Rules
 - 5.3.6 The Use of Poster
 - 5.3.7 Management of Materials
- 5.4 Nature of Chemicals
 - 5.4.1 Handling of Chemicals
 - 5.4.2 Apparatus
 - 5.4.3 Laboratory Book keeping
 - 5.4.4 Supervision
- 5.5 Summary
- 5.6 References/Further Readings/Web Resources
- 5.7 Possible Answers to Self-Assessment Exercise(s)



5.1 Introduction

In this unit, we shall be looking at the Chemistry laboratory in terms of the activities that go on there and the management of the human and material resources to ensure safety. Laboratory plays an important function in the teaching of chemistry. This is because practical exercises take are carried out in the laboratory. All areas of the curriculum are loaded with activities which are expected to be demonstrated by the teachers and students. 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.



5.2 Intended Learning Outcomes

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

- explain the meaning of laboratory
- explain how to store chemicals and equipment
- discuss how to manage both human and material resources in the laboratory successfully.



5.3 The Science Laboratory

The Science laboratory is that school building or block specifically designed to carry out experiments. Safety is the watch word, when setting up a science laboratory, hence it must be well cited 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 what the students are doing on their various desks. Normal laboratory 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.

https://www.google.com/search?q=chemistry+laboratory+organization+and+management&ei=jgPBYSWKFcCGxc8Pi9ud2AM&oq=chemistry+laboratory+organization+and+manage&gs_lcp=Cgdnd3Mtd2l6EAE

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. Acids or corrosive materials 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. Concrete are 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.

Self-assessment exercises 35:

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. -----is the watch word, when working in a science laboratory,
2. Normal chemistry laboratory must have at least ----- doors. (Two, Three, Four, Five)
3. The room where light experiments are carried out is called.....
4. The room used by the teacher to try out experiments before a demonstration or an actual laboratory session is called -----
5. All these are poisonous gases except(H_2S , HCl , NH_3 , Cl_2)

5.3.1 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 and those who have nothing doing should not be in the laboratory.

<https://conductscience.com/fundamentals-of-lab-management/#:~:text=The%20goal%20of%20lab%20management,and%20training%20new%20lab%20personnel.>

5.3.2 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.

5.3.3 Laboratory Technicians/Attendants

The primary duty of technicians is to maintain and repair damaged 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 diluted solutions from stock solutions, 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 Exercises 36

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. It is part of an efficient management technique for science teachers to hold regular science ----- with all those who work in the laboratory.
2. All these are laboratory personnel except..... (chemistry teacher, principal, laboratory attendant, chemistry students)
3. The primary duty of laboratory technicians is to ----- equipment. (maintain and repair damaged, procure, discard, take inventory of)

5.3.4 Management of Students

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

5.3.5 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. Working safely 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.

5.3.6 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 posters are aimed at drawing people's attention to unsafe practices in the 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'.

5.3.7 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.

Self-Assessment Exercises 37

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. One way of managing students in the laboratory is to develop laboratory..... that will ensure safety. (constitution, rules, edicts, legislation)

2. One important rule in the laboratory is..... (break and pay, pay before service, goods parked at owner's risk, no refund of goods after payment).
3. Outline three laboratory ground rules.

5.4 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.

5.4.1 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 labels 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 iodine can damage the skin, eyes respiratory system. H₂S paralysis olfactory organ Mercury vapors is a cumulative poison to all tissues, it is a mutagen. 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.

5.4.2 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 depends, above all on great care and a demonstration of responsible behaviour by those who use the laboratory.

Self-Assessment Exercises 38

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. All chemicals in the laboratory must be -----(stamped, sterilised, labelled, screened)
2. Poisonous reactions are carried out in the (darkroom, prep room, fume chamber, cupboard)
3. All barium salts are (poisonous, sweet, flammable, viscous)

5.4.3 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 equipment 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.

Stock/ Inventory book

S/No	Name of Item	Date of Receipt	Amount bought	Quantity of Materials	Name of Users

ii. Borrower's or Loan book: This is for keeping records of any item(s) loaned to another department, for instance Biology may 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.

Borrower's Record

S/No	Item Borrowed	Name of Borrower/ sign	Date borrowed	Date returned	Name of Lab. Asst. Present
------	---------------	---------------------------	---------------	---------------	----------------------------

- 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

Damages and Breakages Record

S/No	Item Broken	Name of Student	Date	Cause of Breakage	Name of Lab. Asst. Present
------	-------------	-----------------	------	-------------------	----------------------------

- 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.

Accident and First Aid Record Book

S/No	Name of Students	Cause of Accident	Place	Time	First Aid	Name of First aider
------	------------------	-------------------	-------	------	-----------	---------------------

5.4.4 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.

Self-Assessment Exercises 39

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. The record book for all items broken or damaged in the laboratory is called.....
2. A record book for all items supplied or purchased in the laboratory is called -----

3. The responsibility of laboratory safety rests solely on the (principal, teacher, students, security man)



5.5 Summary

In this unit we have learnt about the laboratory in terms of management of human and material resources. Again laboratory book keeping was discussed. The science laboratory is that school building or block specifically designed to carry out experiments. Staff students and materials are always in a dynamic interaction in the science laboratory. Chemicals must be handled carefully in the laboratory to ensure safety of human and material resources.

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.



5.6 References/Further Readings/Web Resources

Anaekwe, M.C. (2019). Maximising the use of Chemistry Laboratory for Effective Teaching and Learning. In Agwagah, U.V.N (ed.). *Science, Technology and Vocational Education*. Enugu: Godfrey Okoye University.

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

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

**5.7 Possible Answers to Self-Assessment Exercise(s)****Answers to SAEs 35**

1. Safety
2. Two
3. Dark room
4. Preparatory room
5. HCl

Answers to SAEs 36

1. Staff meetings
2. Principal
3. Maintain and repair damaged

Answers to SAEs 37

1. **Rules**
2. **Break and pay**
3. Lab Rules:
 - 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.
4. Keep the floor and the bench clean and dry always

Answers to SAEs 38

1. labelled
2. Fume chamber
3. poisonous

Answers to SAEs 39

1. Breakage or damage book
2. Inventory or stock book
3. Principal

GLOSSARY

Barrier a circumstance or obstacle that keeps people or things apart or prevents communication or progress.

Communication the imparting or exchanging of information by speaking, writing, or using some other medium.

Convention is a way in which something is usually done.

Effective means successful in producing a desired or intended result

Innovative (of a product, idea, etc.) featuring new methods; advanced and original (of a person) introducing new ideas; original and creative in thinking.

Laboratory refers to a room or building equipped for scientific experiments, research, or teaching, or for the manufacture of drugs or chemicals.

Lesson Plan is a teacher's daily guide for what students need to learn, how it will be taught, and how learning will be measured.

Management the process of dealing with or controlling things or people.

MODULE 3

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

UNIT 1 TEACHING SCIENCE IN THE FACE OF SCARCITY OF CHEMICALS/EQUIPMENT

Unit Structure

- 1.1 Introduction
- 1.2 Intended Learning Outcomes
- 1.3 Selecting Materials for Chemistry Teaching
 - 1.3.1 Improvisation in Teaching
 - 1.3.2 Assessing Improvisation
- 1.4 Summary
- 1.5 References/Further Readings/Web Resources
- 1.6 Possible Answers to Self-Assessment Exercise(s)



1.1 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 activities in the laboratory. In this case, teacher would need to have the knowledge of how to put alternative chemicals and equipment in places this is referred to as improvisation. In this unit we shall consider the meaning, importance, rationale and considerations for improvisation. You therefore, need to be attentive.



1.2 Intended Learning Outcomes

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.



1.3 Selecting materials for chemistry teaching

Instructional materials occupy a very important place in lesson delivery. Therefore, great care must be taken at the stage of planning the lesson to identify and select instructional materials that are appropriate for the lesson. It is at the lesson planning stage that equipment and the learning materials are selected. The course of the lesson depends on the material chosen. The teacher should not only specify the materials needed but also make arrangement to procure them before then. The choice of appropriate teaching aids depends on a number of factors including the topic, objectives, level of the learners in terms of age, class etc.

1.3.1 Improvisation in Teaching

The term improvisation refers to the process by which science equipment and materials are produced from locally available materials. <https://www.google.com/search?q=improvisation+in+science+teaching+and+learning&oq=improvisation+in+science+teaching&aqs=chrome.1.69i57j0i512j0i22i3014j0i39012.19183j1j7&sourceid=chrome&ie>

Improvisation is a child of necessity. This is because, it only arises when the industrially manufactured science equipment are nowhere to 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 frame work of limited resources available at 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 include:

- (i) It saves money
- (ii) It saves time of waiting indefinitely for ordered or imported materials and funds
- (iii) It encourages innovation and creativity in science teaching
- (iv) It creates opportunity for learners to participate fully in the construction and use of apparatus; and
- (v) It induces learner's interest and understanding of science 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 synthesised or manufactured equipment. 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. These will be discussed later.

Rationale for Improvisation in Teaching

The need for improvisation arises as a result of the following:(Nzewi *et al.*, 2009)

- (1) To achieve one of the main objectives of science education namely: to develop in the student's problems solving and manipulative skills, scientific attitudes, interests and appreciation.
- (2) To serve as alternative resources (materials and equipment) where they are not locally available.
- (3) Reduce cost where some of the equipment and materials are available locally.
- (4) To develop the creative and technical skills of teachers, students, local craftsmen, technicians and technologists.
- (4) Supplement the available resources to meet the demands of large student population.
- (5) Conserving foreign exchange through promotion of utilisation of local resources.

Self-Assessment Exercises 39

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. The process by which science equipment and materials are produced from locally available materials is called -----
2. The choice of appropriate instructional material for a lesson should be made at the stage of -----(Lesson Delivery, Lesson Evaluation, Lesson Preparation, Entry Behaviour)
3. Itemize three rationales for improvisation

1. 3.2 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/principle does the devise seek to 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?

When do you improvise?

The chemistry teacher needs to improvise when:

- (1) Resources (materials and equipment) are scarce and can be substituted with local ones.
- (2) The available materials or equipment are unaffordable due to high cost and the improvise one can serve the same purpose.
- (3) There is need to promote technological transfer through encouraging creativity using environmental resources.
- (4) There is an urgent need to replace damaged equipment in order to continue class activities.
- (5) Teaching becomes ineffective and boring due to lack of materials and equipment.

The two aspects of improvisation are:

Import substitution

A critical look at what obtains in our laboratories at the secondary and tertiary levels of Nigerian education system reveals that a greater percentage of the materials and equipment selected are imported from overseas countries. Purchases are usually made after going through asset catalogues through which they are advertised. Typical of these media of advertisement is the fact that there is no direction as to its use and adaptability to local climate and conditions. The result is that most of these equipment are left unused, misused, damaged or simply left to accumulate dust. Even when the equipment are put to use lack of proper 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.

Improvisation as Activity-Oriented Approach to Science Teaching

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 the powers and 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 science 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, starting 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 will compete favorably with imported and industrially manufactured ones. According to Balogun (1982) history of science has revealed several incidents of producing locally made apparatus from local raw materials.

Self-Assessment Exercises 40

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. Two aspects of improvisation are -----and -----
2. Adduce three reasons why a chemistry teacher should improvise.
3. Describe how you can proceed with a chemistry practical class, if you are faced with the lack of the followings:
 - i. beakers
 - ii. Filter paper
 - iii. test tube holders
 - iv. stirring rods
 - v. No gas for use in bunsen burner



1.4 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.

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.



1.5 References/Further Readings/Web Resources

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

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



1.6 Possible Answers to Self-Assessment Exercise(s)

Answers to SAEs 39

1. **Improvisation**
2. **Lesson preparation**
3. **Rationale:**
 - i. To develop in the student's problems solving and manipulative skills, scientific attitudes, interests and appreciation.
 - ii. To serve as alternative resources (materials and equipment) where they are not locally available.
 - iii. Reduce cost where some of the equipment and materials are available locally.
 - iv. To develop the creative and technical skills of teachers, students, local craftsmen, technicians and technologists.
 - v. Supplement the available resources to meet the demands of large student population.

Answers to SAEs 40

1. **Substitution and activity-oriented improvisation**
2. **Reasons why we improvise:**
 - i. When resources (materials and equipment) are scarce and can be substituted with local ones.
 - ii. The available materials or equipment are not affordable and the improvised one can serve the same purpose.
 - iii. There is need to promote technological transfer through encouraging creativity using environmental resources.
 - iv. There is an urgent need to replace damaged equipment in order to continue class activities.
 - v. Teaching becomes ineffective and boring due to lack of materials and equipment.
3. **Improvised materials**
 - Beakers --cut off and use bottom end of plastic bottle water
 - Filter paper---cut off and use plain white paper
 - Test tube holders -----fold strips of paper
 - Stirring rods ---remove ink nib and use biro pen
 - No gas for use in Bunsen burner-- use kerosine in stove

UNIT 2 THE LANGUAGE OF SCIENCE AND SCIENCE TEACHING

Unit Structure

- 2.1 Introduction
- 2.2 Intended Learning Outcomes
- 2.3 The Language of Science and Science Teaching
 - 2.3.1 Written Materials
 - 2.3.2 The Learning Situation
 - 2.3.3 Science/ Chemistry Textbook
- 2.4 Summary
- 2.5 References/Further Readings/Web Resources
- 2.6 Possible Answers to Self-Assessment Exercise(s)



2.1 Introduction

In the last unit, we studied how to handle situations in which there are insufficient or outright lack of standard instructional material for teaching a science topic - concept of improvisation. In this unit, we shall consider the language of science teaching as well as science/chemistry textbooks. 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. He/she also has the responsibility of recommending appropriate textbooks in the discipline.



2.2 Intended Learning Outcomes

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.



2.3 The Language of Science and Science Teaching

The system of explanations referred to in the preceding 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 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, sees him as a foreigner with a strange language. The problem recognises the pedagogical 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; recognises that science contains a lot of abstract terms which refer to things, to events quite remote to direct sensations; be acquainted with role of language in thinking and 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 exhibited during a lesson can affect learning; be acquainted with interactions strategies and so on.
<https://www.google.com/search?q=language+of+science+and+science+teaching+and+learning&oq=la&aqs=chrome.69i59l3j69i57j46i512j69i6112j69i60.11342j0j7&sourceid=chrome&ie=>

2.3.1 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 rely on the textbooks to shape their 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 centralised examination and where teacher have not learned to explore their immediate environment in the teaching of science. In spite of recent efforts to write simpler reading materials especially for students, it must still be recognised that the communication 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

SELF-ASSESSMENT EXERCISES 41

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1 language of instruction serves the following useful purposes except.....

- Assists in thinking and learning processes
- useful in questioning
- as a means of soliciting information and/or appraising students’ understanding of what is taught
- distracting the teacher in the class

2. Most teachers abuse the use of science textbooks by

- Copying materials verbatim from their books
- encouraging students to make their notes,
- do assignments at home,
- carry out projects in science

2.3.2 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 learning materials and of course, the objective(s) to be achieved. Let us see how those cluster are related.

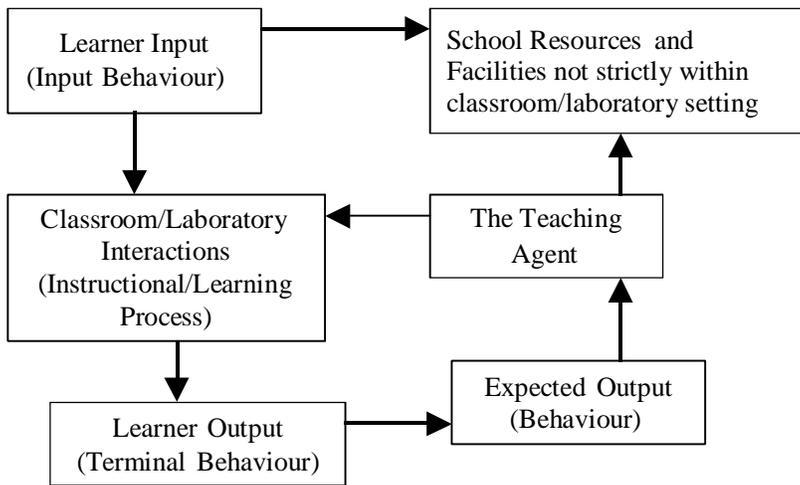


Fig.2.1: A Paradigm of classroom Interactions

In figure 2.1, the learner interacts with the teacher and learning materials and the result of these interactions is the behavioral outputs of the learner. This is why learning is sometimes 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 realising that a student has not been able to demonstrate an expected behaviour might organise 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.

Diagnosis is the process of determining the status of a learner's or learners' 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 achievement deficit a highly intensive individualised attention (Otto, *et al.* 1973). The teaching-learning-material interactions form the context under which learning takes place. Hence, the learning strategies in science must be related to the structures and conditions existing within the context of classroom or laboratory interactions. Good planning is therefore indispensable for successful learning of science. This may not be readily apparent when one is observing class room interactions between an experienced science teacher and mature students. But as the lesson progresses, it becomes obvious that learning is taking place in a rational and well-organised 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, value system, belief, the conditions under which he is taught; the teaching methods; the audio-visual and learning materials used, etc. are all critical to the learning process. In the light of these factors, psychologist have developed various learning theories. Let us consider some of them.

Self-Assessment Exercise 42

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. All but one of these variables is essential in the context of learning science.....

- the teacher or the teaching agent,
- the learning materials

- the culture of the people
 - the objective(s) to be achieved
3. The process of determining the status of a learner's or learners' readiness and the course of action taken by the teacher afterwards is referred to as.....teaching strategy.
- Diagnostic
 - stimulus-response
 - prescriptive
 - diagnostic-prescriptive.

2.3.3 Science/Chemistry Textbooks

A 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 characterise scientific investigations-honesty, perseverance, skepticism etc.

Importance In science teaching and learning, the importance of the text-book cannot be over-emphasised. 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 towards different 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

utilising scientific knowledge in solving human problems in everyday life.

Self-Assessment Exercises 43

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. A science textbook serves the following useful purposes except

- Enables a science teacher to make effective preparation for his lesson.
- Serves as repository of scientific information and knowledge
- Contains diagrams for entertainment
- contains practical activities which guides the development of science process skills

2. A good science text-book should enable the teacher to motivate the learners towards different career prospects in science as well as the academic and personality attributes needed for such careers

- Strongly agree
- Disagree
- Strongly disagree
- Not sure

Qualities of a good science text-book. Quality of a book is very essential.

[https://www.google.com/search?q=qualities+of+good+science+textbooks&ei=OhHBYqOmMIXylwTK_YGIDg&ved=0ahUKEwjq53J59v4AhUF-YUKHcp-](https://www.google.com/search?q=qualities+of+good+science+textbooks&ei=OhHBYqOmMIXylwTK_YGIDg&ved=0ahUKEwjq53J59v4AhUF-YUKHcp-AOEQ4dUDCA4&oq=qualities+of+good+science+textb)

[AOEQ4dUDCA4&oq=qualities+of+good+science+textb](https://www.google.com/search?q=qualities+of+good+science+textbooks&ei=OhHBYqOmMIXylwTK_YGIDg&ved=0ahUKEwjq53J59v4AhUF-YUKHcp-AOEQ4dUDCA4&oq=qualities+of+good+science+textb)

- 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-matter treatment 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.
 - i. **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.
 - ii. **Illustrations:** In the treatment of the subject-matter, proper illustrations including numerical spatial, graphical, diagrammatic examples should be used where necessary.
 - iii. **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.
 - iv. **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.
 - v. **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.
 - vi. **Legibility of the Print:** The printing should be legible and appetising to read.
 - vii. **Quality of Print and Paper:** The quality of print and paper used should be attractive.
 - viii. **Quality of Binding:** The quality of binding the text-book should be such as to be durable.
 - ix. Must have International Standard Book Number -ISBN. For journals, it must have ISSN- International Standard Serials Number

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 EXERCISES 44

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. List five essential qualities required in evaluating science textbooks
2. Give the full meaning of ISBN and ISSN

2.4 Summary

In this unit you have learn:

The teacher must interpret the language to the students' advantage
Learning is defined as permanent behavioral changes.

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. A knowledge of the learning situation of the learner is very important. Teachers need to interpret the learning situation and make it conducive to the learner. Textbooks of appropriate qualities need to be recommended to the learners.

2.5 References/Further Readings/Web Resources

Anaekwe, M.C. (2019). Maximising *The Use of Chemistry Laboratory for Effective Teaching and Learning*. In Agwagah, U.V.N (Ed). Science, Technology and Vocational Education. Enugu: Godfrey Okoye University.

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Stallberg, R. (1955). Science Demonstrations for improved Learning *Science Teacher*, Nov. 277-279.

Victory, E. and Learner, M.S. *Readings in Science Education for the Elementary School*. New York: Macmillan Pub. Co.



4.8 Possible Answers to Self-Assessment Exercise(s)

Answers to SAEs 41

1. Distracting the teacher in the class
2. Copying materials verbatim from their books

Answers to SAEs 42

1. The culture of the people
2. Stimulus-response

Answers to SAEs 43

1. Contains diagrams for entertainment
2. Strongly agree

Answers to SAEs 44

1. Qualities

- Authorship
- Clarity of Language
- Affordability
- Diagram/Sketches/Illustrations
- Use of Examples from the local Environment
- Gender balance in presentations and illustrations
- Comprehensiveness of subject matter
- Appropriateness to the level of the learner

2. ISBN= International Standard Book Number

ISSN= International Standard Serials Number

UNIT 3 LEARNING THEORIES

Unit Structure

- 3.1 Introduction
- 3.2 Intended Learning Outcomes
- 3.3 Robert M. Gagne-Learning Hierarchies
 - 3.3.1 Jerome S. Bruner – Learning by Discovery
 - 3.3.2 David P. Ausubel – Meaningful Verbal Learning
- 3.4 Summary
- 3.5 References/Further Readings/Web Resources
- 3.6 Exercise(s) Possible Answers to Self-Assessment



3.1 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.

<https://www.google.com/search?q=educational+learning+theories&oq=educational+learning+theories&aqs=chrome..69i57j0i51216j69i60.20421j1j7&sourceid=chrome&ie=UTF-8>



3.2 Intended Learning Outcomes

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

- Explain learning theories
- Discuss the importance of learning theories in a teaching learning process
- Explain the learning theories of Gagne and Ausubel.



3.3 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 capability he maintains must be stated specifically and behaviourally. He defines capability as the ability to do what one was originally unable to do before a learning situation; i.e. the ability to perform certain specific tasks under specific situation. 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 of prerequisite intellectual 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.

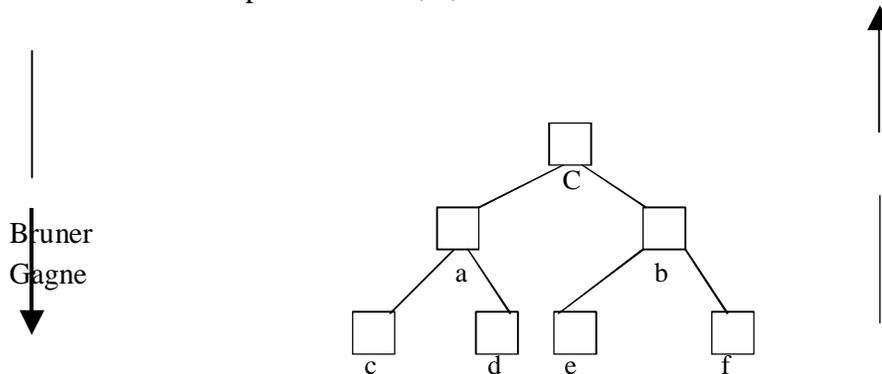


Fig.3.1: Pyramid of Learning

Self-Assessment Exercises 45

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. The learning theory which stipulates that the learning of a concept or skill depends upon the mastery of prerequisite concepts or skills was propounded by-----.
2. Gagne begins with the task analysis of the instructional objectives as bases for the -----(prerequisite concepts, instructional materials, presentation, evaluation)
3. According to Gagne's structure, the desired concept is located at the position of the pyramid while, the prerequisite concepts are located at the position.

3.1 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 contradictions among sources of information of relatively equal status; or

The quest for structure or symmetry in situations where such order is 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 may require an internal re-organisation or “cognitive restructuring” of previously known ideas in order to accommodate the new experience. To Bruner, the essence of discovery is something, which takes place within 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 his ideas from Piaget’s theory of cognitive development, Bruner contends that a child moves through three successive stages 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 synthesised this theory with the Socratic notion of learning as an internal re-organisation into what is now known as learning-by-discovery approach. To Bruner, learning by discovery in 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 equilibria until the desired cognitive state is reached or discovered. Although the same diagram of learning hierarchies (Fig. 3.1) is appropriate for Bruner, the direction of the arrow is in the opposite of Gagne’s. For Bruner, learning by discovery begins with problem solving: a process analogous to teaching someone to swim by throwing him into a deep pool of water. The assumption is that he will learn the necessary skills because he 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 starts with the complex and learns the simple mechanisms in the context of working with the complex (Shulman, 1968).

Self-Assessment Exercises 46

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. The learning theory by process of discovery was propounded by
2. According to Bruner, learning by discovery begins with (creating problem, problem solving, assimilation, accommodation)
3. By the analogy of throwing someone who is learning to swim into a deep pool of water, the concept ----- can be understood (stimulus and response, learning by discovery, learning by reinforcement, learning by withdrawal)

3.3.2 David P. Ausubel – Meaningful Verbal Learning

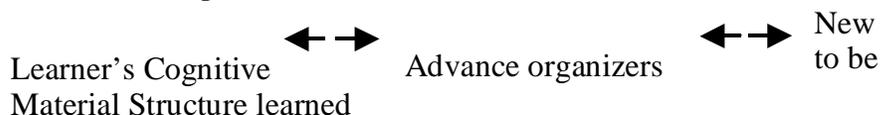
Ausubel, like Gagne, emphasises the essence of systematically guided exposition in the teaching-learning process. The key is the careful sequencing of experiences so that any unit taught is related to previous experiences. It is the continuity or ratability between the learners existing cognitive structure 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.

Unlike Bruner, Ausubel does not see any justifiable reason for introducing a learner to a problem-solving situation before he has internalised the new learning material. If the material can be meaningfully organised 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. organised knowledge), which provides the necessary interactions necessary for meaningful meaning, are called "subsumers". Ausubel defines a subsumer as a generalised 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 organisers".

Ausubel begins the instructional sequence with a set of broad but comprehensive statements at a higher level of abstraction to what is to be learned. He calls such statements "advance organisers." These organising statements are learned already; i.e. his cognitive structure.

This can be represented thus:



Thus, advance organisers are useful alternatives to subsumers. 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 organiser) they can be led 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 in terms of embedding specific into the already assimilated context of complex generalisation. Gagne's assertion in recent years that learning of processes and skills is more important and more fundamental than that of context mastery and Ausubel's theory of meaningful verbal learning has made the two positions far distinctive. 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's subsumption theory or meaningful verbal learning as a graphic and terse description of how an organised body of knowledge can best be acquired (Shulman and Tamir, 1973).

Self-Assessment Exercises 47

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. Ausubel defines a as a generalised body of knowledge possessed by the learner for anchoring new knowledge
2. The theory of advance organisers or subsumption theory was propounded by.....
3. Ausubel's theory is supported by all these educational principles except that 'meaningful learning occurs from -----(simple to complex, concrete to abstract, known to unknown, difficult to simple)



3.4 Summary

In this unit, you have been exposed to the learning theories by Gagne, Bruner and Ausubel. Specifically, we have been made to understand according to Gagne's theory that the learning of a concept or skill depends upon the mastery of prerequisite concepts. According to Bruner, learning by discovery in which an "old" knowledge gives way to the new one is consistent with the nature of science. Ausubel's theory emphasises systematically guided exposition in the teaching learning process.

The central focus of learning theories are that learning follows a particular sequence. This is to say that in learning concepts, there are particular steps or sequence of arrangements, which have to be followed in order to learn the whole concepts. Of great importance to this unit are the learning theories as was propounded by Gagne, Bruner and Ausubel.



3.5 References/Further Readings/Web Resources

- Akpan, B.B. (2015). The Place of Science Education in Nigeria for Global Competitiveness. *Journal of Science Teachers Association of Nigeria*. 50(1), 1-23.
- Ndirika, M. C. (2018). Pedagogy Issues in Science and Technology Education: Towards Equipping Biology Students for Challenges of 21st Century. In Njoku, Z.C, Nzewi, U.M & Nnaka, C.V.(eds.). *Perspectives on Science and Technology Education in Nigeria*. Nsukka: Great AP Express Publishers.
- Ogunniyi, M.B. (1986). *Teaching Science in Africa*. Ibadan: Salem Media (Nig.) Ltd.
- Popper, K. (1959). *The Logic of Scientific Discovery*. London: Hutchinson and Company.
- Jibrin, A.T. & Amina, D.S. (2019). Investigation into the Level of Compliance to Ethical Issues in Science Education Among University Lecturers in Nasarawa State University, Keffi. 3(1), 65-71.

**3.6 Possible Answers to Self-Assessment Exercise(s)****Answers to SAEs 45**

1. Gagne
2. prerequisite concepts
3. top/upper, bottom/lower

Answers to SAEs 46

1. **Jerome S. Bruner**
2. problem solving
3. learning by discovery

Answers to SAEs 47

1. subsumer
2. **David P. Ausubel**
3. difficult to simple

UNIT 4 **PIAGET’S THEORY AND APPLICATION OF LEARNING THEORIES TO SCIENCE TEACHING**

Unit Structure

- 4.1 Introduction
- 4.2 Intended Learning Outcomes
- 4.3 Jean Piaget – Theory of Intellectual Development
- 4.4 Summary
- 4.5 References/Further Readings/Web Resources
- 4.6 Possible Answers to Self-Assessment Exercise(s)



4.1 Introduction

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



4.2 Intended Learning Outcomes

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’.



4.3 Jean Piaget – Theory of Intellectual Development

The emphasis of this theory is that learning ability corresponds 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).

In this book we shall be concerned 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

Application of learning theories is very essential. <https://www.phoenix.edu/blog/educational-learning-theories.html>

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, the learner is actively involved in the learning process, 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, generalisations, 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 some discovery through the process of what we earlier 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 with concrete materials before they are asked to learn abstract concepts and generalisation. Before learners can deal meaningfully with numbers and computations, they must comprehend what numbers mean.

They must understand symbols before the manipulation of such symbols. Since most of the pupils at the primary and the lower secondary school are still at the concrete operational stage. Piaget would recommend the use of real materials or models in dealing with theoretical concepts and generalisations. From experience, we know that many of the pupils at the upper secondary school level have not

completely outgrown the need for concrete referents in their study of science. In reality, even adults 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 our 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 of learning which at the moment are mainly descriptive will develop to the explanatory and predictive stages reminiscent of the theories of science, when theories of knowledge and pedagogy become more comprehensible than they are now.

Self-Assessment Exercises 48

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. Specify Piaget's four stages of mental development with their corresponding age ranges
2. The learner gains new experiences through his interaction with things in his/her
3. Specify the application of learning theories of Gagne, Bruner, Ausubel and Piaget in chemistry teaching and learning.

Teaching Science According to Fundamental Structures or Big Ideas

As a basic issue of which all learning psychologists are agreed, as the importance of structuring the context of science for effective learning. https://www.ea.gr/ea/myfiles/File/publications/04_The%20Big%20Ideas%20of%20Science%20for%20the%20school%20classroom.pdf 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 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 conceptualise the dynamic nature of science in terms of constant interplay between the product and process of science.

A number of science and mathematics 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 generalisations which hopefully can be organised into a sound learning sequence from simple to complex (Akpan, 2015).

It should be realised, however, that mastery of the “big ideas” of a given field involves more than the mere acquisition of the facts, concepts and generalisations; it also includes the development of desirable manipulative skills and attitudes necessary for solving problems that may emerge. <https://www.youtube.com/watch?v=vTOOP9E9D2w>

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 a brief history relating to discovery of the subject in 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 he remembers the critical or regenerative 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 able to say whether the animal is a vertebrate or invertebrate; whether a plant is an angiosperm or gymnosperm; whether a chemical is

an acid or 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. $\sqrt{\frac{r}{d}}$ where r and d denote rate of diffusion and density of a given gas respectively.

According to Bruner (1960) what understanding 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.

Self-Assessment Exercises 49

Attempt the following reflective exercise before you move to the next section:

Estimated time of completion: 3 minutes

1. Outline any three different ways of making the teaching of chemistry concepts interesting to learners
2. The understanding of 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.



4.4 Summary

In this unit, you have been exposed to the fact that learning ability corresponds to levels of cognitive development as propounded by piaget’s theory of mental development. Learning theories could be applied to the teaching of science. Structuring the content of science into big ideas is important to science teaching and learning.

A teacher should have in-depth 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.

4.5 References/Further Readings/Web Resources

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4.6 Possible Answers to Self-Assessment Exercise(s)

Answers to SAEs48

1. Piaget specified four stages as: sensori 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) and Formal operational stage (from about 12 years upwards).

2. Environment/surrounding

3. Application of

Gagne= instructional programme should be carefully guided in a step wise manner from simple to complex until the desired objective is achieved. The appropriate sequence in learning is, that one begins with simple prerequisites and works up, pyramid-wise, to the complex capability to be attained.

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 some discovery through the process of what we earlier referred “cognitive restructuring.”

To Ausubel, learning by discovery is time wasting and inefficient. For Ausubel, those parts of the learner’s cognitive structure (i.e. organised knowledge), which provides the necessary interactions necessary for meaningful meaning, are called “subsumers”. Ausubel defines a subsumer as a generalised 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 organisers”.

For Piaget, learners should deal with concrete materials before they are asked to learn abstract concepts and generalisation. Before learners can deal meaningfully with numbers and computations, they must comprehend what numbers mean.

Answers to SAEs 49**1. Making the teaching of concepts in chemistry interesting**

- i. Asking thought provoking questions;
 - ii. Telling a short story;
 - iii. Giving a brief history relating to discovery of the subject in questions;
 - iv. Performing a short demonstration, etc.
 - v. using local and familiar examples
 - vi. Pointing out the rationale/justification for teaching the topic/concept
2. “big”ideas”

Glossary

Chemical relating to chemistry or the interactions of substances as studied in chemistry.

Equipment the necessary items for a particular purpose

Improvise the art or act of improvising, or of composing, uttering, executing, or arranging anything without previous preparation

Learning the acquisition of knowledge or skills through study, experience, or being taught.

Scarcity the state of being scarce or in short supply; shortage

Teaching is the process of attending to people's needs, experiences and feelings, and making specific interventions to help them learn

Textbook a book that contains detailed information about a subject for people who are studying that

Theory a supposition or a system of ideas intended to explain something, especially one based on general principles independent of the thing to be explained.