NATIONAL OPEN UNVERSITY OF NIGERIA

SCHOOL OF EDUCATION

COURSE CODE: EDU 756

COURSE TITLE: SUBJECT METHODS II (PHYSICS)

COURSE GUIDE

EDU 756
SUBJECT METHODS II (PHYSICS)

Course Developer — Dr. Femi A. Adeoye
School of Education,
National Open University of Nigeria
Lagos

Unit Writers — Dr. Augustine, U. Okoronka
Kings College,
Lagos.

Dr. Femi A. Adeoye
School of Education,
National Open University of Nigeria
Lagos

Course Editor — Dr. Apata Funke Susan
School of Science and Technology
NOUN
Victoria Island
Lagos

Programme Leader — Dr. Timothy James
School of Education,
National Open University of Nigeria,
Lagos.

Course Coordinator — Dr. Apata Funke Susan
School of Education,
National Open University of Nigeria
Lagos

Course Reviewer — **Dr. Apata Funke Susan**
School of Education,
National Open University of Nigeria
Lagos

NATIONAL OPEN UNIVERSITY OF NIGERIA

National Open University of Nigeria
Headquarters
14/16 Ahmadu Bello Way
Victoria Island
Lagos

Abuja Annex
245 Samuel Adesujo Ademulegun Street
Central Business District
Opposite Arewa Suites
Abuja

e-mail: centralinfo@nou.edu.ng
URL: www.nou.edu.ng

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Introduction

This Course Guide tells you briefly what the course is about, what course materials you will be using and how you can work your way through these materials. It suggests some general guidelines for the amount of time you are likely to spend on each unit of the course in order to complete it successfully. It also gives you some guidance on your tutor – marked assignments. Details of information on tutor – marked assignments is found in the separate Assignment File, which will be available to you.

What You Will Learn In This Course

This course is to bring to consciousness of those to be involved in physics teaching at senior secondary level. So the overall aim of EDU 756 (Science Methods II) physics is to introduce you to some of the rudiments of physics teaching. You will as well learn about the meaning
of science, historical development of science education in Nigeria and the nature of science; science education curriculum reforms at both primary and secondary school levels and psychological theories of learning and its implications for science teaching.

Course Aims

The aim of this course is to prepare you towards teaching physics at senior secondary level. This will be achieved by aiming to:

* introduce you to meaning of science and historical development of science education in Nigeria
* help you appreciate the nature of science
* outline all the science education curriculum reforms both in Nigeria and outside Nigeria.
* examine the contributions of some cognitive psychologists like David Ausubel, Jerome Brunner, Robert Gagne and Jean Piaget to enhance our knowledge of the nature of science teaching
* deal with the basic methods and techniques of teaching physics.

Course Objectives

To achieve the aims set above, the course sets overall objective. In addition, each unit has specific objectives included at the beginning of a unit. You may want to refer to them during and after you might have completed a unit to check on your progress.

Set out below is wider objectives of the course as a whole. By meeting these objectives, you should have achieved the aims of the course as a whole.

On successful completion of the course, you should be able to:

1. explain the meaning of science
2. define science
3. discuss the history of science
4. trace the historical development of science education in Nigeria from missionaries to colonial government and to post independence period
5. give reasons why science should be taught in schools
6. explain the nature of science
7. advance reasons for science education curriculum reforms in both Nigeria and outside Nigeria.
8. discuss the contributions of some cognitive psychologists such as Ausubel, Brunner, Gagne and Piaget to science teaching and their implication for science teaching
9. outline the methods of teaching physics
10. describe the various resources for teaching physics
11. prepare a scheme of work, lesson plan and lesson note for teaching physics at the senior secondary classes.

12. describe the design and organisation of physics laboratory
13. outline the safety and management procedure in physics laboratory
14. develop test items for multiple choice, essay and practical physics.

Working through the Course

To complete this course, you are required to read each study unit of this study material and read other materials, which may be provided by the National Open University of Nigeria. Each unit contains self-assessment exercises for this course and at certain points in the course you would be required to submit tutor-marked assignments for assessment purposes. At the end of the course, there is a final examination. The course should take you about a total of 17 weeks to complete. 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 to complete the course on time and successfully.

I would advice that you avail yourself the opportunity of attending the tutorial sessions where you will have the opportunity of comparing knowledge with your peers.

The Course Materials

Major components of the course are:

(1) The Course Guide
(2) Study Units
(3) References
(4) Assignments
(5) Presentation Schedule.

Study Units

There are fourteen study units listed under three modules in this course. They are as follows:

Module 1

The meaning of science, historical development of science education in Nigeria and the nature of science

Unit 1 The meaning and history of science
Unit 2 Historical development of science education in Nigeria I

Unit 3 Historical development of science education in Nigeria II
Unit 4 Justification for teaching science
Unit 5 Nature of science

Module 2

Science education curriculum reforms and how students learn science

Unit 1 Science education curriculum reforms in Nigeria I
Unit 2 Science education curriculum reforms in Nigeria II
Unit 3 Psychological theories of learning and their implications for science teaching I
Unit 4 Psychological theories of learning and their implications for science teaching II

Module 3

Methods and techniques of teaching physics

Unit 1 Methods of teaching physics
Unit 2 Resources for teaching physics
Unit 3 Preparation for teaching physics
Unit 4 Evaluation of science teaching and learning with reference to physics

Each unit consists of table of content, introduction, statement of objectives, contents, conclusion, summary, tutor marked assignment and references; There are activities written at every point these activities will assist you in achieving the stated objectives of the individual units and of the course.

Presentation Schedule

Your course materials will give you important dates for the early and timely completion and submission of your TMAs and for attending tutorials. You should remember that you are required to submit all your assignments by the stipulated time and date. You should guard against lagging behind in your work.

Assignment File

There are fourteen assignments in this course. That is one assignment per units. These are designed to ensure that you really understood each of the unit. In this file, you will find all the details of the works you must submit to your tutor, for marking. Remember your assignments are as important as the examinations as they carry the weightings 40% for undergraduate.

Assessment

Two major methods will be used to assess the course. The first major method is through assignments while written examination will be the second one. The course material had been prepared to assist you to do these assignments. You are also expected to use information and knowledge from the recommend text at the end of each unit. The assignment will carry 30% of the total marks for the undergraduate students while 70% for the postgraduate diploma students. Final examination of about two hours duration will be written at the end of the course and this will also carry 60% of the total mark for the undergraduate students and 50% for the post graduate diploma students.

Tutor-Marked Assignment (TMAs)

The TMA is a continuous assessment component of your course. It accounts for 30% of the total score. You are required to submit at least four (4) TMAs before you are allowed to sit for the end of course examination. The TMAs would be given to you by your facilitator you are to be return them to the facilitator as and when due

Assignment questions for the units in this course are contained in the assignment file. You will be able to complete your assignment from the information and materials contained in your reading your study units and, references. However, it is desirable to demonstrate that you have read and researched more into other references, which will give you a wider view point and may provide a deeper understanding of the subject.

Make sure that each tutor-marked assignment reaches your facilitator on or before the deadline given in the presentation schedule and assignment file. If for any reason you cannot complete your work on time, contact your facilitator before the assignment is due to discuss the possibility of an extensions. Extension will not be granted after the due date.

Final Examination and Grading

The final examination for EDU 756 will be for two hours duration and will carry 60% of the total marks for undergraduate students. The examination will consist of questions, which reflect the type of self

testing, practice activities and tutor-marked assignments/problems you have encountered previously. All areas of the course will be assessed.

You may wish to form a discussion group of considerable numbers of your colleagues and practice or discuss the activities and assignments written in each unit before the examination period.

Course Marking Scheme

Assessment	Category of Student	Scoring	Mark
Assignment 1 – 14	postgraduate	Each counts for 10 marks	40 mark
Final Examination	postgraduate		60 marks
TOTAL			**100% of course marks**

How to Get the Most from This Course

1) In distance learning, the study units replace the university lecture. This is one of the advantages of distance learning. You can read and work through specially designed study materials at your own pace, and at a time and place that suits you best. Think of it as if you are reading the lecture instead of listening to the lecturer. In the same way a lecturer might give you some reading to do, the study units tell you when and what to read. You are provided activities, to do at appropriate points, just as a lecturer might give his students an in-class activity.

2) Each of the study units 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 to this is a set of learning objectives. These objectives allow you to know what you should be able to do, by the time you have completed the unit. These learning objectives are meant to guide your study. The moment a unit is finished, you must go back and check whether you have achieved the objectives. If this is made a habit, then you will significantly improve your chances of passing the course.

3) The main body of the unit guides you through the required reading from other sources. This will usually be either from your references or from a reading section.

4) Self activities are interspersed throughout the units, working through these activities will help you to achieve the objectives of the unit and prepare you for the assignments and the examination. You should do each self activity as you come to it in the study unit.

5) The following is a practical strategy for working through the course. If you run into any trouble, telephone your tutor or visit the study centre nearest to you. Remember that your tutor's job is to help you. When you need assistance, do not hesitate to call and ask your tutor to provide it.

Read this Course Guide thoroughly, it is your first assignment.

6) Organise a Study Schedule- Design a 'Course Overview' to guide you through the Course. Note the time you are expected to spend on each unit and how the assignments relate to the units. Important information, e.g. details of your tutorials, and the date of the first day of the Semester is available at the study centre. You need to gather all the information into one place, such as your diary or a wall calendar. Whatever method you choose to use, you should decide on and write in your own dates and schedule of work for each unit.

7) Once you have created your own study schedule, do everything to stay faithful to it. The major reason that students fail is that they get behind with their course work. If you get into difficulties with your schedule, please, let your tutor know before it is too late for help.

8) Turn to Unit 1, and read the introduction and the objectives for the unit.

9) Assemble the study materials. Information about what you need for a unit is given in the 'Overview' at the beginning of each unit. You will always need both the study unit you are working on and one of your set books on your desk at the same time.

10) Keep an eye on the course information that will be continuously posted to you. Visit your study centre whenever you need up to date information.

11) Well before the relevant due dates (about 4 weeks before due dates), visit your study centre for your next required assignment. Keep in mind that you will learn a lot by doing the assignment carefully. They have been designed to help you meet the

objectives of the course and, therefore, will help you pass the examination. Submit all assignments not later than the due date.

12) Review the objectives for each study unit to confirm that you have achieved them. If you feel unsure about any of the objectives, review the study materials or consult your tutor. When you are confident that you have achieved a unit's objectives, you can start on the next unit. Proceed unit by unit through the course and try to space your study so that you can keep yourself on schedule.

13) When you have submitted an assignment to your tutor for marking, 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, both on the tutor-marked assignment form and also the written comments on the assignments, consult your tutor as soon as possible if you have any questions or problems.

14) After completing the last unit, review the course and prepare yourself for the final examination. Check that you have achieved the unit objectives (listed at the beginning of each unit) and the course objectives (listed in the Course Guide).

Tutor and Tutorials

Tutorials shall be provided in support of this course. You will be notified of the dates, times and location of these tutorials as well as the names and phone number of your facilitator, as soon as you are allocated a tutorial group.

Your tutor or facilitator will mark and comment on your assignments, keep a close watch on your progress on any difficulties you might encounter and provide assistance to you during the course. Summit your tutor-marked assignment to your tutor before the due date; at least two working days are required. They will be marked by your tutor and returned to you as soon as possible.

Do not hesitate to contact your facilitator on telephone, e – mail and discuss problems if you need assistance. The following might be circumstances in which you would find help necessary. Contact your facilitator if:

- You do not understand any part of the study units or the assigned readings.

- You have difficulty with the self-test or activities.
- You have a question or problem with an assignment,

with your tutor's comment 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 course facilitator and to ask questions which are answered instantly. You can raise any problem encountered in the course of your study. To gain much benefit from course tutorials prepare a question list before attending them. You will learn a lot from participating in active discussion.

Summary

EDU 756 intends to introduce you to Subject Methods II (Physics). Upon completing the course, you will be equipped with basic knowledge and skills that will place you in the status of practicing physics teachers.

Among others, you will be able to answer these kinds of questions:

- What is the meaning of science?
- What are the justifications for teaching physics?
- What are the possible reasons for science curriculum reforms in Nigeria at both primary and secondary levels?
- How have the psychological theories of learning contributed to the teaching of science in our schools?
- Which of the teaching methods will you suggest for the teaching of physics in our schools?
- How can you manage the resources in the physics laboratory?
- What are the roles of the unit head of physics, physics teacher, physics laboratory technician and attendants?
- How will you assess physics practical lessons in your school?

Course Code	EDU 756
Course Title	Subject Methods II (Physics)
Course Developer	Dr. Femi A. Adeoye School of Education, National Open University of Nigeria Lagos
Unit Writers	Dr. Augustine, U. Okoronka Kings College, Lagos. Dr. Femi A. Adeoye School of Education, National Open University of Nigeria Lagos
Course Editor	Dr. C. A. Okonkwo School of Science and Technology National Open University National Victoria Island Lagos
Programme Leader	Dr. Mercy F. Ogunsola –Bandele School of Education, National Open University of Nigeria, Lagos.
Course Coordinator	Dr. Femi A. Adeoye School of Education, National Open University of Nigeria Lagos

NATIONAL OPEN UNIVERSITY OF NIGERIA

National Open University of Nigeria
Headquarters
14/16 Ahmadu Bello Way
Victoria Island
Lagos

Abuja Annex
245 Samuel Adesujo Ademulegun Street
Central Business District
Opposite Arewa Suites
Abuja

e-mail: centralinfo@nou.edu.ng
URL: www.nou.edu.ng

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MODULE 1 THE MEANING OF SCIENCE, HISTORICAL DEVELOPMENT OF SCIENCE EDUCATION IN NIGERIA AND THE NATURE OF SCIENCE

INTRODUCTION

In this module, you will be exposed to the meaning and definitions of Science, the historical development of Science Education in Nigeria as well as the nature of Science.

The module is divided into five different units as follows:

Unit 1 The meaning and history of science
Unit 2 Historical development of science education in Nigeria I
Unit 3 Historical development of science education in Nigeria II
Unit 4 Justification for teaching science
Unit 5 Nature of science

UNIT 1 MEANING AND HISTORY OF SCIENCE

CONTENTS

1.0 INTRODUCTION

2.0 It is believed that you must have read through the course guide which is part of your instructional package for this course. If you have not, it Is advised that you read the course guide before reading your course material as it provides a comprehensive outline of the materials you will cover on a study unit basis, starting with the topic you are about to study: Meaning and definitions of Science, the historical development of Science Education in Nigeria as well as the nature of Science.

2.0 OBJECTIVES

After studying this unit, you should be able to:

- Explain the meaning of science
- Define science
- State and explain the processes/methods of science

3.0 MAIN CONTENT

3.1 Meaning of science

Different scholars, depending on the background and scholastic inclinations of authors have proposed many definitions for science. For instance, some philosophers of science see science as a body of knowledge, a way of investigating natural phenomenon and a way of thinking in an attempt to understand nature. This definition entails the three components of the structure of science which include the products, the methods and the motives of ethics of the discipline. The products of science include knowledge in the form of concept, facts, generalizations, principles/rules/ Laws, and theories that are subject to error and change. The methods of science include processes involved in how scientific knowledge comes into being. Examples are observing, classifying, inferring, measuring, communicating, interpreting data, making operational definitions, formulating questions and hypotheses, experimenting, formulating models, etc. The ethics of science consist of a set of standards or attitudes which guide the day to day activities of the scientists. Some of these are: curiosity, willingness to suspend judgment, open-mindedness, skepticism, positive approach to failure, etc. Some others refer to science as series of endless study of the universe and the phenomena within it through the process of empirical observations, which often result into the formulation of tentative concepts and theories within the universe. In a less philosophical perspective, science can be viewed as an organized system of explanations of nature through the process of experimentations, which are

usually open to modifications in the light of further empirical evidences by the practitioners of science.

SELF ASSESSMENT EXERCISE 1

a. How would you define science?
b. State four reasons why you think you would need to understand the meaning of science.

History of science

The history of science can be regarded as the history of man. The early man observed natural phenomena and speculated on its causes so as to find explanation for his own crude and primitive way. From the early man to the Greek times, to the Roman, then the British and Arab times, man has always wanted to understand the wonders of nature. They ask questions like what is sun, moon, the stars, rocks, air and other living and non-living things surrounding us.

Between 4000 and 3000 BC, the ancient scientists have perfected the arts of smelting, healing and building which had some scientific basis, However, the Greek Philosophers were the first to introduce the tradition of speculation which later formed the basis of today's scientific theories. Thales (640 – 540 BC) had theorized about the universe and its composition without laboratories or other observatories. They only made use of their brains and mind. Thales proposed that water was the fundamental substance of all things. He saw the earth as a disc which floated on water below, and the waters above formed the rains. Other student of Thales gave counter and opposing theories between (611 – 547 BC). These were the likes of Anaximander and Anaximenes respectively. However, a Greek philosopher by name Empedocles (495 – 435 BC) gave his theory of everything being made of four elements. – earth, air, fire and water and that any two or more combinations of these elements might account for various materials present in the universe (Abdullahi, 1982). Plato (428 – 347 BC) a student of Socrates introduced logic in an attempt to

explain and understand nature. This has led to the geometric views of the structure of elements in chemistry today. Another philosopher worthy of mention in tracing the history of science is Democritus (470 – 380).He was the first to develop or conceive the atomic theory and was also the first to use the word 'atom" derived from the word atomos – meaning indivisible. His atom had such attributes like physically indivisible, different in sizes and shapes, non-porous, impervious and was like perfect elastic spheres.

Aristotle succeeded Plato but deviated from his view of the universe. For him, the four elements of earth, fire, water and air were qualities or properties rather than substances. One element could be converted into another merely by the combination of two opposite properties as shown below:

	Cold	Hot
Dry	Earth	Fire
Wet	Water	Air

Table above shows the quality or property of elements and their possible combinations.

Property: Earth - dry - cold

Water - wet - cold

Fire - hot - dry

Air - hot - wet

These properties were interchangeable on their combination. The heavens according to Aristotle were composed of a fifth element he called quintessence.

Greek science majorly regarded as conceptual science was not based on sound data and was merely preserved or further enlarged between 600 to 1600 AD by the civilizations of the Romans, Asians, and Europeans.

What is practiced today as modern science emerged as a result of the demise of the Greek science in the 15^{th}, 16^{th} and 17^{th} centuries as a result of discovery that

Observation and experimentation were more valid ways of explaining, predicting and establishing theories and principles for describing phenomenon and events in the world.

SELF ASSESSMENT EXERCISE 2

Trace the origin of modern science.

In your opinion, which of the early philosophers had the greatest influence on the present day science and why?

4.0 CONCLUSION

Science as an enterprise as practiced today was greatly influenced by the early ideas of Greek philosopher. They initiated speculation and later logic as tools for systematic reasoning and the explanation of events and phenomenon in nature. Other civilizations further expounded the Greek science while still preserving it.

5.0 SUMMARY

In this unit, you have learnt that science has different definitions depending on who is defining it. Specifically, science means “to know”. It means must include how (the method/process) and what it knows (the products). It is systematic and therefore can become a dependable method of knowing anything.

Science is also as old as man. Its formal nature derives from the activities of earliest Greek philosophers who raised questions about events, object, phenomenon and activities observed in nature and in their environment. They had no laboratories and therefore they performed no experiments. They only relied on the ability of their minds and brains. Thus, their concepts, theories and principles were not based on data. Modern science relies heavily on

experimentations, data collection, analysis and interpretation in order to arrive at the laws and principles and theories.

6.0 TUTOR - MARKED ASSIGNMENT

As a budding scientist, give a definition of science and justified your definition.

7.0 REFERENCES/FURTHER READINGS

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

Bajah, S. T. and Okebukola, P. (1984). What is science. Position paper No. 1. Science Teachers' Association of Nigeria.

Maton, A. Hopkin, J. , McLaughlin, C. W. , Johnson, S., Warner, M. Q. ,Da Hart,

D. and Wright, J. D. (1993). The nature of science. Prentice Hall: U. S. A.

UNIT 2 HISTORICAL DEVELOPMENT OF SCIENCE EDUCATION IN NIGERIA 1

CONTENTS

1.0 INTRODUCTION

The development of science education in Nigeria is strongly tied to the initial work of the colonial masters and their agents like the missionaries. They had a twofold agenda - trade and evangelism. To achieve these goals, they needed to teach the people how to read and write as well as do arithmetic. Thus, they focused on what is today referred to as the 3r – reading, writing and arithmetic. This marked the beginning of introduction of any form of western

formal education in Nigeria in the mid 19th century. Unlike in the western world where science education started from the high schools to the universities, in Nigeria it was started first in primary schools in 1843 by Methodist Church in Badagry and then in secondary schools later.

2.0 OBJECTIVES

After studying this unit, you should be able to:

- Narrate the role of the various mission schools in championing science education in Nigeria;
- Explain why only very little science was taught by the missionary in their curriculum to schools;
- Explain why practical science was not part of the mission schools.

3.0 MAIN CONTENT

3.1 Historical Development of Science Education in Nigeria 1 (Role of Missionaries)

The evangelism mission of the early church propelled and determined the thrust of the primary and secondary education at that time. The first primary school was established in 1843 by the Methodist church while the first secondary came up in 1859. It was established by CMS. These schools were modeled after the English Grammar Schools which emphasized literary education. Abdullahi (1982) summarized the secondary schools established as follows:

i. Grammar/Classical Education School
ii. The teacher – Trainig/Pastor Training Schools, and
iii. The Vocational and Agricultural Schools.

In the first category, we have the following schools: the CMS Grammar Schools in Lagos, St. Gregory College, Lagos opened by the Roman Catholic in 1876; Methodist Boys' High School in Lagos opened by the Methodist Mission in 1887 and the Baptist High School in Lagos established in 1885 by the Baptist Mission.

The early Teachers and Pastors training institutions include: St. Andrews College, Oyo established by CMS (Church Missionary Society) in 1876,

the Hope Wadel Institute, Calabar opened in 1861 and the Baptist Training College, Ogbomoso opened in 1899.
Under the third category, the prominent institution opened was the Roman Catholic Agricultural School Topo, Badagry. In most of these institutions, there were attempts to teach science in the curriculum through the inclusion of subject such as Botany, Nature Study, Natural Philosophy and Physiology. However, it cannot be said that serious science teaching took place at this period due to some obvious reasons.

First, the missionaries were not ready to bear the huge cost involved in building science laboratories. Second, they had no trained teachers to handle the science subjects. Finally, they were interested in producing clerks and evangelists to support their missionary efforts and not necessarily in giving functional education to Nigerians. It is also important to note the total lack of science textbooks in Nigerian Schools, lack of a uniform curriculum and the difficulties in comprehension between the teachers then (mainly whites) and the pupils. These factors combined to make most efforts towards the introduction of science in Nigeria by the missionaries to be only rudimentary.

SELF ASSESSMENT EXERCISE 1

Trace the history of the introduction of rudimentary science in the Nigerian educational system.

4.0 CONCLUSION

This unit exposed you to the historical background of primary and secondary education in Nigeria by the various Missions as well as the extent of science inclusion in the curriculum at that time and possible reasons why so little science was done.

5.0 SUMMARY

In this unit, we learnt that the primary school in Nigeria where any form of science could have been taught is the Methodist School established in 1843. This was followed by the first secondary school in 1859 - CMS Grammar School. These schools were to emphasise literary education. Other schools later followed which had some slightly different focus including Grammar Schools, Teachers/Pastors training/ Vocational Schools/Agricultural Schools all

established by the missionaries who were more interested in training clerks and evangelists to help them in their missionary assignment.

6.0 TUTOR – MARKED ASSIGNMENT

1. Give a brief account of the role of the church in the introduction of science education in Nigeria.
2. What were the major reasons why little science was done in the schools?

7.0 REFERENCES/FURTHER READINGGS

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

Bajah, S. T. and Okebukola, P. (1984). What is science. Position paper No. 1. Science Teachers' Association of Nigeria.

Maton, A. Hopkin, J. , McLaughlin, C. W. , Johnson, S., Warner, M. Q. ,Da Hart,

D. and Wright, J. D. (1993). The nature of scie

UNIT 3 HISTORICAL DEVELOPMENT OF SCIENCE EDUCATION IN NIGERIA 11 (ROLE OF THE COLONIA MASTERS AND OTHERS)

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1.0 The trade mission of the colonialist also determines the initial aim of education in Nigeria. The government then was interested in production of clerks and interpreters, cooks and servant that will help

towards the achievement of their set goal. This attitude set the stage of science education in Nigeria which possibly affected the state of affairs in the educational sector till date.

SELF ASSESSMENT EXERCISE 1

Government's target of 60% to 40% enrolment ratio for science and humanities/Arts subjects respectively has remained a tall dream. Suggest any historical antecedents leading to this state of affairs as may have been occasioned by the colonial rule of the past.

2.0 OBJECTIVES

After studying this unit, you should be able to:

- Explain the role of the colonial administration in developing science education in Nigeria;
- Give reasons why science teaching in schools did not receive an initial boost/support from government;
- Narrate the history of government participation in science education;
- Explain the disparity in science education in particular between the North and the South.

3.0 MAIN CONTENT

3.1 Historical Development of Science Education in Nigeria II (Role of Colonial government and others)

The colonial governments, apart from being interested in producing manpower to support their mission, were also latently afraid of the positive impacts of science on the people. In addition, they had the belief that blacks were inferior in intelligence and lack what it takes to do science. These and

many more reasons explain why they treated with levity the teaching of quality science in Nigeria schools.

The government did not show any enthusiasm in encouraging the vital efforts of missionaries in laying the foundation for modern science education. Their support came by way of meager grants to mission schools as stipulated by the Education Ordinance of 1908. Schools were at liberty to decide how to use the grant and some did use it to acquire science equipment for laboratory instructions.

SELF ASSESSMENT EXERCISE 2

To what level did King's College offered science subjects when it was established?

Government's first direct involvement came in 1909 when it established what is now called King's College, Lagos to serve as a model in staffing, quality of teaching and equipment. It offered science up to Cambridge University senior local examination level. In 1927, government opened Queen's College, Lagos for girls and two years later in 1929, two more government colleges were opened at Ibadan and Umuahia to serve the Western and Eastern regions respectively. These institutions all had provision for the teaching of science. However, Kings College remained the only school that offered science up to the high school certificate level and had a standard chemistry laboratory.

The story in the North was somewhat different. The religious intolerance of Moslems did not allow the missionaries a free hand to open secondary schools and to initiate science teaching. The first government college in the North came up in 1938 in Kaduna.

The effort of African Education Commission sponsored by the Phelps strokes of U.S.A. in pointing out to the British government the consequences of a deliberate policy to shortchange Africans in science education in 1920 perhaps became the right tonic that forced them to start at all. It categorically reminded the colonial masters that physics, chemistry and biology have revolutionised many of the industrial and social activities of mankind. Further pressure was brought on government by Nigerian nationalist who had

opportunity to study overseas as well as further Education Ordinances. Government was then forced to open post secondary institutions for the teaching and learning of science. The first of the higher institutions was Yaba Higher College (now Yaba College of Technology) established in 1934 to produce intermediate manpower in Agriculture, Medicine, Engineering, Surveying teachers to teach basic science subjects in secondary schools. The college ran a four year programme to the award of Master Diploma in Science and Mathematics. The colleges produce the first set of teachers that laid the foundation for development of an appropriate curriculum in science for secondary schools.

SELF ASSESSMENT EXERCISE

What role did Science Teachers Association of Nigeria (STAN) played in popularizing science teaching in Nigeria?

Another important factor which accelerated the science education development efforts in 1950 was the establishment of the West African Examinations Council (WAEC) by an ordinance. From this point, changes were introduced in the syllabus. British syllabus which was foreign in content was made to reflect indigenisation of content and scope of science teaching in Nigeria schools. Popularization of science teaching received a boost in 1957 as the Science Teachers Association of Nigeria (STAN) was inaugurated.

This body later pursued and developed the Integrated Science Curriculum which is in use till today. The establishment of the Federal School of Science, Lagos in 1958 a year after the establishment of the University College, Ibadan was another step by government in popularizing science. The school specialized in offering basic sciences for O and A levels in GCE and had contributed in no small measure in providing basic science education to young Nigerians of that time.

After independence in 1960, foreign technical aids led to the establishment of higher institutions and Universities. A.B.U. started in Zaria in 1962 with University of Ife while University of Nigeria Nsukka had stated two years earlier in 1960. These institutions with the Advanced Teachers' Colleges produced teachers who took over the teaching of science in secondary schools.

4.0 CONCLUSION

This unit has established that colonial masters were not too keen in developing science education in Nigeria schools. This lukewarm attitude determine the time of intervention of government in the establishment of secondary schools and other higher institutions where science teaching were to be fully implemented.

5.0 SUMMARY

In this unit, you have learnt that the first government owned secondary school is Kings College, Lagos and this was established in 1909. Here, the basic sciences of physics, chemistry, biology and mathematics were taught. It also had the first standard chemistry laboratory. The British syllabus and curriculum were used for science instruction and this made content very foreign. It was not until 1950 when WAEC was established that real indegenisation of content started. The establishment of higher institutions to train teachers also came very late. The first higher institution being Yaba Tech in 1934 while University of Ibadan was established in 1957. Therefore it could be stated that several factors both real and imagined had contributed to the slowing down of the pace of development of science education in Nigeria starting from the colonial era.

6.0 TUTOR – MARKED ASSIGNMENT

List and explain the factors that contributed to the slow pace of development of science education in Nigeria?

7.0 REFERENCES/FURTHER READINGGS

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

Bajah, S. T. and Okebukola, P. (1984). What is science. Position paper No. 1. Science Teachers' Association of Nigeria.

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D. and Wright, J. D. (1993). The nature of science. Prentice Hall: U. S. A.

UNIT 4 JUSTIFICATION FOR TEACHING SCIENCE

CONTENTS

1.0 INTRODUCTION

In this module, an attempt is made to provide a justification or rationale for science teaching in schools. This is important if one must be able to justify the call for investment of resources – human, material and financial resources as well as time in the development of science education.

SELF ASSESSMENT EXERCISE 1

What does society stand to benefit by investing in science education?

2.0 OBJECTIVES

After studying this unit, you will be able to:

- Give/state reasons why science should be taught in schools;
- Explain the importance of scientific knowledge to the society;
- Discuss the role of science in the socio-economic development of a society or nation;
- Discuss the implication(s) of scientific development in stabilizing world order or politics.

3.0 MAIN CONTENT

3.1 Why teach Science?

All over the world, science has become a great tool for solving socio-economic problems of mass unemployment, hunger, poverty, poor health facilities, rural-urban drift, population explosion, environmental degradation and a host of other problems besetting a developing country like ours. This is based on the great gains (social, economic, technological and political) which science and the application of its knowledge (technology) has brought to such advanced nations of the world such as Japan, USA, Canada, Britain, France, Germany, etc. These nations have nurtured science and its application to an enviable status where it has become part and parcel of the peoples' culture. It was discovered that the tendency to adopt science and technology for solving societal problems and for creating further wealth dates back to the era of industrial revolution in Europe. For example, the British Empire grew in leaps and bounds in economic and political power because of the use of machines and such other contrivances of science and technology for mass production of goods and services.

3.2 The Importance of Scientific Knowledge to the Society

The various African nations have long realized the importance of science in the development of their various economies. This had led the African Ministers of Education as far back as 1962 to recommend sixty percent of admission into higher institution of African countries for scientific and technologically based courses as opposed to forty percent for social sciences and humanities courses. No African nation however has yet achieved this target. Scientific knowledge and its application have elevated the status of man from Stone Age to space and computer age, subsistence farmer to mass producer. Science has also librated man from superstition and fear of nature

by offering plausible explanations to natural events and phenomenon. These have added meaning to life and empowered man to manage and live more comfortably in his environment.

SELF ASSESSMENT EXERCISE 2

What does the applications of knowledge of science achieved in human life?

3.3 The role of Science in Socio-economic development

The knowledge of science is instrumental to technological, economic, social and political growth across the globe. The application of scientific knowledge has led to discovery of hydro and thermal electric power, gas turbine and thermonuclear power plants which in turn have led to modern industrializations. The fertilizer and petrochemical plants which have boosted agriculture and other sectors of industrial activities are only made possible through science. The telephone and the world of information and communication technology (ICT) would be impossible without the basic laws of acoustics, electricity, magnetism and waves in physics. The principles and laws of physics and chemistry are employed in the construction/manufacture of vehicles (land, sea and air) and in the development of modern rockets, nuclear bombs and missiles used in modern warfare. The same can be said of the principles of semi-conductor devices and electronics which have led to the development of diodes, rectifiers, integrated circuits (ics) and logic gates, which are widely used in computers and other electronic systems.

The developments of organic components, drugs and medicines have not only helped in producing large yield agricultural products but also in improving on the living standards of the people. Our oil and other natural resources must be processed into finished products through the instruments of industries like refineries, steel plants, paper mills and chemical industries for making soaps, cosmetics, perfumes, plastics, glass, pesticides, etc.

SELF ASSESSMENT EXERCISE 3

As a science teacher, do you agree that teaching of science can lead to attitudinal change in the learners?

3.4 The implications of Scientific Development

Exposure of people to knowledge of medical sciences has brought sophisticated gadgets, which are now used to probe even the innermost part of the human anatomy. Also, the use of automatic patient monitoring system in hospital's intensive care units which not only improve health care delivery system, but also helps in unattended and more reliable patient monitoring which such as measurements of vital parameters like pulse, blood pressure, body temperature etc.

In addition, the problem of environmental degradation being tackled now around the globe stemmed from our understanding of the atmosphere and the overbearing effects of certain human activities on it; and how this impacts negatively on man.

Besides, the knowledge of the concepts, empirical laws, theories and principles of science as well as the attitude and processes/methods of science combine to add more meaning and satisfaction to our lives. The scientific explanation of phenomena around us help to dispel unwanted fears, banish timidity and superstition and provide us with the needed knowledge to be set free at heart

The science also provides us with the requisite experts professionals that would move the nation out of its present woods into the exalted position of national development and economic emancipation. These include the engineers, doctors, surveyors, scientists, technologists, nurses, computer scientists, pharmacists, etc.

4.0 CONCLUSION

This unit discussed the reasons for teaching physics, importance of scientific knowledge to society as well as the roles of science in Socio-economic development of a nation. The implication of scientific development in stabilizing world order was also discussed.

5.0 SUMMARY

In this unit, we have learnt about the roles played by sciences and its applications in shaping our collective and individual lives. We also saw how science has helped the so called developed nations get to where they are today. Science has therefore become a "sine qua non" in developing and creating wealth in any nation. The more a nation has scientific and

technological power, the more it tends to be respected among the comity of nations. Having been blessed with a lot of natural resources – rivers, oils, forests, arable land, etc; we must employ the instrument of science and technology to wriggle ourselves out of poverty, which presently stares us in the face. This will be made possible only through a sound, and well articulated science education programme mounted in our schools at all levels.

6.0 TUTOR – MARKED ASSIGNMENT

1. What is the justification for inclusion of the science subjects in the curriculum?

7.0 REFERENCES/FURTHER READINGS

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UNIT 5 THE NATURE OF SCIENCE

CONTENTS

1.0 INTRODUCTION

In units 1 and 4, you learnt about the meaning/definition(s) of science and the justification for teaching science respectively. In this unit, we shall further extend the ideas of those two units by looking at the nature of science. What exactly is the true spirit of science?

SELF ASSESSMENT EXERCISE 1

Science has been said to mean different things to different people. What do you suppose should be the true nature of science?

2.0 OBJECTIVES

After studying this unit, you should be able to:

- List the process or methods of science;
- List and explain the attitudes of scientific attitudes;

- List and explain the products of science;
- Explain the nature of science.

3.0 MAIN CONTENT

3.1 The Nature of Science

Science is organized into a hierarchical deductive system in which concepts and facts are subsumed under the laws, while the laws, concepts and facts are subsumed under the theories. A major goal of science is to understand the world around us. How do scientists go about understanding the mysteries of our world? Like good detectives, they use special methods or processes peculiar to science alone to determine the "truth and facts" about nature, which constitute the major products of science.

Fact

A fact is an event that occurred in the past that people recorded with no disagreement among observers. It is important to note that fact of the past may not be fact in the present if there are changes or revisions in observations, the object of observation, or the meaning attached to the observation.

PROCESS OF SCIENCE

Processes of science are the methods and skills that scientists employ in their work. Processes of science are the scientific activity per se and are self-correcting, self-evaluating and independent of the people or event on whom they operate. They include:

identifying problem
observation
hypothesizing / prediction
analyzing
inferring
extrapolating
synthesizing
evaluating
classifying
measuring

describing
experimenting
asking insightful questions
formulating problems
designing experiments
constructing laws, principles and generalizations, etc.

These form the basis of what is referred to as the scientific method or process.

In addition, the scientific enterprise – as a human endeavour entails some personal way(s) of exploring or knowing as the scientific attitudes or attitudes of science. These are the beliefs, values, qualities and opinions held in awe by scientists, which keep alive or maintain the spirit of the scientific enterprise as an unfinished business and also self-correcting. They include among others:

- suspending judgement until enough data is collected;
- objectivity while collecting, analyzing, evaluating and interpreting data;
- intense curiosity by being fascinated with the world around him/her;
- humility and skepticism (being free from pride and arrogance as

- well as taking everything with a pinch of salt);
- tenacity by thinking positively about failure and not giving up very easily;
- open-mindedness – free from prejudice and personal biases;
- strong determination;

- honesty;
- asking questions (divergent and convergent) – questions of what, how, when, where and why?

The products of science are not necessarily the finished goods and services derived from the application of the knowledge of science. Rather they constitute mainly of the knowledge, concepts, models, generalizations, algorithms, principles, theories, laws, etc. which are used for creating further scientific knowledge. While the scientific methods are systematic and tend to be static, the products of science are dynamic and generative depending on the extent of data available at anytime.

On the other hand, the natures of science are those qualities or elements which make science what it is. Thus, science is organized into a system in which there are linkages between the elements.

The nature of science is described using the three basic elements of science as follows:

(i) the processes or methods of science;
(ii) the products of science;
(iii) the human attitudes of science.

Thus, in investigating a phenomenon or event, scientific processes are used to gather data while the products of science will be applied in analysis and interpretation. However, the human attitudes of science must remain in focus at any point of the investigation. Applying the methods and attitudes of science lead us to new scientific products, which are subsumed under the old ones.

SELF ASSESSMENT EXERCISE 2

How are concepts, laws, theories and principles related?

3.2 Scientific Concept

A concept can be defined as a word, group of words, label or symbol which defines the regularity perceived in events or record of events or phenomenon. There are two types of concepts:

(i) concrete or empirical concepts;
(ii) abstract or theoretical concepts.

Concrete concepts are observable, demonstrable and may be defined operationally. They are easy to measure. Examples include plant,

volume, density, mass, temperature, table, stone, etc. Abstract concepts are non-observable and cannot be perceived or measured in a simple direct way. Examples include atoms, molecules, electrons, genes, field, force, etc.

All concepts can be taught at any level depending on the teacher and the background of those to be taught relative to the level of mastery expected.

SELF ASSESSMENT EXERCISE 3

What is a scientific theory? Give any three scientific theories you know.

3.3 Scientific Theory

Scientists use the 'facts' or concepts they have gathered to propose explanations for observed events or phenomenon. Then experiments are performed to test their explanations. After studying the facts; making observations and performing experiments, scientists may develop a theory.

A theory is a logical explanation for events, which occur in nature based on facts, observations or experimentation. It is a powerful, time-tested idea or group of ideas that makes useful and dependable predictions about our natural world. A theory must undergo series of experimentation and testing. If it survives the tests, the theory may become accepted by the scientific community. However, a theory could be wrong and therefore change after additional tests, observations and data. Examples of theories in science include Dalton's atomic theory, the kinetic theory of matter, theory of evolution, theory of relativity, etc.

SELF ASSESSMENT EXERCISE 4

What is the difference between a scientific theory and law? Use any two examples as illustration.

3.4 Scientific Law

When a theory survives many tests and becomes accepted as true, scientists then call it a law. A law is a statement of what happens or will happen under certain given initial conditions. For a statement to be regarded as a scientific law, it must express a consistency or uniformity among observations of natural phenomena and must involve the use of concepts. Examples of law of science include – Newton's law of universal gravitation:

- Charles and Boyle's laws
- Hooke's law
- Ohm's law
- Medelev's law, etc.

As with theories, scientific laws may change as new information is provided or new experiments performed. This points out what is known to cement, the spirit of science, which is always asking mind bugging questions and seeking further and new explanations.

4.0 CONCLUSION

Science though meaning different things to different scientists has a single focus i.e. to unravel the mysteries of nature using the same "tools" and "methods". The processes of science because they are dependable make the investigations of science replicable. Thus, we have developed what is now known and referred to as the scientific method which is applicable now in all fields of knowledge. This comprises of the following steps:

identifying / recognizing a problem;
collecting relevant information ./ data;
formulating hypothesis;
conducting / performing experiment;
recording, analyzing and deducing from data;
drawing / stating a conclusion.

These also form the method of science and together with the attitudes of science the products of science are obtained. The processes, attitudes and products of science combine to give science its nature.

5.0 SUMMARY

In this unit, we have discussed the methods or processes of science known as the scientific method; the attitudes which enable these processes to remain what they are as well as the products of science.

The "truths" or "facts" of science of today may not be accepted tomorrow as more experiments and observations are carried out and more data obtained. Hence, the scientific enterprise is not necessarily a finished business. This is because as more facts emerge, new questions are raised and new explanations and products are proffered.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is the nature of Science?
2. Discuss briefly how the nature of Science portrays the spirit of the scientific enterprise.
3. What do you understand by the scientific method? Briefly discuss it.

7.0 REFERENCES/FURTHER READINGS

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

Bajah, S.T. and Okebukola, P. (1984). What is Science. Position paper No. 1. Science Teahers' Association of Nigeria.

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6.0 TUTOR –MARKED ASSIGNMENT

As a budding scientist, give a definition of science and justify your definition.

7.0 REFERENCES/FURTHER READINGS

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

Bajah, S.T. and Okebukola, P. (1984). What is Science. Position paper No. 1. Science Teahers' Association of Nigeria.

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MODULE 2 SCIENCE EDUCATION CURRICULUM REFORMS AND HOW STUDENTS LEARN SCIENCE

INTRODUCTION

The dynamic nature of science education in the world has resulted to constant revisiting or reformation in the curriculum to cope with the changing world of science and technology. In Nigeria, science educations at all levels are in the past and presently facing serious problems emanating from poor achievement, low enrolment, declining popularity etc. In order to check these problems, science education curriculum experts embarked on regular reformation of the curriculum. Some efforts made in the past resulted to various science education curriculum projects at both primary and secondary school levels. In this module two, you will be exposed to development of some science education curriculum and science education packages.

This module also discussed psychological rationales essential for answering such question as "when can the science concepts be taught"? this question has to do with how students learn science. How are concepts formed in the human mind? What are the science concepts that you hope to encourage your students to develop? Cognitive psychologists such as David, P. Ausubel, Jerome Brunner, Robert Gagne and Jean Piaget, have attempted to provide answers to these questions as well as impact on curriculum development and the methodology of science teaching at both primary and secondary school levels. So this module is divided into four units as follows:

UNIT 1 FOREIGN SCIENCE EDUCATION CURRICULUM REFORMS

CONTENTS

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INTRODUCTION

This unit introduces you to foreign curriculum reform in science education .

2.0 OBJECTIVES

After studying this unit, you should be able to:

advance reasons for a reform in the science curriculum;
list some foreign science curriculum projects;
list the financiers of each of the projects;
mention the dates when each of the projects was initiated;
mention the focus of each of the projects;
list the curriculum materials produced for execution of the projects.

3.0 MAIN CONTENT

3.1 Science Curriculum Development

Curriculum development efforts in the sixties were sparkled off on October 4, 1957 by the launching by the Soviet Union of the first man- made satellite to orbit the earth. The name of the satellite is the sputnik 1. This event led to a re evaluation of science curricular throughout the world under the leadership of the USA.

Some of the foreign curricula are Secondary school science curriculum projects in the U.S.A include: Harvard Project Physics, Chemical Bond Approach (CBA) Chemical Education Materials Study (CHEM Study). Secondary school science projects in the United Kingdom, include: Scottish Integrated Science Project, Nuffield Combined Science, Nuffield Secondary Science, The School Council Integrated Science Project.

SELF ASSESSMENT EXERCISE 1

Mention some of the foreign science curriculum projects development in Nigeria.

Notable among the developed foreign science projects are as follows:
Secondary school science curriculum projects in the U.S.A include: Harvard Project Physics, Chemical Bond Approach (CBA) Chemical Education Materials Study (CHEM Study).

Secondary school science projects in the United Kingdom, include: Scottish Integrated Science Project, Nuffield Combined Science, Nuffield Secondary Science, The School Council Integrated Science Project.

3.1.0 Secondary school science curriculum projects in the USA

3.1.1 Physical Science Study Committee (PSSC). This project was established in 1956 at the Massachusetts Institute of Technology. The materials produced by the committee were in general use by 1960. The materials were developed with the support of the National Science foundation.

The general purpose of the project was to present physics as a unified but continuing process by which we seek to understand the nature of the physical world.

The course has been offered as an alternative to the traditional physics course because more emphasis is placed on modern physics. The textbook is divided into

four parts: the universe, optics and lenses, mechanics and electricity and modern physics. The laboratory is essential to this approach as students are expected to experience science phenomena first and then discuss the theory underlying their observations in the classroom setting. The ultimate goal of this methodology is to promote the development of the attitudes and skills of the scientist.
The materials and resources of the project include physics textbooks such as PSSC physics, laboratory apparatus, 16mm films, teacher's resource book and guide, science study series, and PSSC tests.

3.1.2 Harvard Project Physics (HPP).

This committee was established in 1964. The pilot version of the course was available in 1967. The course was developed to take care of a wide range of student abilities. In contrast to the focus of PSSC course for above average students. The National Science Foundation supported the project.
The purpose of the course was to develop a new kind of physics course for the science oriented and the science-shy, centered on a solid introduction to physics but stressing the humanistic background of the sciences.
Inspection of the HPP textbook reveals that it has a different orientation from PSSC and other conventional physics textbooks. The project physics textbook develops topics through a story line that uses history, present-day events, and numerous examples to develop science topics. It shows how scientific thought and ideas evolved and accomplish this through historical events, stories, explanations, and formulae. The project physics course is designed to be flexible, Teachers can use it in a conventional manner or individualize the programme. This is possible because either a single textbook is available or individual booklets for each chapter can be purchased. The programme consists of five units, namely: (1) concepts of motion (2) Motion in the heavens, (2) the triumph of mechanics. (4) Light and electromagnetism, and (5) Models of the atom.
The materials produced by the project include: the textbook, project physics, teacher's guides, student handbooks, physics apparatus, transparences, film loops, film strips, tests, programmed instruction, booklets, and newsletters.

3.1.3 Chemical Bond Approach (CBA). The Chemical Bond Approach was developed by the Chemical Bond Approach Committee established at Earlham College, Richmond, Indiana, in 1958. The materials were first published in 1963. The project was supported by the National Science Foundation.
The general purpose of the project was to design an introductory course in chemistry which emphasized chemical bond and chemistry as a process of investigation.
This approach is most appropriate for high-ability students. The commonly used textbook (Chemical systems), attempts to discuss the following questions: What is the nature of a chemical system? When a chemical reaction occurs how does the change alter the surroundings of the system? Why do chemical elements

from certain compounds but not others? What determines the conditions under which a chemical change is complete?
Some of the materials produced by the project includes: Textbook, Chemical Systems, student laboratory guide, teacher's guide, supplementary readings, chart of electronegative and four self-instruction programmes.
The project has terminated.

3.1.4 **Chemical Education** materials **Study (CHEM study).**

The materials for the CHEM study programme were prepared by the Chemical Education Materials study committee first established by the American Chemical Society in 1959. The pilot programme was ready in 1961, and the material was rewritten in 1962. The programme was under the auspices of the National Science Foundation.
The general purpose of the CHEM study course is to stimulate and prepare high school students for university chemistry and to give other high school chemistry students an understanding of the importance of science.
The CHEM study programme takes an inductive approach to learning. Students are expected to perform laboratory exercise that requires collection and analysis of data. The purpose of this structure is to help students independently discover relationships that exist before class discussion on the topic.
Some of the materials produced by the project include textbook, laboratory manuals, a teacher's guide, examinations, and films for both students and teacher use. The CHEM study textbooks have been published in the following 3 editions:

(a) Chemistry: An Investigation Approach ed. 2 1980.
(b) Chemistry: Experiment and Principles, ed. 3 1982.
(c) Chemistry: Experimental Foundation, ed 3 1982

The project has essentially terminated. Distribution of written materials and films both in English and as translated will be continued. A minimum staff will be maintained to supervise remaining business activities and to carry out contractual obligations.

3.1.5. Biology Sciences Curriculum Study (BSCS). The Biological Science Curriculum study project was started in 1959. Originally three versions of a first course in biology were produced. The project was supported by the National Science Foundation.
The general purpose of the project is to contribute to the improvement of biological education through the preparation of curriculum materials related to the study of biology. The three most commonly used curricula developed by SSCS are the Blue version (molecular approach), Green version (ecological approach), and the Yellow version (organism approach). Their corresponding textbooks are Biological Science: Molecules to man (blue version): Biological science: An Ecological Approach, (green version); Biological Science: An Inquiry into life (yellow version). All these are for the equivalent of SS1 while

Biological Science: Interaction of Experiments and ideas is for the equivalent of SS3. Other materials include: special materials for low-ability students, laboratory blocks biology teacher's handbook, and numerous supplemental materials for biology teachers and students, BSCS newsletter.
Additional materials are being developed, e.g., for Educationally Mentally Retarded, programmed materials and inquiry slides.

3.2.0 SECONDARY SCHOOL SCIENCE PROJECTS IN THE UNITED KINGDOM

3.2.1 The initiative for curriculum development in the U.K belonged to science teachers. There were two associations: Science Masters' Association (SMA) and Association for Women Science Teachers (AWST) which grew rapidly and merged form Association for Science Education (ASE) in 1961, because of their dissatisfaction with existing syllabi, the association published.

(i) Biology for Grammar Schools
(ii) Chemistry for Grammar Schools
(iii) Physics for Grammar Schools

With the support of Nuffield Foundation for ASE, the Nuffield Science Schemes were launched in 1961-1962.

3.2.2 Scottish Integrated Science Project

This course is different from most modern curriculum projects in the manner in which curricula were produced. The 1964 working party was initially established to review the existing science curricula for Scottish students' non-certificate courses and to consider the "Alternative syllabus" to the lower level courses. The working party was not established to produce materials for students' or teachers' use. Later, their mandate was expanded but the working party, not only reviewed according to the expanded mandate but also prepare a workable syllabus for the first two years of school – grades 8 – 9. The resulting approach is now known as Scottish Integrated Science. Worksheets were distributed during the period of trial-testing in school which were later revised and published after evaluation. Textbooks were later published following the order of the syllabus and associated teachers' guides.

SELF ASSESSMENT EXERCISE 2

What is the main focus of Scottish Integrated Science Project?

The general purpose of this syllabus was to expose students to experimental methods of scientists, and the apparatus and methods used for drawing conclusions. The Scottish Integrated Science courses involved extensive laboratory work. Students were expected to work individually or in small groups: teachers, however, were expected to demonstrate the dangerous techniques to the students. In Scotland, Science is treated as a "practical subject" with only 20 students in a class.

3.2.3 Nuffield Combine Science

Nuffield Combine Science team was set up in 1966. Teachers were expected to exercise their professional judgment concerning details of content and order of the provided structured syllabus in producing a suitable teaching sequence. Hence,

they had the task of synthesizing the materials provided for children in the first two years of British Secondary Schools.
Emphasis in the recommended teaching sequence is placed on students' firsthand experience which is reflected in the laboratory experiments. Home assignments are learnt through guided discovery method.
The materials produced are teacher's guide, activity books, and film loops.

3.2.4 Nuffield Secondary Science

The Nuffield Secondary Science is for the lower 75% of the ability range of the population age 13 – 16.
The aims of the Secondary Science was to provide opportunities to pupils to understand things at the scientific background and implications of economic, social and moral problems and to equip them for everyday life. It also included the need to solve problems, to predict the consequences of actions and, to evaluate assertions of politicians, advertisers, and scientists.
The objectives in secondary science are to provide immediate opportunity for , and encouragement of, accurate observations deduction of generalizations, design of simple experiments and formation of hypotheses. This opportunity is taken to improve verbal fluency, literacy and numeracy, to encourage self-discipline and responsibility for organization of work.
The curriculum consisted of 8 themes. There was provision for pupil's experiments and teacher's demonstrations on each theme. Students are expected to perform the experiments all by themselves. By so doing, they learn a lot and even discover new things which are useful to them.

SELF ASSESSMENT EXERCISE 3

What is the general purpose of this project?

Other Nuffield Curricula are Nuffield 'O' level Science Schemes which were the first of the curriculum development projects in science to be sponsored by the Nuffield Foundation in the early 1960s. They represent schemes of work in the separate sciences - - biology, chemistry and physics – for the secondary school students, grade 7 – 11 following a science course of five years duration and leading to the

General Certificate of Education at the Ordinary Level (GCE 'O' level). This type of course and examination is taken by the top 25-30 percent of the ability range.
The basic aim of these schemes was to foster a different attitude to science subjects in both student and teacher - - one of curiosity and inquiry rather than an emphasis on the uncritical assimilation of facts and the "verification" of scientific laws by routine experiments. The schemes employed a "guided discovery", rather than pure heurism, calls for a diversity of teaching techniques, and is therefore challenging to teacher and student.
Examples are: Nuffield 'O' level Biology, Nuffield 'O' level chemistry, Nuffield 'O' level physics, etc.

SELF ASSESSMENT EXERCISE 4

Mention the materials produced to execute **Nuffield Secondary Science** project.

3.2.5 The School Council Integrated Science Project

The schools council integrated science project was established for students of above-average ability. This was to enable students perform better in GCE examinations. The primary aim of the project was to inculcate in pupils attitudes such as critical thinking and objective observation; as such SCISP emphasizes intellectual work. Students were expected to be able to reason why a reaction occurs rather than just recording its occurrence.
To guide the development of materials it adopted a "Patterns Approach" which is a combination of existing "Process Approach" and "Conceptual Approach".

4.0 CONCLUSION

This unit examined the details of the foreign science curriculum innovative projects.

5.0 SUMMARY

In this unit, you leant about the following:

Foreign curriculum innovations in sciences projects:

- Secondary school science curriculum projects in the U.S.A.
- Secondary school science projects in the United kingdom.

6.0 TUTOR-MARKED ASSIGNMENT

Enumerate the overall objectives of the schools council integrated science project.

8.0 REFERENCES/FURTHER READINGS

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UNIT 2 SCIENCE EDUCATION CURRICULUM REFORMS IN NIGERIA I

CONTENTS

1.0 INTRODUCTION

This unit introduces you to curriculum reform in science education and some primary science curriculum projects embarked upon in Nigeria.

2.0 OBJECTIVES

After studying this unit, you should be able to:

advance reasons for a reform in the science curriculum;
list some primary science curriculum projects;
list the financiers of each of the primary projects;
mention the dates when each of the projects was initiated;
mention the focus of each of the projects;
list the curriculum materials produced for execution of the projects.

3.0 MAIN CONTENT

3.1 Science Curriculum Development

The sudden launching into space of the satellite "sputnik" by the Soviet Union sparked off science curriculum development efforts in the western world. This led to the awareness as regards the need to re-examine the school science curricula, objectives, content and evaluation.

In Nigeria, a lot of external influences and foreign curricula motivated many of the curriculum innovations in science at the primary school level. Some of the foreign curricula are Elementary Study of Science (ESS) of 1960, Science – A Process Approach (SAPA) of 1962; Science Education for Africa Project (SEAP) of 1970; Science Teacher Education Project (STEP) of 1970 etc. Because of these influences and the historic National Curriculum Conference held in 1969 spurred various bodies including government agencies to develop science curricula for both primary and secondary levels of education.

SELF ASSESSMENT EXERCISE 1

Mention some of the primary science curriculum projects development in Nigeria.

Notable among the developed primary science projects are as follows:

University of Nigeria Primary Science Pilot Scheme;
African Primary Science Project (APSP);
Bendel State of Nigeria Primary Science Project (BPSP);
Ife Six Year Yoruba Language Primary Science Project;
The Primary Education Improvement Project (PEIP);
Ondo State Primary Science Project;
National Primary School Science Project (NPSSP).

3.1.1 University of Nigeria Primary Science Pilot Scheme

This project is the first Nigeria Primary Science Curriculum project in Nigeria began at the University of Nigeria, Nsukka in the then Eastern part of Nigeria as a pilot scheme in 1963. The scheme was jointly sponsored by the Faculty of Education, University of Nigeria and the Ford Foundation.

The focus of the scheme was on local materials and improvised

equipment such as the use of jam-jars, bamboo microscopes, bamboo cages etc. in the teaching of primary science.

SELF ASSESSMENT EXERCISE 2

Who was the initiator of this scheme?

This project, which came into being through Prof. Babs Fafunwa placed emphasis on pupils' practical activities.

3.1.2 The African Primary Science Project (APSP)

The APSP is another earliest curriculum innovative project in science at primary school level. It was launched in Kano in January, 1965. The project was sponsored materially and financially by United States Agency for International Development (USAID), Ford Foundation of America and the Education Development Centre (EDC) of Massachusetts. The programme was later referred to as the Science Education Project for Africa (SEPA).

SELF ASSESSMENT EXERCISE 3

What is the main focus of SEPA?

The purpose of the project was to create in the children, the spirit of inquiry, and a sense of curiosity and to develop in them the skills, techniques and mental attitudes to satisfy the inquiry spirit.

About 25,000 copies of printed materials consisting of pupils books and Teachers Guide covering over 30 topics were sent to Nigeria from APSP headquarters in Accra from 1965 to 1970. These printed materials and educational films were distributed to teachers mostly in Lagos schools. The teachers' guide was in booklet form. It was divided into two sections. Book one was for the lower primary classes and book two was for the upper primary classes. Also printed was the "Child Observation Checklist" used in evaluation of child learning.

3.1.3 Bendel State Primary Science Project (BPSP)

The BPSP which started in Benin-city in 1966 was first called Mid-western State Primary Science project and later became known as the Bendel State Primary project. The project was directed by the State Ministry of Education. It was jointly financed by United Nations Educational, Scientific and Cultural Organisation (UNESCO), United Nations Children's Fund (UNICEF), United Nations Development Programme (UNDP) and the Government of the former Mid-western State of Nigeria.

SELF ASSESSMENT EXERCISE 4

What is the focus of BPSP?

The general purpose of the project is the development of primary science curriculum and the training of teachers to teach primary science. The project was designed to be child-centred with the aims of developing in the child the mind of inquiry, self-confidence and self-reliance through problem-solving.

The following materials were produced: text book, "Science is Discovery" in pupil's books and teachers' guides for years one to six. Primary school science syllabus for classes 1 to VI. Also, Evaluation for innovation – A handbook for teachers was produced. The last two were published by the Science Curriculum Development Centre, Abraka.

The project was one of the few projects evaluated by experts. The evaluation team found that the project plans were implemented to a large extent but printed books for primary four were not distributed according to the policy of the Ministry. The printing of books for primary five was also delayed for two years by the press.

3.1.4 Ife Six Year Yoruba Language Primary Science Project

This project was part of an enlarged Ife Six Years Yoruba Primary project initiated in 1970 at the University of Ife under the chairmanship of Prof. Aliu Babatunde Fafunwa, then, Director of the Institute of Education of the University.

Some of the overall objectives of this project were:

- To develop a primary education curriculum with a strong surrender value since primary education is terminal for many Nigerian children.
- To develop materials, together with appropriate methodology for teaching the prepared curriculum effectively
- To use Yoruba language as the medium of instruction throughout, in order to demonstrate that the primary instruction, when given in the child's mother tongue rather than in a second or foreign language, is more effective and meaningful.

The revised aims and objectives of the projects are

- The project was to organize writing workshops for the development and evaluation of curriculum materials.
- The project was to develop materials with appropriate methodology for teaching and learning the prepared curriculum

effectively.

- Curriculum materials were to be developed in both Yoruba and English

SELF ASSESSMENT EXERCISE 5

Suggest other subjects apart from science that the project was designed to use mother tongue to teach.

The project generally was designed to exploit the use of mother tongue (Yoruba) in the teaching and learning of the underlisted primary school subjects:

English Language
Mathematics
Elementary Science
Religious Knowledge (Christian/Muslim)
Agricultural Science
Physical Education
Social Studies
Cultural and Creative Arts
Family living
Yoruba.

The project was supported financially by the Ford Foundations of America and former Western State Ministry of Education. The main objective of the project according to Fafunwa (1975) was "to develop a primary education for the child and make him an intelligent citizen of this country".

The writing group of the curriculum development team did a lot of work as the group had to battle with writing science concept in Yoruba as none of the group members learnt or taught science in Yoruba language before. The group therefore set up a "Lexical Committee" to select the right choice of words and concepts that would correctly express in Yoruba for those scientific concepts and expressions not easily identifiable with local Yoruba language.

SELF ASSESSMENT EXERCISE 6

Mention the materials produced to execute this project.

The materials produced are 'Sayensi' for primary classes Books 1 to 6 both teachers' guide and pupils text. So also the teacher manuals.

Some of the problems encountered with the project were:

absence of the equivalence of some scientific terms such as sodium, iron, lead etc.
finding a commonly acceptable word from possible list of varying dialects.
The problem of proceeding to higher institutions of learning where no such programme may be provided for, was very prominent.

Mobility of the local labour produced was restricted.

3.1.5 The Primary Education Improvement Project (PEIP)

The PEIP was initiated in 1970 at the Institute of Education, Ahmadu Bello University, Zaria. The project was jointly sponsored and financed by the then six Northern States of Nigeria, UNESCO, UNICEF, USAID and the British Council. The project was formerly called UNICEF/UNESCO assisted project but later called PEIP.

SELF ASSESSMENT EXERCISE 7

What is the aim of this project?

The project is aimed at making children think and study science like the scientists, hence it adopted the philosophy of the American Association for the Advancement of Science (AAAS) processes and skills for achieving this aim, with emphasis on the following process of science such as observing; measuring; classifying; using numbers; manipulating; communicating; predicting; inferring; interpreting; formulating; hypothesizing and experimenting.

SELF ASSESSMENT EXERCISE 8

Does this project have materials produced for its execution?

The curriculum materials produced for the project were a series of pupils textbooks (Books 1 to 6), Workbooks and teachers' guide which provides detailed information for the teacher to carryout science activities which must have been specified in the pupils' text.

The project was owned by the Northern States of Nigeria. It was based at the Institute of Education, Ahmadu Bello University, Zaria. The materials were therefore used in the Northern States.

The following materials were produced:

a) Activities for lower primary classes 1 - 3
b) Primary science for primary classes 1 - 6
c) Social Studies for primary classes 1 - 6
d) Oxford Modern Mathematics books 1 - 6

Pupil's textbooks, workbooks and teacher's guides were produced for the science and mathematics books.

Most of the materials produced were used during the introduction of the national programme of the Universal Primary Education in 1976. The science curriculum is just a component of the whole programme.

3.1.6 Ondo State Primary Science Project

The project was initiated in 1974 by former Western State of Nigeria. But later continued in Ondo State after the creation of states in 1976. The project drew its inspiration from the outcome of the APSP workshop.

SELF ASSESSMENT EXERCISE 9

What is the purpose of this project?
The main purpose for the project was to produce a child-centred curriculum with an investigative approach.

The curriculum materials produced for the project were pupils textbooks and teacher's guide. But the teachers guide was not completed for all the classes before the creation of states in 1976.

SELF ASSESSMENT EXERCISE 10

What is the general purpose of this project?

The concern and effort to improve, coordinate and regularize the quality of science taught at the primary school level led to the idea of having a core-curriculum for primary school science. So the NPSSP was developed in order to rectify some inadequacies found in the core-curriculum. Thus, the general purpose of the project was to provide guidelines for meaningful action to make education in Nigeria a true instrument for the reconstruction of our society and to achieve the development of National Capacities in support of nationalism, social, scientific, technological and economic development.

SELF ASSESSMENT EXERCISE 11

Could you name the approaches recommended for the teaching of this project?

Combinations of approaches were recommended for the teaching of the project which are processes, conceptual, thematic or project approach and the guided discovery approach that involves the activity of the child. This was made to run through the entire project.

The materials produced for the execution of the project include the followings:

Textbook on Integrated Primary Science for Primary Schools;
Teachers' Guide;
National Primary Science and Mathematics Project;
Syllabus and teaching materials;
Apparatus / equipment for teaching;
A project Newsletter and kits.

4.0 CONCLUSION

This unit examined the details of the science curriculum innovative projects undertaken at the primary school level in Nigeria.

5.0 SUMMARY

In this unit, you leant that:

external influences and foreign curricula motivated many of the curriculum innovations in science at primary school level.
Notable among the developed primary science projects in Nigeria.

- University of Nigeria Primary Science Pilot Scheme
- African Primary Science Project
- Bendel State Primary Science project
- Ife Six Year Yoruba Language Primary Science Project.
- The Primary Education Improvement Project
- Ondo State Primary Science Project
- National Primary School Science Project.

6.0 TUTOR-MARKED ASSIGNMENT

Enumerate the overall objectives of Ife Six Year Yoruba Language Primary Science Project as well as revised aims and objectives of the project after the writing workshops organised by Curriculum Development experts.

7.0 REFERENCES/FURTHER READINGS

Ogunleye, A.O. (1999). Science Education in Nigeria: Historical Development Curriculum Reforms and Research. Sunshine International Publications (Nig.) Ltd.

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UNIT 2 SCIENCE EDUCATION CURRICULUM REFORMS IN NIGERIA II

CONTENTS

1.0 INTRODUCTION

The content of Science Curriculum existing in our secondary schools before and after independence in 1960 did not provide enough learning experiences for students to become useful to the society. The curriculum was intended for the Cambridge University by West African Examinations Council (WAEC) and was designed partially to satisfy the requirements of its external examinations in science.

The poor state of the type of curriculum in the sciences gave a lot of concern to Science Teachers Association of Nigeria (STAN) and WAEC in 1968 who jointly examined and revised the existing syllabi in science.

Efforts made by some curriculum agents such as STAN, WAEC, NERDC (Nigerian Educational Research and Development Council) and CESAC (Comparative Education Study and Adaptation Centre) resulted in the following science curriculum projects undertaken at the secondary school level.

Therefore, this unit focuses on the following secondary science curriculum projects:

i) The Basic Science for Nigerian Secondary Schools (BSNSS);
ii) The Nigerian Integrated Science Project (NISP);
iii) The Nigerian Secondary Schools Science Project (NSSSP);
iv) The National Science Curriculum for Senior Secondary Schools.

2.0 OBJECTIVES

After studying this unit, you should be able to:

mention the date when each of the project was initiated;
mention the organization that financed each of the project;
mention the philosophy of each of the projects;
mention the curriculum materials produced for execution of the projects.

3.0 MAIN CONTENT

3.1 Basic Science for Nigerian Secondary School (BSNSS)

BSNSS was the first science curriculum development project undertaken in Nigeria between 1963 – 1967 at the Comprehensive High School, Ayetoro. The project which was popularly known as Ayetoro project was financed jointly by the Ford Foundation of America and the Western Nigeria Regional Government and coordinated by CESAC of the University of Lagos.

SELF ASSESSMENT EXERCISE 1

What approach did the syllabus of this project adopt?

The BSNSS was a curriculum in general science, which covered the first two years of secondary school. The basic science syllabus developed in Ayetoro was written by Nigerians and was published in 1967 with the Teachers Guide. The syllabus was conceived to be child-centred with emphasis on the discovery teaching method and laboratory oriented activities.

SELF ASSESSMENT EXERCISE 2

What is the philosophy of the project?

The philosophy of the project is "Doing science the way the scientist do it", observing carefully, reporting honestly what is observed and being patient. The underlying theme of the project is energy transfer – how energy is acquired, supplied and transferred between living organisms and their surrounding.

The contents of materials produced for the project were divided into two main blocks. Block I for Form One and Block II for Form two. In block 1, there were five units while block II contain four units.

SELF ASSESSMENT EXERCISE 3

What are the topics listed in each of the units in the two blocks?

Block I, with five units:

Unit I - Introduction to Science
Unit II - Heat
Unit III - Mechanics
Unit IV - Electricity
Unit V - Chemistry

Block II, with four units:

Unit I - Small organisms and cells
Unit II - Food and Nutrition
Unit III - Diseases
Unit IV - Ecology

The project was not widely adopted in schools, as it did not go beyond the pilot-testing stage.

SELF ASSESSMENT EXERCISE 4

What could be responsible for the project not being acceptable nationwide in Nigeria?

This could have been that the objectives of BSNSS may have been at variance with our traditional sciences curricula used in schools throughout the federation at that time and also the advent of Integrated Science syllabus worldwide.

3.2 The Nigerian Integrated Science Project (NISP)

The NISP was the first science curriculum project developed by STAN in 1970.

SELF ASSESSMENT EXERCISE 5

What are the skills that the project expected students to acquire in Integrated Science?

Some of the skills listed for the students to acquire after having been exposed to a course in integrated science are observing, measuring, classifying, reporting, organizing, generalizing, predicting and experimenting.

SELF ASSESSMENT EXERCISE 6

Give the name of the approach used in the NISP.

STAN commissioned its members to write Pupils Textbook and Teachers Guide for the NISP with emphasis on the child-centred approach which was basically activity-oriented. This means involving the students actively in open-ended laboratory activities just like being a scientist.

The philosophy of NISP was designed to assist the child to:

gain the concept of the fundamental unity of science;
gain the commonality of approach to problems of a scientific nature;
gain an understanding of the role and function of science in everyday life and the world in which he/she lives.

The contents of materials produced for NISP were divided into six units. These are:

Unit 1 You as a living thing
Unit 2 You and your home
Unit 3 Living components of the environment
Unit 4 Non-living components of the environment
Unit 5 Saving your energy
Unit 6 Controlling the environment.

3.3 The Nigerian Secondary Schools Science Project (NSSSP)

The Nigerian secondary school science project was developed by the Comparative Education Study and Adaptation Centre (CESAC) in 1970. The centre was formerly at the University of Lagos, Lagos but has now been merged with the former Nigeria Educational Research Council and the Nigerian Language Centre to form the new Nigerian Educational Research and Development Centre.

SELF ASSESSMENT EXERCISE 7

What method of teaching does the project adopted?

The general purpose of the project was preparation of the young ones for useful living in the society and higher education through training in the use of both the brain and the hands. It hoped to teach

conceptual thinking with manipulative skills so that adequate foundation may be laid for the improvement of Nigeria. The approach is on discovering facts, explaining them and applying them. Rote learning is to be completely discouraged.

Chief H.M.B Somade was the original Director of the project from 1968 – 1975. The next Director was the late Dr. O. Ozoro from 1975 – 1982. Dr. U. M. O. Ivowi was the last acting Director of CESAC. Support for the project came from the Ford Foundation through Dr. Adam Skapski and later by the Federal Government.

The materials produced for the NSSSP were based on CESAC's alternative syllabus which was accepted by WAEC for use in examining School Certificate candidates. These materials include; Senior Secondary biology textbooks I-III. Chemistry textbooks I-III, and Physics text books I-III. Teacher's guides were also prepared for each book. Textbooks for students and Teachers Guides were developed for the three science subjects namely: biology, chemistry and physics as Books
1, 2 and 3. The book 1 is for Year III, Book 2 for Year IV and Book 3 for Year V.

The textbooks were used throughout the country by several associate and volunteer schools on a trial basis.
The CESAC, before its merger, has revised the senior secondary syllabus and has also developed a core curriculum for the senior secondary level.

3.4 The National Science Curriculum for Senior Secondary Schools

The advent of the new 6-3-3-4 system of education in Nigeria called for the development of new curriculum in every subject area for both the junior and senior secondary levels of education.

In science subjects namely biology, chemistry and physics new curricula were developed which was referred to as National Science Curriculum for Senior Secondary Schools.

SELF ASSESSMENT EXERCISE 8

What do you think was responsible for the advent of this project?

The critique of the draft copy of NSSSP submitted to the Joint Consultative Committee on Education (JCCE) by CESAC resulted to the birth of National Science Curriculum for senior secondary schools.

The new senior secondary schools science curriculum adopted spiral or concentric approach to the teaching of concepts through the use of guided discovery method. This was to ensure that learning as an activity takes place during exploration, experimentation and discussion.

SELF ASSESSMENT EXERCISE 9

Could you suggest how the teaching syllabi were arranged?

The science curriculum has its contents arranged in a logical, developmental and sequential order. The performance objectives for each topic in the curriculum were identified. Also the teaching syllabi were arranged into five sections namely:

Topic
Performance objectives
Content
Activity
Notes.

The curriculum also recommended the use of improvised local materials.

4.0 CONCLUSION

This unit examined the details of the science curriculum innovative projects undertaken at secondary school levels in Nigeria. The issue of curriculum in science education has been a highly controversial one, in the sense that, there has never been a yardstick by which various science curriculum projects designed for use in schools could be measured, thus there is no definite ways to ascertain whether the use do meet their set objectives.

5.0 SUMMARY

In this unit, you learnt that:

Basic Science for Nigerian Secondary Schools (BSNSS) was the first pioneering science curriculum project undertaken in Nigeria between 1963 – 1967 at the Comprehensive High School Ayetoro.

Nigerian Integrated Science Project (NISP) was the first science curriculum projects to be developed by the Science Teachers Association of Nigeria (STAN) in 1970.

Nigerian Secondary Schools Science Project (NSSSP) was developed by the Comparative Education Study and Adaptation Centre (CESAC) in 1970.

National Science Curriculum for Senior Secondary Schools came into being as a result of the birth of the new education policy called 6-3-3-4 system in Nigeria.

6.0 TUTOR-MARKED ASSIGNMENT

Draw a table to reflect the distribution of the major topics in Physics over the three years under the National Science Curriculum for Senior Secondary Schools.

7.0 REFERENCES/FURTHER READINGS

Ogunleye, A.O. (1999). Science Education in Nigeria: Historical Development Curriculum Reforms and Research. Sunshine International Publications (Nig.) Ltd.

Omolewa, M. (1977). Some Earliest Problems of Science Education in Nigeria (1959 – 1982). Journal of Science Teachers Association of Nigeria, 15 (3), 72 – 92.

UNIT 3 PSYCHOLOGICAL THEORIES OF LEARNING AND THEIR IMPLICATIONS FOR SCIENCE TEACHING 1

CONTENTS

1.0 INTRODUCTION

Students generally already have their patterns of thinking. How do these expand to include new ones? How are concepts formed in the human mind? Can the concepts in science be handed over entire and ready-made or must the learner build them up for himself step by step? What are the science concepts we hope to encourage our students to develop? Various cognitive psychologists such as David Ausubel, Jerome Brunner, Robert Gagne and Jean Piaget to mention few have attempted to provide answers to these questions. Answers to these questions carry very large consequences for the organization of science lessons.

2.0 OBJECTIVES

After studying this unit, you should be able to:

Describe David Ausubel's theory of learning.
Discuss the implications of David Ausubel's theory of learning to science teaching and curriculum development.
Describe Jerome Brunner's theory of learning.
Discuss the implications of Jerome Brunner's theory to science teaching and curriculum development.

3.0 MAIN CONTENT

3.1 David Ausubel's Theory of Learning

Ausubel's theory of learning distinguishes between rote and meaningful learning of science and how prior knowledge affects the learning process of science. (Ausubel,1960). Ausubel therefore stresses the value of prior (i.e. previous) knowledge in students learning. It is generally accepted that what a student already knows could aid or hinder new learning. According to Ausubel as cited in Abdullahi (1982), meaningful learning occurs when there is appropriate link between prior knowledge and new learning task i.e. interaction between the students' appropriate elements in the knowledge that already exists and the new material to be learnt. When there is no such interaction, rote learning occurs.

SELF ASSESSMENT EXERCISE 1

What is the meaning of subsumer?

Those parts of the learner's cognitive structure (organization of knowledge), which can provide for the interaction necessary for meaningful learning are called Subsumers.

Subsumer, according to Ausubel is defined as a principle or generalised body of knowledge that the learner already acquired that can provide for association or "anchorage" for the various components of the new knowledge. That is a new learning must be linked to the existing knowledge to create meaning. Where relevant subsumers do not exist to link new materials with the previous knowledge, 'advance organiser' can be introduced.

SELF ASSESSMENT EXERCISE 2

What is advance organiser?

Ausubel advocates for introduction of what he called advance organiser. Advance organizers are alternative set of link or 'anchorage'. Ausubel is an advocate of verbal learning. He proposes that meaningful learning can take place by two processes namely:

the use of relevant subsumers when they exist in the knowledge already possessed by the learner, and
the use of advance organisers where the subsumers are absent.

3.1.1 Implications of David Ausubel's Theory of Learning for Science

Teaching and Curriculum Development

Teaching of science subjects must not begin until the teacher is sure of previous knowledge and if not, it should be provided.
Teaching of science subjects must begin with new learning or knowledge in a sequential manner.
Science teacher must not present new materials during teaching unless the learner is ready.
Ausubel supported the use of expository method in teaching of science subjects as the method can lead to high level of understanding and generality as against the use of discovery approaches which are extremely time consuming.
Contents in the science curriculum must be arranged in sequential order.

SELF ASSESSMENT EXERCISE 3

What is discovery?

3.2 Jerome Brunner's Theory of Learning

Jerome Brunner introduced the concept of learning by discovery. Discovery is used according to this theory as all forms of obtaining knowledge for oneself by use of one's mental processes. Brunner believed that learning by discovery begins when science teacher purposefully create problem and present the problem to students by introducing some inconsistencies among source of information which are given in the process of instruction. According to Brunner such inconsistencies lead to intellectual discomfort that will stimulate (i.e. motivate) the students to initiate individual discoveries through cognitive restructuring (i.e. internal reorganization).

SELF ASSESSMENT EXERCISE 4

How many forms of discovery processes does Brunner say exist?

According to Brunner (1960), two forms of discovery process exist, which are:

Assimilation: This occurs when a student spontaneously recognizes a new situation that is familiar to one of the elements in his existing structure of knowledge (i.e. cognitive structure) and he easily assimilates it.

Accommodation: This occurs when a new situation (i.e. new knowledge) is incompatible to the existing structure of knowledge (i.e. cognitive structure). The learner first restructures (i.e. organises) his cognitive framework in order to be able to accommodate the new knowledge.

SELF ASSESSMENT EXERCISE 5

Name the three types of human activities for learning which Brunner's theory emphasized.

Brunner's theory emphasizes that the students should find out information on their own through the use of mental processes. It also places great importance on the three types of human activities for learning i.e. the three information-processing systems, which are:

(i) Physical activity (i.e. motor activities) referred to as Enactive representation.
(ii) Imagery referred to as Ionic representation.
(iii) Symbolic activities.

The three activities coexist with each other and for this reason the attainment of one does not mean the total abandonment of the others.

SELF ASSESSMENT EXERCISE 6

List the activities that accompany each of the three information processing systems.

At enactive stage: The child manipulates the learning materials directly by neuro-muscular activities.
At ionic stage: The child deals with mental images of objects but could not manipulate the objects directly.
At symbolic stage: The child uses language to express the objects.

The interpretation of these three stages together is that when a child at junior secondary school level for example shows deficiencies in his learning capacity especially in symbolic representation, it could be that such a child was deficient at the two earlier stages, which he/she skipped. It is therefore compulsory to fill in the skipped gap by providing concrete support that will make up for the deficiency.

3.2.1 Implications of Jerome Brunner's Theory of Learning for Science Teaching and Curriculum Development

Science teachers should place great emphasis on the most important ideas and relationships of a subject, thus offering a structure that will allow students to generate new concepts, ideas, relationships and principles.

Science teachers should deliberately create or present problems for the science students either in form of apparent contradictions or inconsistencies among sources of information, which are given in the process of instruction. Such inconsistencies according to Brunner lead to 'intellectual discomfort' that will result into students initiating individual discoveries through cognitive structuring.

Science teachers should encourage discovery learning in the science class as these aids problem-solving and development of creativity in the science students.

Science teachers should encourage science students to make intuitive guesses more systematically as this will make students to have a chance to practice their ability to go beyond the information given.

Science teachers should be inductive.

Science teachers should emphasis on a radical reorganisation of the science curriculum across all school levels such that in the new curriculum, the fundamental structure of all the subjects students are likely to encounter throughout the school years are presented very early in a very simplified form.

4.0 CONCLUSION

The importance of psychological theories of learning to both science teachers and students cannot be overemphasized. In the light of this, the study and application of the two theories discussed in this unit should be intensified.

5.0 SUMMARY

In this unit, you have learnt that:

- David Ausubel's theory of learning stresses
- the value of prior knowledge;
- that meaningful learning takes place when there is appropriate link between prior knowledge and new learning task
- sequence of instruction.

- Jerome Brunner's theory of learning centers on:
- learning through discovery
- discovery aids problem-solving and creativity development
- two forms of discovery namely: assimilation and accommodation.

Three types of human activity for learning namely:

- Enactive representation
- Ionic representation
- Symbolic activities.

6.0 TUTOR-MARKED ASSIGNMENT

1. Discuss how you as a physics teacher will apply Jerome Brunner's ideas in the teaching of physics in your laboratory.

7.0 REFERENCES/FURTHER READINGS

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UNIT 4 PSYCHOLOGICAL THEORIES OF LEARNING AND THEIR IMPLICATIONS FOR TEACHING II

CONTENTS

1.0 INTRODUCTION

In the last unit, you studied two cognitive psychologists whose works have had tremendous impact on teaching/learning process. These two and other psychological theories that you will learn in this unit are very important and valuable because they are fundamental theoretical foundations for the present instructional strategies in science teaching.

In this unit, you will learn about other two cognitive psychologist namely Robert Gagne and Jean Piaget as well as the general implications of the theories for science teaching and curriculum development.

2.0 OBJECTIVES

After studying this unit, you should be able to:

Describe Robert Gagne's theory of learning;
Discuss the implications of Robert Gagne's theory of learning to science teaching and curriculum development;
Describe Jean Paget's theory of learning;

Discuss the implications of Jean Piaget's theory of learning to science teaching and curriculum development.

3.0 MAIN CONTENT

3.1 Robert Gagne's Theory of Learning

Robert Gagne's theory of learning is often referred to as Gagne's theory of learning hierarchy. The theory states that the learning of a new concept or skill depends upon the mastery of prerequisite concepts. This implies that prior (i.e. previous) knowledge determines what further learning may take place and that materials meant for learning must be sequentially structured by the science teacher. Gagne emphasizes the importance of task analysis of instructional objectives. He also believes in task analysis of the concepts, skills and knowledge to be taught.

SELF ASSESSMENT EXERCISE 1

Name the highest level of Gagne's learning hierarchy.

Gagne's Theory believes that in order for the students (i.e. learners) to acquire the desired knowledge (i.e. terminal task), the materials meant for learning must be sequentially structured so that the learning of one topic (i.e. acquisition of one knowledge) aids the learning of the next higher topic (i.e. acquisition of the next higher knowledge). This invariably implies that learning of science must be sequentially structured by the science teacher from simple to complex until the desired objectives are achieved. In Gagne's hierarchy of learning, problem-solving is the highest level while the lower levels involved facts, concepts and generalization.

SELF ASSESSMENT EXERCISE 2

What is the importance of pre-testing in the teaching/learning process?

Gagne's theory also advocated the administration and use of pre-test to find whether the students possess the relevant prerequisites for the next knowledge (i.e. higher knowledge) (Akanbi & Opasina, 2000). The result of the pre-tests will help the teacher to know the entry point for teaching/learning process to begin in the hierarchy of learning tasks. Gagne also suggests that in a teaching/learning situation, the teacher should begin with a question like "what is it that I want the learner to be able to do?" The answer to this question should form the statement of objectives which must be stated in behavioural form.

3.1.1 Implications of Robert Gagne's Theory of Learning for Science Teaching and Curriculum Development

For learning of science to be effective, contents in science subjects should be arranged in hierarchical order so that those simpler concepts are mastered first before the more complex ones.

Science teachers should carefully state the objectives for learning any topics in science subjects.

Science teachers should arrange the learning tasks sequentially so that the learning of one science topic should aid the learning of the next higher topic until the desired body of knowledge or skills is acquired.

The contents in science curriculum should be arranged hierarchically so that simpler contents are treated first at lower class before the complex ones at higher class.

After completing the structured hierarchy of learning tasks, the teacher administers diagnostic pre-tests in order to find out the point where the learning hierarchy can start.

3.2 Jean Piaget's Theory of Learning

Jean Piaget, a developmental psychologist pioneered the studies on cognitive and mental development. Piaget's theory emphasize that learning ability corresponds to the level of intellectual development (i.e. cognitive development).

SELF ASSESSMENT EXERCISE 3

What are the developmental stages identified by Jean Piaget?

The four human intellectual developmental stages identified by Piaget together with the approximate ages to which they correspond are as follows:

Stage		Age
-	Sensory – motor stage	0 – 2 years
-	Pre – operational stage	2 – 7 years
-	Concrete operational stage	7 – 11 years
-	Formal Operational stage	11 – 15 years

3.2.1 Sensory – motor stage (0 – 2 years)

This stage can be thought of as a pre – verbal stage. The entire child's learning activities at this stage consist mainly of sensory and motor activities like seeing, sucking, tasting, touching, pushing and shaking the objects in his/her environment. The child also learns that objects are permanent and go out of existence when they can no longer be seen. The child experiences during that period form the basis for later knowledge. By the end of the period, certain aspects of the child's behaviour can be called Intelligent. He/she can, for example, pull a string to get an object or pull a blanket on which an object is resting.

In this stage, the major intellectual activity is interaction of the senses and the environment.

3.2.2 Pre – operational stage (2 – 7 years)

SELF ASSESSMENT EXERCISE 4

What is operation in Piaget's theory of mental development?

The term 'operation' in Piaget's theory of mental development is a way of thinking that follows a definite pattern. It is a subconscious act of thinking which is prerequisite to logical reasoning. Urevbu (1990) has it that until a child can think 'operationally', he/she is unable to completely analyze or organize information presented to him.

SELF ASSESSMENT EXERCISE 5

List the child attributes at pre-operational stage.

At the pre – operational stage, the child may be able to speak clearly, use symbolic representations by drawing, writing and reading and perform complex physical manipulations; he/she is perceptually oriented and cannot reason logically or see contradictions that, to an adult, are glaringly obvious.

The child also develops the idea of volume, length and number. He/she easily confuses the physical changes of an object with the change in quantity of the object. For example, if the same volume of soft drink is poured into two different cups having different shapes e.g. narrow and wide. To the child, the soft drink in the narrow cup is more than the wide one, which illustrate that the child has confused height with volume. At this stage, the thinking of the child is irreversible.

At this stage also, the child represents objects by images. For this reason, he constantly reorganizes his picture of the world (i.e. his/her

environment) through imaginative play. The child also uses language (i.e. words) by talking, questioning, listening and experimenting. Talking to self or object is part of the characteristics of this stage.

3.2.3 Concrete – operational stage (7 – 11 years)

At the concrete operational stage, the child's mental process is limited to thinking about things. He is able to solve problems, but he/she is limited in his ability to do so. He/she is limited by the nature of the problem. Problems involving concrete objects that can be observed and manipulated can be solved. He/she cannot cope with problems where hypothetical situations must be considered, beyond simple extensions, extrapolations or interpolations. In consequence, solutions are achieved mainly by trial – and – error. A child at this stage also develops the ideas of conservation of matter, length, weight, volume and concepts of time and space.

SELF ASSESSMENT EXERCISE 6

What is the implication of concrete – operational stage?

At this stage, the child performs logical operation with concrete objects, which implies that the child can carryout some logical processes like observing, describing, classifying and measuring real objects.

The implication of this stage to primary school years is that it is a period of exploration (i.e. the time for children to examine relationship between man and the physical and biological environment). This implies that the study of science in primary schools should begin with the art of observation, which involves the use of the basic senses of seeing, smelling, hearing, touching and tasting. Greater emphasis should be placed on doing than telling i.e. talking. Teaching at this stage should involve the use of models i.e. specimen, real objects, apparatus etc. because the child depends on facts and not theories.

3.2.4 Formal operational stage (11 – 15 years)

SELF ASSESSMENT EXERCISE 7

How does this stage relate to other earlier discussed developmental stages?

Progression through the previous stages results in accumulation of experiences and development of mental structures, which are necessary background for logical and prepositional reasoning. This stage is characterized by freedom from reality. Reality provides merely a

starting point for thinking, the first step being the consideration of other possibilities. At this stage also, the child develops abstract thinking. He can think in abstract terms. He has developed full formal patterns of thinking. He can follow logical arguments. It is only when this stage has been reached that the more complex relationships of mathematics and science and the hypothetico – deductive nature of reasoning can be fully understood. The child at the formal operational stage can make deductions, comparisons and inferences from ideas. The child can solve ideological problems and can relate symbols with concepts.

3.2.5 Implications of Jean Piaget's Theory of Learning for Science Teaching and Curriculum Development

Science teachers should promote exploration and interaction with environment using locally available materials.

Science teachers should ensure that learners deal with concrete materials before going to the complex ones. Later they will learn abstract concepts and generalizations.

Science teachers should commence teaching of science concepts starting from simple to complex ones.

Science teachers should present new ideas and knowledge at the level consistent with the child's present state of development thinking and language.

Science teachers should focus on problem solving rather than rote memorization during teaching / learning process.

Science curriculum should be designed in such a way that student will have opportunities to perform desirable mental operations.

4.0 CONCLUSION

In this unit, you have been exposed to two cognitive psychologists namely Robert Gagne and Jean Piaget. You have equally been exposed as a science teacher to implications of the two theories for science teaching and curriculum development.

5.0 SUMMARY

In this unit, you have learnt that:

Robert Gagne's theory of learning which is often referred to as Gagne's theory of learning hierarchy states that the learning of a new concept or skill depends upon the mastery of prerequisite concepts.

Gagne believes that the materials meant for learning must be sequentially structured.

In the implications of Gagne's theory for science teaching and curriculum development:

- contents in science should be arranged in hierarchical order.
- Emphasizes on science teachers stating the objectives for learning science topics…..
- Emphasizes on pre-testing……..

Jean Piaget's theory of learning emphasises that learning ability corresponds to the level of intellectual development.
Piaget identified four human intellectual developmental stages as:

- sensory – motor stage (0 – 2 years)
- pre-operational stage (2 – 7 years)
- concrete operational stage (7 – 11 years)
- formal operational stage (11 – 15 years)

in the implications of Piaget's theory for science teaching and curriculum development, the following are proposed:

- science teachers should make use of locally available materials to promote exploration and interaction with environment.
- Science teachers should commence teaching from simple concepts to the complex ones.
- Science teachers should place emphasis on problem solving rather than rote memorization.
- New ideas and knowledge to be presented by the science teacher should be at the appropriate level and consistent with the child's level of development thinking and language.
- Science curriculum should be designed to give learners the opportunities to perform desirable mental operations.

6.0 TUTOR-MARKED ASSIGNMENT

List and discuss the Jean Piaget's general principles of how you, as a physics teacher, should teach physics in your laboratory.

7.0 REFERENCES/FURTHER READINGS

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MODULE 3 METHODS AND TECHNIQUES OF TEACHING PHYSICS

INTRODUCTION

This third module deals with another very important aspect associated with methods of teaching and issues to consider in selecting the techniques and the resources for teaching Physics. The module also focuses on providing necessary information on documents that are available for teachers to teach physics, the physics laboratory in your school, its design, safety and organisation and how the physics teachers will assess physics teaching in school. This module is divided into five units as follows:

Unit 1 Methods of teaching physics
Unit 2 Resources for teaching physics
Unit 3 Preparation for teaching physics
Unit 4 Physics laboratory design, safety and Management
Unit 5 Evaluation of science teaching and learning with reference to physics

UNIT 1 METHODS OF TEACHING PHYSICS

CONTENTS

1.0 INTRODUCTION

The word teaching embraces curriculum planning, instruction, measurement and evaluation. Several methods are available for lesson presentations. However, experiences have shown that no teacher restricts himself to a single method in lesson presentations. Usually, related methods are combined to present lessons successfully. The methods of teaching are the approaches or means, which a teacher could adopt in order to carryout the function of instruction of lessons. Some of the methods used by science teachers in presenting scientific information, principle or skill to the pupils include: lecture or chalk-talk, demonstration, discussion, project, discovery, laboratory or

investigative, field trips, etc. Each method specifies the various activities to be carried out by both the teachers and learners in order to achieve the stated objectives of an instructional programme or a lesson. Modern theories of learning and trends in educational practices emphasize teaching methods, which are learner-centered as opposed to those that are teacher-centered.

SELF ASSESSMENT EXERCISE 1

In selecting the methods to teach a topic in physics, list the key factors that must be considered?

2.0 OBJECTIVES

After studying this unit, you should be able to:

List some methods that are adequate for teaching physics;
Describe the activities involved in each method;
State the advantages and disadvantages of each method;
Explain the factors to be considered in choosing any method(s) to be used for teaching a particular lesson.

3.0 MAIN CONTENT

3.1 Selection of Teaching Method

In selecting appropriate methods of teaching in physics, teachers are guided by the following factors:

(i) Learners' age and expected previous experiences in the topics to be taught.
(ii) Suitability of the method for topic under discourse
(iii) Competence of the teacher to use his/her chosen/selected method
(iv) Size of the class
(v) Resources available for instruction and teaching e.g. laboratory, library, computer, models, charts, realia, etc.
(vi) Time when lesson or topic will be taught (morning, afternoon or evening).

Age of the learners: Delicate equipment as well as hazardous chemicals will not be left for young learners to handle. Therefore, laboratory method involving such will be wrong method to be used at this level. The demonstration method will be a better choice.

Suitability of the method: Certain techniques will be used to achieve the stated instructional objectives better than others. The lecture method for instance will teach factual information – laws, concepts, principles, while the laboratory method will teach practical skills better respectively. Similarly, the inquiry or discovery method and project

method will teach problem solving skills better than discussion or lecture methods.

Competence of teachers to use a particular method: The physics teacher should select a method that he or she can effectively handle. This implies that if the teacher feels more competent in the lecture method, regardless of its limitations that method should be employed instead of using another method which the teacher is not proficient and therefore cannot use effectively.

Size of the class: The size of a class is an important factor to consider in selecting a method to teach physics lesson. Large classes are better taught using lecture and discussion methods. However, laboratory methods will make use of small groups or individual learners.

Resources available for instruction: The resources available to a teacher often constrain him/her to the method(s) to select. If a school does not have a laboratory for instance, it is impossible for the teacher to employ the laboratory method. However, he can use the demonstration method in the class to show some of the practical skills or use the field trip or excursion methods where students will visit industries to see things done practically. If the school has computers, he can simulate some practicals that are difficult to perform in the laboratory.

Time of the lesson: The learners are more active in the morning hours than later in the day when boredom and tiredness may set in. Therefore a selected teaching method must be such that make the learners active participants. A lecture method adopted in the morning will therefore be more effective than in afternoon during the heat of the sun. It must be noted that no single teaching method is recommended by experts for teaching physics. The choice is left in the hand of the teacher and the method could change or vary as many times as the need arises depending on the concept, skill or attitude that is to be developed in the learners.

SELF ASSESSMENT EXERCISE 2

Take a particular topic in physics and select a teaching method/method(s) you consider effective for teaching it. Justify your selection.

3.2 Methods of Teaching Physics

The methods of teaching physics could be grouped into two:

(i) The general methods

(ii) Specialized methods or strategies.

The general methods of teaching physics include:

- lecture method for large group or class
- discussion method for small group or class
- demonstration method
- experimentation/laboratory method
- discovery/inquiry method
- project method
- field trip/excursion method.

The specialised methods are used for specific purposes in physics teaching. They include:

- Concept learning/attainment methods or techniques e.g. concept mapping, mapping/diagram, etc.
- Rule learning technique e.g. Advance Organizers
- Algorithms and procedure learning techniques
- Problem solving, problem based – learning techniques
- Model – based teaching strategies for difficult and abstract physics concepts – uses analogies, simulation, vignettes, etc. to create understanding
- Conceptual changes strategies e.g. concept mapping chucking, framing, rehearsals, mnemonics etc.

Lecture Method: This is the most popular teaching method used by teachers in presenting scientific information – ideas, concepts, laws, generalization, theories and facts. It is a one-way communication approach in which the teacher dishes out the points, explains a process, clarifies issues or summarizes a discussion. The students are passive. They only listen and perhaps take notes. It has its merits and demerits. It allows for easy handling of large classes, leads to easy coverage of cognitive aspects of syllabus, and entails economy of time, effort and teaching materials. On the other hand, it renders learners passive, does not develop critical thinking and creative ability in learners, involves only the sense of hearing, does not meet the varied needs of the mixed ability group in large class, and leads to disciplinary problems as learners become restless and disruptive. It encourages rote learning.

Demonstration Method: This is used for explaining how to use an equipment, how to carryout an experiment, how to solve a mathematical problem, or how to do anything in a specified way. The teacher demonstrates while the learners observe. It is used as an exhibition lesson or to show parts of an object or to show the correct use of science equipment by the teacher to the students. The demonstration method is

not synonymous with the laboratory method. A laboratory experiment is used to verify a science principle or as a means of observing, measuring or interpreting data. Also laboratory method involves exercises or activities in which all members of the class participate to find out something for themselves. But the results of experiments or demonstration are known to the teacher who either due to time, space or resources cannot allow every member of the class to carry it out, so he performs it to show the learners.

The advantages of this type of teaching method include:

1. It is an attention-inducer and a powerful motivator when used at the beginning and ending of a lesson.
2. It saves time and materials
3. It enables teachers to show the learners the correct use of equipment to avoid breakages and accidents and how to secure reliable measurements and results
4. Enables the teacher to review students experiments
5. It enables the teacher to handle activities that may be dangerous to students e.g. those involving high voltage, radio-active materials, etc.

Its disadvantages include:

1. It does not allow the pupils to develop manipulative skill.
2. Pupils may have difficulty in seeing details of the object/experiment being demonstrated.
3. It offers less scope for learners to observe, touch, manipulate or record events.
4. It involves only the senses of hearing and sight.

SELF ASSESSMENT EXERCISE 3

(a) Discuss any four methods of teaching physics.
(b) State their advantages and disadvantages.

The discovery method / inquiry method: The discovery method involves a structured or unstructured exploration in the laboratory in which the student, through his mental processes such as observing, measuring, classifying, hypothesizing, etc. can draw conclusion from data, which has been gathered and analysed.
There are two types of discovery method namely: (1) Guided inquiry (2) Unguided inquiry methods. Both involve "finding out" and lead to what is generally regarded as the scientific method, which includes the following processes:

1) Formulating problem for investigation
2) Formulating hypothesis to guide the investigation
3) Designing experiment to collect data
4) Analyze and synthesise data to form generalization or solution to problem
5) Possessing/acquiring certain scientific attitudes such as objectivity, curiosity and open mindedness.

Advantages

1. Equips the learner to be the builder/owner of his knowledge through active participation and leads him to become problem solver.
2. Instruction is student – centered.
3. inculcates manipulative skills.
4. Retention, recall and transfer of knowledge is facilitated
5. Encourages analytical thought and promotes intuitive development.

Disadvantages

1. It is slow and time consuming method and so less content is covered.
2. Effective teacher supervision is difficult for a large class size
3. The method is cost intensive as equipment and apparatus involved cost a lot of money.
4. Is student placement centered and may not achieve much in imparting organised body of knowledge into learners.

Discussion Method: This method contrasts with the lecture method. It is learner-centered and is anchored on the principle of self construction of knowledge. That is an individual is the sole builder or owner of his knowledge. So knowledge springs from within the individual and not from external sources. Here, the teacher's role is to moderate or facilitate learning process, negotiate and act as catalyst to set the learner's mind into thinking and reflection on an issue or topic or concept. This method presumes that the learner is not an empty slate ready to be written on. Rather he/she has some knowledge which may be wrong or right about a given concept. The teacher's role is to help the learner to build on this prior knowledge. His thought provoking questions will not only act as guide to the learners line of thought but will also motivate them to reason more and recall less. This will lead to reflection and originality of ideas.

Advantages of discussion method

1. It is useful in motivating students' activities

2. It develops positive interpersonal relationship between the students themselves and with the teacher
3. Students construct/build their own knowledge through active participation
4. It builds confidence into the learner as he/she is the owner of the knowledge.

Disadvantages

1. Does not allow for easy coverage of syllabus
2. Not all topics can be handled through discussion since there are topics in which students may not have any prior knowledge
3. Students with knowledge in the topic under discourse loose interest and get bored.
4. If the discussion lasts for a long time, attention of learners may wade.
5. It consumes a lot of time during the course of knowledge negotiation.

Project method: This is used either to reach individual students or small groups so as to help them get fulfilled. Project method unlike the verification aims of the laboratory or experimentation method, requires originality from the student. The student may generate his / her own problem or the teacher provides one. The problems could be found in textbooks, journals, abstracts, classroom interactions, field trips, etc. which will constitute the project topic.

Laboratory method: This is an activity packed method for individual or group of learners targeted at making personal observations of processes, products, or events. There are two procedures which characterize this method. These are laboratory exercise and experiments. The laboratory exercise involves activities carried out in order to provide practice in designing, operating and interpreting experiments. The experiments are procedures used for the purposes of testing a hypothesis, confirming what is known and discovering new things. All laboratory exercises/activities are experiments but not all experiments are laboratory work.

Advantages of laboratory method

1. Adequate for illustrating scientific principles, laws and inculcate in students how to write laboratory reports.
2. Provides opportunity for students to develop practical and manipulative skills while using science equipment and apparatus.
3. It enables students to imbibe the culture of replication of experiments done by others in the past.

4. Inculcate the habit of critical thinking and improves understanding of concepts, laws, principles and facts.
5. It leads to better retention and recall of scientific information, hence engenders positive attitude towards science by the learner
6. It makes students to become familiar with the scientific processes of observing, inferring, classifying, measuring, interpreting data, hypothesizing, etc.

Disadvantages

1. It is expensive as equipment and apparatus must be bought.
2. Delicate and dangerous experiments may lead to accident.

Field trip Method: This method adopts excursion taken outside the classroom for the purpose of making observations and obtaining specific information/data. It replicates demonstration method but in the real world where the teacher is not in charge.

Advantages

1. It helps to create a positive attitude in the learner towards science as he/she sees the "real life" application of laws, principles, concepts in industry and commerce.
2. It involves many of the senses of the learner and therefore make them to create keen interest in the learning most especially the young ones.
3. It enables stronger student – student and teacher – student relationship to be built which will in turn be of use in discussing formal lessons in class.

Disadvantages

1. It is difficult to plan and execute.
2. It entails extra financial burden for the school and the learner who may be asked to pay for the trip.
3. There is the fear and danger of accidents.

4.0 CONCLUSION

No single teaching method is a "sine qua non" for teaching physics. However, some strategies/techniques are more effective than others depending on the size of class, age of learners, topic involved, time of lesson and the stated objectives for the lesson. Each method has its merits and demerits. An effective lesson combines two or more methods to achieve various stated objectives of a lesson.

5.0 SUMMARY

In this unit we have discussed some of the general methods of teaching physics, their advantages and disadvantages and how to select them to teach a particular topic or lesson. An experienced teacher must be flexible on the methods and could vary them even during a single lesson. The overriding principles are that the learner must be actively engaged and participate in constructing his/her own knowledge. In physics in particular, he/she should also be made to solve problems; develop critical/reflective-thinking skills as well as manipulative skills through the methods adopted.

6.0 TUTOR MARKED ASSIGNMENT

1. Take a topic in physics, list your instructional objectives, select teaching strategies which you consider effective for achieving your stated objectives. Justify your selection.

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UNIT 2 RESOURCES FOR TEACHING PHYSICS

CONTENTS

1.0 INTRODUCTION

In this unit, we will address the issue of resources required for teaching physics. Learning resources for teaching or instructional materials are devices or tools, which facilitate the quality of instruction (teaching) and learning. They are no substitute to the teacher, rather they are to be used by the teacher in making teaching and learning more meaningful, and effective. Therefore, this unit will further focus on classification, functions and selection as well as production/improvisation of teaching resources.

2.0 OBJECTIVES

After studying this unit, you should be able to:

List resources for teaching physics
Classify resources for teaching physics
Justify the use of resources for teaching physics
State and discuss reasons to be considered in selecting resources for teaching a particular physics topic or lesson.
Describe the resources for teaching giving their merits and demerits.

3.0 MAIN CONTENT

3.1 Resources for Teaching Physics

The resources for teaching physics are almost inexhaustible and limited only by the creativity and resourcefulness of the teacher. They include all form of information carriers that can be used to promote and encourage effective teaching and learning activities. They could be in form of textbooks, reference books, journals, posters, charts, programmed texts, non-print materials such as films, tapes, models, pictures, recorders, transparencies, apparatus, and chemicals, laboratories, and realia (real object). Others are experiments, specimens, symbolic and pictorial representations, etc. Because the learning/teaching resources are many and varied, the physics teacher must be careful to select resources on their merits to enable him/her achieve the stated instructional objectivities.

3.2 Classification of Instructional Materials/Resources

Resources for teaching physics can be classified into human and material resources. The material resources can further be classified into tangible and intangible resources. The tangible resources are grouped into visual, aural and audio-visual aids. The intangible resources consist of methods and techniques of instruction. The human resources consist of the physics teacher, the learners and the resource persons as well as the entire academic and non-academic staff of physics department.

A further breakdown of the resources can be given as shown below:

Visual resources: These are resource materials or tools which appeal to the sense of sight and touch as well as smell. They can be classified into:

1. Non projected resources – the chalkboard and adhesive,
2. Pictorial resources or aids – charts, pictures
3. Three-dimensional aids – model like, train, car, heat engine, etc.
4. Projected aids – filmstrips and slides, projector tubes
5. Laboratory equipment, chemicals and apparatuses
6. Books – textbooks, journals, magazines, encyclopaedias, etc.

Aural aids: These are resources which appeal to the sense of hearing and touch. They include:

i. Records and record players
ii. Tape and tape recorders
iii. Radio

Audio –visual aids: Resources here appeal to the senses of sight, hearing and touch. They include:

i. Sound film
ii. Sound film projector
iii. Television
iv. Video tape recorder and tapes
v. Computer

SELF ASSESSMENT EXERCISE 1

What are the major functions of the teaching resources imply?

3.3 Functions of resources for teaching physics

The functions of resources for teaching physics are many and varied. They include among others that:

i. They are sine qua non to the achievement of curriculum objectives
ii. They provide basic information which are not contained in prescribed textbooks
iii. They encourage and enhance self instruction
iv. They enrich learning through increased interaction with the learner
v. They explain, illustrate or elucidate teaching and learning activities
vi. They arouse interest of and motivates the learner
vii. They support/enhance teachers' presentation of the learning task.

SELF ASSESSMENT EXERCISE 2

What factors would you consider as a physicist/physics teacher in selecting the resources for teaching a particular content?

3.4 Selection and use of resources for teaching physics

The extent to which instructional resources facilitate teaching and learning activities leading to the attainment of the lesson objectives depends to a large extent on the adequacy and appropriateness of materials/resources selected. This implies that teaching resources are not selected haphazardly. There is therefore the need for criteria or guidelines, which will enable the teacher to select resources that will enhance and maximize the teaching – learning process.

The following criteria are of importance:

a) Relevance
b) Appropriateness
c) Availability
d) Quality
e) Cost
f) The learners
g) Approach of producers

Relevance

The resources selected must be relevant to both the objectives and the target learners for whom the materials are to be used. This takes into account the age of the learners, level of maturation, interest, needs, ability, aspirations, aptitude, etc. Relevance of resources makes for easy and meaningful teaching and learning.

Appropriateness

The resources should suit the local community of the learners or the content under discourse. Material must relate to learners' ages, interest, experiences, etc.

Availability

The resources the teacher intends to use must be available and accessible to himself and the learners. Sometimes the best materials may not be available hence the need for the teacher to be able to improvise.

Quality

This involves consideration for the physical features of resources. These include durability, size, clarity, usefulness, drawings, paintings, weight and ease of storage. Quality resources will last more.

Cost

The teacher should be economical. So cheap but quality resources are preferable. It is also more cost effective to invite resource persons to the school rather than take the learners to the persons. Cost also has implication for time, storage and energy.

Learner as an important factor for selection and use of resources for teaching

Every child is unique due to so many factors such as socio-economic status of parent, intelligence, interests, needs and aspirations. The teacher should select resource materials that will take care of the diverse interests and needs of the learners for a meaningful interaction and learning. Materials, which will encourage interactivity and participation, are the best to be selected. Resources must also make learning interesting to the learners, be varied and combined.

SELF ASSESSMENT EXERCISE 3

What steps should guide a physics teacher in the production or improvisation of instructional materials?

3.5 Production and Improvisation of Teaching Resources

When instructional materials are either not available or expensive, the teacher must be equipped with skills to improvise instructional materials. The most simple and common ones are charts, posters, pictures, drawings, models, etc. using available local materials. Steps undertaken by a teacher in the production of instructional materials are the:

1. Selection of specific objectives
2. Identification of the characteristics of the learners
3. Selection of the content
4. Selection of the medium for prescribing the message
5. Determination of cost
6. Production of materials
7. Evaluation of improvised material.

SELF ASSESSMENT EXERCISE 4

What are resources centers? What important functions do they perform?

3.6 Resources Centres

A resource center is a place where a wide range of educational materials, equipment and information are stored. It is a place which offers services and facilities for effective utilization of available materials and equipment to promote the attainment of instructional and curriculum objectives. It could be likened to a bank where instructional materials, equipment and facilities are deposited for safe keeping but which are at the teacher's disposal to use whenever he needs them for instruction.

The resource center is usually carefully planned and stocked with materials. The physical facilities available include spaces for planning, designing, production, viewing of films, demonstrating the use of materials and their storage. Such centers also have space for workshops, seminars and in-service training of teachers, inspectors and other school administrators.

Simple repairs and maintenance services are also rendered in such centers. Equipment and materials are provided for graphics, duplicating, photocopying, typing, photographing, printing and reproduction of good instructional materials. Resource centers could be established at the federal, state, local government or school levels.

4.0 CONCLUSION

Teaching and learning are enhanced through activities. This forms the basis for use of teaching resources or materials. The resources must be selected based on a number of criteria. The resource center is a resource bank, which the teacher could consult to make teaching and learning more effective.

5.0 SUMMARY

This chapter dealt with resources for teaching and the criteria for their selection and use. Resources have been classified as human and material. It can also be classified as visual, aural, audio-visual. The role of instructional materials/resources in facilitating the achievement of curriculum and instructional objectives was also discussed. The teachers skill to improvise and steps or guidelines for such improvisation were presented. Resources centers and their essence were also discussed.

6.0 TUTOR-MARKED ASSIGNMENT

1. State and explain five criteria for the selection and effective use of resources.
2. Explain the term ‘improvisation’ of instructional materials and the steps for improvisation.
3. Why is improvisation of instructional materials important to the Nigerian teacher?

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UNIT 3 PREPARATION FOR PHYSICS TEACHING

CONTENTS

1.0 INTRODUCTION

This unit introduces you to the preparation for physics teaching in schools. The task of teaching physics could be taken as an effort made to transfer the nature of physics to the learners in a school laboratory setting. Because of the complexities surrounding the teaching of physics to students in the physics laboratory, considerable thought must be given to the planning of teaching of the subject. This unit therefore, focuses on providing necessary information on documents that are available for physics teachers to teach physics in school effectively. The documents are as follows: physics curriculum, syllabus, scheme of work, lesson plan and note of lesson.

2.0 OBJECTIVES

After studying this unit, you should be able to:

Describe a physics curriculum, syllabus and scheme of work
Prepare a physics scheme of work
Prepare a lesson plan on a chosen physics topic
Prepare a note of lesson on a chosen physics topic.

SELF ASSESSMENT EXERCISE 1

How does a physics teacher begin the teaching of physics with senior secondary students?

As a physics teacher you should begin by looking at the physics curriculum for the topics to teach and think of the materials (i.e.

reference books, resources etc) to use in the teaching before you begin to develop the lesson plan and lesson note.

3.0 MAIN CONTENT

3.1 What is a Curriculum?

The concept of curriculum has been given a range of meanings. Some educators according to Abdullahi (1982) define curriculum in terms of synonymous to syllabus, time-table and academic disciplines. It can also be referred to as an educational programme planned for a specified level of an academic institution.

The term physics curriculum can therefore be defined as:

> a systematic arrangement of a number of physics topics into a unit for a particular level of physics students.
> all physics experiences the physics students have under the schools direction

Whatever the definitions of curriculum, it should reflect all the four interrelated components suggested by Kerr (1968). In relation to physics curriculum, the four components are:

1) What is the end product of the physics instruction – objectives?
2) What is studied – the 'content' or 'subject matter' of physics instruction?
3) How are the physics study and teaching done – the "methodology of physics instruction"?
4) How the results of physics teaching are assessed – "evaluation"?

SELF ASSESSMENT EXERCISE 2

Give another definition of physics curriculum that will reflect the four interrelated components of the curriculum.

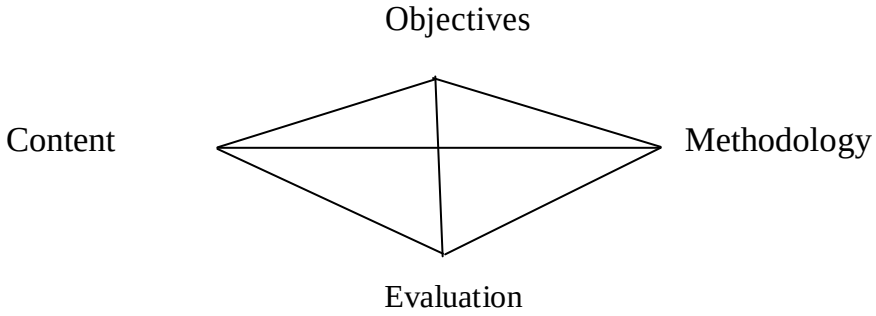

Fig. 1: Interrelated Components of Curriculum

Each component of the curriculum influences the others. For instance, objectives determine the selection of content, and methodology. Also, the methodological approach adopted for instruction is based on the objectives and content as well.

3.2 Physics Syllabus

A physics syllabus could be described as a condensed outline or statement of the main topics of a course of study in physics drawn from the broad physics curriculum of the school system. It can also be described as a broad outline of units or topics in physics arranged in a logical sequence for coverage of physics students for specific examination and certification.

There are two types of physics syllabus:

i) Physics examination syllabus
ii) Physics teaching syllabus

SELF ASSESSMENT EXERCISE 3

Mention two each of physics examination and teaching syllabi.

The physics examination syllabus indicates physics topics to be covered for a particular examination in physics. For instance, Joint Admissions and Matriculation Board (JAMB) and West African Examinations Council (WAEC) syllabi on physics are physics examination syllabi.

The physics-teaching syllabus is an outline of the work planned to be done in a course of one term or one year with each class at senior secondary school level in physics. The physics topics are arranged in a logical sequence according to the relationship between the various physics topics in the syllabus.

SELF ASSESSMENT EXERCISE 4

Who are the people responsible for the development of the physics syllabi in Nigeria?

The physics examination syllabus is drawn up by a team of physics experts (physics educators) usually outside the school system. In physics teaching syllabus, various related parts of the physics topics or units, which are related are brought together.

As a physics teacher, you should employ the following principles in drawing up a physics-teaching syllabus from physics examination

syllabus and the Physics curriculum for level of students being considered. These are

arrange the physics topics in such a way that your teaching proceeds from the known to the unknown. Taking into consideration the background of the students
proceed from easy physics concepts to the abstract concepts.

In physics teaching at senior secondary one (SS1) for instance, causes of motion of material bodies should be preceded first by the concepts of distance, time and speed. You as a physics teacher should ensure that the physics-teaching syllabus is arranged so that the topics suit the intellectual or academic level of the students. A most effective physics-teaching syllabus lends itself to the formulation of the scheme of work from it since it spells out the following necessary information:

- What physics topics are to be covered in a specific period;
- The depth of coverage of the physics topics
- The sequence of treatment indicating the physics topics that will require more time than others
- Guidelines for methods of teaching
- References and materials needed for each physics topics.

SELF ASSESSMENT EXERCISE 5

Which of the two physics syllabi has a direct relation with physics scheme of work?

3.3 Physics Scheme of Work

A physics scheme of work is the weekly arrangement of physics topics from a physics-teaching syllabus to cover the academic year. This is achieved by dividing the physics-teaching syllabus into three parts corresponding to three terms of the senior secondary school academic year. The physics topics in each term's schedule are broken up to the number of weeks on the term. As a physics teacher, if you can successfully do this, you have succeeded in drawing up a scheme of work on physics.

SELF ASSESSMENT EXERCISE 6

Do you consider the scheme of work on physics to be a rigid document?

The physics scheme of work should be revised from time to time depending on the rate at which the physics students progress in the

learning of the physics concepts. The physics scheme of work which can also be referred to as a written plan showing what physics topics are to be covered weekly or fortnightly is drawn up from a physics-teaching syllabus taking into consideration the following factors as stated by Abdullahi (1982).

The need for logical sequence
The age, ability and previous knowledge of the students
The amount of time required by each physics topic
The number of effective weeks of learning in a term or a year
The number of physics teaching periods per week including practical periods.
Resources and materials for each physics topic.

SELF ASSESSMENT EXERCISE 7

List the components of a good physics scheme of work.

The scheme of work on physics will also assist you as a physics teacher to fulfill the following functions in the school:

it will direct attention to major physics topics
it will facilitate careful and meaningful planning on the part of the physics teacher
it will allow for greater flexibility in the implementation of physics teaching syllabus.

3.4 Physics Lesson Plan

Physics lesson plan can be described as a daily guide to physics instruction. It is also a guide to the physics teacher in presenting a good and effective physics lesson in the laboratory / classroom. Therefore, a good physics lesson plan is a guide to effective physics teaching as it directs the physics teacher in same manner as a compass gives a navigator his bearing.

SELF ASSESSMENT EXERCISE 8

Should the preparation of a physics lesson plan be a weekly or monthly affair?

A physics lesson plan is a daily outline of learning activity for physics students at senior secondary school level. The plan is usually drawn up after the preceding physics lesson.

SELF ASSESSMENT EXERCISE 9

Why is it not proper for a physics teacher to prepare a physics lesson plan several weeks in advance?

As a physics teacher, you should be able to take the advantage of the extent of materials covered in the preceding physics lessons, and the success or failure of past physics lesson. These are the main reasons why it is not proper for you as a physics teacher to think of preparing a physics lesson plan several weeks in advance. A physics lesson plan also provides a kind of instruction route to be followed by the physics teacher so as not to live out or omit the important concepts.

Format of a suggested Daily Physics Lesson Plan

Subject:	Physics
Class:	SS1
Date:	Day/Month/Year
Unit:	Work, Energy and Power
Topic:	Concept of Work
Average age:	13 years
Time of the lesson:	9.05 – 10.25
Duration:	80 minutes (double periods)

Instructional Objectives: These are the objectives that are stated in terms of what a physics teacher is going to do during this particular lesson or period. It focuses attention on the teaching processes rather than on the learning outcomes to be attained by the students. As regards this lesson, the instructional objectives are:

- To explain the concept of work
- To explain measurement of work.
- To derive the units of work
- To discuss the work done in a force field in:
  i. lifting a body
  ii. falling bodies
- To discuss the work done in stretching or compressing a spring.

Behavioural objectives: These are the objectives that are stated in terms of the outcomes the physics teacher expects from his/her teaching. Here the attention is shifted from the teacher to the

learners. As regards this lesson, the behavioural objectives are stated as follows:

- At the end of the lesson, students should be able to:

    i. define work done
    ii. explain how to measure work done
    iii. derive the units of work
    iv. explain the work done in a force field in:
        1. lifting a body
        2. falling bodies

- explain the work done in stretching or compressing a spring

- calculate the work done, given a force and displacement it produces in its direction.

TIME	PART OF THE LESSON	ACTIVITY
9.05 – 9.15 (10 mins)	Introduction	Instruct a student to bring his desk to the front and ask the students to push the desk forward to cover some distance. Ask the students to mention the concepts that are involved in the task.
9.15 – 10.05 (50 mins)	Presentation	i. define work done ii. demonstrate the measurement of work done using a boy that is being asked to lift some bricks on to the top of a wall which is being built as example iii. derive the units of work done using the definition given above iv. deduce the formula for work done when lifting a body up using a student that is lifting up a desk to demonstrate this action v. deduce the formula for work done when a body is falling vertically and inclined using a stone falling from a top to demonstrate the two positions vi. deduce the formula for work done in stretching or compressing a string using a spring balance that a load is attached to demonstrate the stretching vii. solve problems that require the calculation of work done for the students.
10.05 10.25 (15 mins)	Summary	Highlight some of the important points on the chalkboard
10.10 10.25 (15 mins)	Evaluation / Assignment	Ask questions on what you taught either orally or written.
	Home work	The students should read their textbook as homework in order to be able to define and solve problems on concepts of energy and power.

SELF ASSESSMENT EXERCISE 10

Apart from the general information in the physics lesson plan, list the other parts in which the plan is divided.

The physics lesson plan when properly written should reflect the following elements:

*	General Information:	- School - Subject - Class - Age - Time and Duration - Topic - Unit
*	Objective	What product, process or affective objectives does the physics teacher have for this physics lesson? These should be written in precise terms, they can be stated either instructionally or behaviourally, or both.
*	Resources	What equipment, teaching aids, text material etc. will be needed?
*	Introduction	This relates to how the physics teacher will prepare physics students for this lesson.
*	Learning Activities	Presentation / Development of lecture, laboratory work, discussion etc. should fit the objectives
*	Time Allotment	Approximately how long do you expect each activity to last
*	Evaluation / Assignment	How will the physics teacher determine if physics students have learned what he/she have taught. The physics teacher may decide to give physics students some work to do at home or during the lesson or at students' free time in the school. All these should feature in the physics lesson plan.

SELF ASSESSMENT EXERCISE 11

What is the difference between a physics lesson plan and lesson note?

3.5 Physics Lesson Notes

Physics lesson notes contain all learning activities selected for a particular physics lesson showing such details as how the lesson will be produced, list of previous knowledge, description of the presentation of lectures, laboratory exercise, questions to be asked etc. The form which a lesson note takes depends on the nature of the subject, the category of learners and the available resources, among other things.

The difference between a physics lesson plan and lesson note is a matter of detail.

Each has its own advantage, while a physics lesson plan is short enough to be read quickly and arranged in a way that makes it easy to find each step, a physics lesson note indicates clearly the content and method of the lesson; it also aids the physics teacher's memory. Both have similar format, while the physics lesson plan is an outline of the business of the physics lesson, the physics lesson note gives full account of the step by step business of the physics instruction.

A specimen of a Physics Lesson Note prepared by a B. Sc. (Ed.) student:

School: Name of the School
Date: Day / Month / Year
Subject: Physics
Class: Senior Secondary One (SS 1)
Time: 9.05 – 10.25 am (80 minutes)
Unit: Work, Energy and Power
Topic: Concept of Work
Objectives: At the end of the lesson the students should be able to:

define work done
explain how to measure work done
derive the units of work
explain the work done in a force field in:
(i) lifting a body
(ii) falling bodies
explain the work done in stretching or compressing a spring
solve problems on work done.

Previous Knowledge: Students must have learnt the cause of motion which are force and friction.

Teaching Aids: Charts showing boys and girls lifting up/down and pushing/pulling objects

References: CESAC (1980) Nigerian secondary schools science project physics. Book1. Heinemann Educational Books (Nig.) Ltd. Pp. 22 – 28

Introduction: The teacher introduces the lesson by asking the students the following question:

1. As students, when you are reading and your parent ask you, "what are you doing", you often reply that you are working.
   How is this work different from a man lifting a block to a workman at a higher level or a man pushing a stationary car?

   The teacher links the answers given by the students to the day's lesson by linking the daily experience to the Physics lesson.

Presentation or Development

Step I

The teacher leads the students on the definition of work and asks them to give examples of work done.

Step II

The teacher assists the students to explain how to measure work done.

Step III

The teacher assists the students to derive the units of work.

Step IV

The teacher explains the work done by lifting a body and a falling body such that the formula for work done below is derived.

Work done against gravity = Weight (W) x Vertical upward displacement (h) Work done = W x h = Wh

Step V

The teacher explains the work done in stretching or compressing a spring such that the formula for work done as shown below is derived.

Work done = ½ x Force (F) x Displacement (x)
= ½ Fx

Summary

Work done is defined as the product of the force and the displacement in the direction of the force.

The unit of work is Newton metres. One Newton metres is equal to a Joule (J)

Work done by lifting a body = Weight x Vertical upward displacement
Work done for elastic substances = ½ x Force x Displacement.

Evaluation

The teacher instructs the students to solve the following problems in his presence in the laboratory while the teacher goes round to mark the written response of the students.

1) A mother raises her baby of weight (W) through a vertical height (h). What is the work done?
2) A faulty car was causing obstruction at the middle of the road. When a force of 200N was applied to push it to a car park, the work done was 8000J. How far away was the car park?
3) A spring is stretched 5 cm by a Force of 20N. What is the work done?

Assignment: Teacher instructs the students to answer the following questions at home as homework.

1) What is energy?
2) How will you classify energy?
3) Give the definition of each of the classification.
4) What is meant by conservation of energy?

SELF ASSESSMENT EXERCISE 12

Write a physics lesson note for a choice physics topic for SS1 students that will cover a 40 minutes period.

4.0 CONCLUSION

In this unit, you learnt that physics teaching is a serious business that involves a lot of dedication. So as a physics teacher, you should be committed to the noble profession by making sure that you observe all that is expected of a quality physics teacher.

5.0 SUMMARY

In this unit, you learnt:

Different definitions of a curriculum.
Description of physics syllabus and the two types of physics syllabi namely: physics examination and physics teaching syllabi.
The description of physics scheme of work.
The description of physics lesson plan and its format.
The description of physics lesson note and a specimen of a physics lesson note.

6.0 TUTOR-MARKED ASSIGNMENT

1. List the components of a well written physics lesson note.
2. Develop a physics lesson note that you will use to teach the concept of motion in senior secondary One (SS1) physics class for forty minutes.

7.0 REFERENCES/FURTHER READINGS

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UNIT 4 PHYSICS LABORATORY DESIGN, SAFETY AND MANAGEMENT

CONTENTS

1.0 INTRODUCTION

Laboratory generally is an integral part of science teaching. In the teaching of physics, chemistry, biology, etc. the laboratory occupies a central role. As separate sciences make special demands of their own, special laboratories for the various subjects are required. These must be taken into account in the planning of the school laboratories and their accommodation.

2.0 OBJECTIVES

After studying this unit, you should be able to:

Describe a physics laboratory

Discuss some of the safety rules that should be enforced in the physics laboratory

Describe the organisation of the physics laboratory

Discuss how physics laboratory is managed

Discuss the major roles of the head of physics unit

Discuss the roles of the physics teacher and laboratory attendant in the physics laboratory

3.0 MAIN CONTENT

3.1 The Physics Laboratory

Unlike the biology and chemistry laboratory, the layout of the physics laboratory should be flexible. The patterns of physics teaching are changing and a rigid design, which may be suitable for the present needs, may be found inconvenient in the future. A maximum of adaptability should be looked for.

SELF ASSESSMENT EXERCISE 1

Why is it that the benches in physics laboratory must be movable?

On some occasions, the physics students will work in sets on the benches, while at times they will have to be grouped to watch a demonstration and may need to make notes during this, so that they should have a writing surface available. There will be times when an area of clear floor space is needed which is visible to all, or several smaller clear areas are wanted for ripple-tanks and the final arrangement of the laboratory should make all of these possible.

To meet these conditions requires that at least some of the benches must be movable to make clear spaces possible. Strong tables therefore seem preferable to the traditional long benches, but these must be sufficiently stable to afford firm surface, which are reasonably free from vibration and not easily displaced by knocks.

In a physics laboratory, there should be adequate supply of electrical mains outlets, radioactive source store, storage facilities for expensive equipment such as electron diffraction tubes, vacuum pumps and so forth, if they are available.

SELF ASSESSMENT EXERCISE 2

What will you consider as the general layout of a physics laboratory design?

3.2 Physics laboratory design

Any modern physics laboratory design has the following general features:

(a) Preparation Room:

This room should have the following facilities:

distill water machine
dry oven
storage shelves for tools to be used for services and maintenance
trolleys for moving equipment about

(b) Central Storage Room

This room is provided with cabinets where dangerous chemicals such as radioactive and carcinogenic substances are kept. Inflammable liquids are also stored in this room.

(c) Resource Room

This is where physics students carryout their projects. Audio-visual materials can also be kept here. Sometimes, a darkroom is attached to this area.

(d) Detached Store

Highly inflammable substances like ether, petroleum product, toluene, acetone and alcohol are kept in a special store which are located in a separate place outside the laboratory.

(e) Staff office for laboratory technicians

(f) Provision for plenty of ventilation, water, light, heat services, drainage supply etc.

SELF ASSESSMENT EXERCISE 3

How safe is your school physics laboratory?

3.3 Physics laboratory safety

Safety is the first thing to know in teaching science, be it physics or any of the other sciences. It is a must for an assiduous school physics teacher to heed this important note of warning in order to prevent laboratory accidents and guard against physical health hazards.

SELF ASSESSMENT EXERCISE 4

How do health hazards occur in physics laboratory?

Health hazards in the school physics laboratory are known to rear their heads in many ways. Such as shocks from electrical appliances, skin damage from short-wave radiation, retina damage from ultraviolet radiation, liver and kidney damage from dangerous volatile organic solvents, cuts from glass-ware and sharp-edged objects, etc.

Right from the drawing board, precautionary safety measures should form part of the basic components of any good physics laboratory.

SELF ASSESSMENT EXERCISE 5

List some other basic features of a physics laboratory that provide for safety right from the construction stage.

These features could be:

adequate storage facilities
fire equipment
escape routes
ventilation facilities
first aid box.

3.3.1 Physics laboratory techniques for safety

Order, they said, is the first rule in heaven. This saying should also be applicable to physics laboratory and physics teaching if we want to ensure safety. Because of the wave of indiscipline that permeates every facet of our society, there is need to regulate the behaviour of our students in the schools laboratory for safety reasons. Every physics student in your care should be made to adhere strictly to the ten rules listed in the "do's and don'ts" versions.

SELF ASSESSMENT EXERCISE 6

How will you as a physics teacher enforce the ten safety rules?

The rules are:

i) Do wait outside the laboratory until you are asked to come in;
ii) Do only the experiments authorized by your teacher;
iii) Do heat liquids slowly and rotate test tubes to avoid overheating one area;

iv) Do wet the end of glass tube before inserting it into rubber-tube or stopper and use a towel to insert the glass tube;
v) Do report any gas leakage, water leakage, breakage and accidents promptly to your teacher;
vi) Do not rush or run into or out of the laboratory;
vii) Do not smoke, eat, drink or chew gum in the laboratory to prevent dangerous chemicals from getting into your mouths or lungs;
viii) Do not discard matches, filter papers or any slightly soluble solid into the sink;
ix) Do not direct the open end of a test tube being heated at anyone;
x) Do not work with wet hands when performing electrical experiment involving the use of the mains or capacitors.

SELF ASSESSMENT EXERCISE 7

What are the common injuries that students can sustain in the physics laboratory?

It is a common knowledge that even when all necessary precautionary measures have been taken, when pertinent safety regulations have been observed in the physics laboratory and when recommended laboratory experimental techniques have been employed, accidents which could result in injury could still happen in the physics laboratory.

The common injuries that can be sustained in the physics laboratory are:

* bleeding – due to cuts from broken glassware, sharp objects and the like;
* burns – from naked fire and chemicals;
* shocks – from electricity;
* suffocation – from inhaling injurious vapours, gases or aerosols;
* eye injury – due to the presence of foreign particle(s) in the eye.

You, as a physics teacher, owes it as a duty to offer appropriate first aid remediation to your injured student(s). In this wise, you are expected to be familiar with the rudiments of first aid procedures.

SELF ASSESSMENT EXERCISE 8

List the necessary facilities required for proper organisation of a physics laboratory.

3.3.2 Organisation of the physics laboratory

The organisation of the physics laboratory has to do with the provision of essential services, storage and proper maintenance of equipment. In the physics laboratory, the facilities required for services are:

* **Water**: Two or three small sinks will be found adequate for a physics laboratory and these should be located on side benches and are to be well separated from each other to allow simultaneous access by groups of physics students. One of these sinks should be provided with a hot water supply, which is conveniently done by a sink heater.

* **Gas**: If gas is fitted to the working benches, these should be properly placed so as to leave a clear working surface. Where movable tables are used, it will usually be found sufficient to have gas points on the side benches only and to move tables up to these areas when gas is needed. The gas point should be arranged such that one gas supply will accommodate two or more groups of physics students.

* **Electricity**: Low-voltage supply is an essential requirement for a physics laboratory. Apart from the fact that it allows physics students to perform with safety all the elementary experiments in the study of electricity, it will also find applications in other parts of the work, for lighting low-voltage bulbs for ray boxes. The voltage must be varied in steps and a current of 3 – 4 amperes must be available at each working point.

SELF ASSESSMENT EXERCISE 9

How secured is the physics store-room in your school?

* **Storage**: The storage of apparatus is a serious and growing problem in most school physics laboratories. It is strongly recommended that teachers of physics should insist on the provision of a store room of generous size, in addition to a preparation room. A store room which is merely a large cupboard is not sufficient and an area of at least 138 square metres (138 sq. m) is required, but it could well be larger if the geometry of the building will allow this.

SELF ASSESSMENT EXERCISE 10

Do you store both small and large size apparatus together in your school physics laboratory?

The apparatus to be stored in the store room vary in sizes and in shapes, the small pieces of apparatus, magnets, polythene rods etc. can conveniently be stored in shallow drawers and other sets of apparatus of slightly larger sizes such as ray-boxes requires rather deeper drawers. It is suggested that one wall of the storeroom should have cupboards containing trays of three different depths. Such trays enable the whole volume of a cupboard to be utilized, whereas the conventional cupboard with a shelf uses only a fraction of the total volume for actual storage.

3.4 Physics laboratory management

The physics laboratory is usually a center of physics activities where physics teachers, laboratory staff, students and materials are always in a dynamic interaction.

The physics teacher as the sole administrator of a physics laboratory has the responsibility of managing these interacting factors, in such a way that accidents are reduced to the barest minimum level. The physics teacher must ensure that all those who use the physics laboratory perform their work as directed.

SELF ASSESSMENT EXERCISE 11

What do you think should be the major concern of head of physics in the management of the physics unit in your school?

3.4.1 The Head of Physics Unit

The task of managing the affairs of the physics unit is the sole responsibility of the head of physics and other support staff in the unit. This includes the physics teaching staff and physics laboratory technicians/attendants. The head of the unit, who is one of the human resources in the unit has three major areas to be concerned about.

These are:

* **Organisation and coordination of duties**: As the head of physics unit, you should as much as possible, open and maintain effective communication channel between yourself and other staff members. This invariably means that you should operate an open door policy for corrections, advice and suggestions towards the progress of the unit.

* **Delegation of responsibilities**: As the head of physics unit, you should identify staff members with their talents and capabilities and delegate the unit duties to them.

* **Training of personnel in the unit**: This should be one of the major concerns of physics unit head. You should make sure that the staff members both teaching and non-teaching in the unit are recommended for promotions, attend conferences, workshops and seminars and are also given study leave when appropriate.

SELF ASSESSMENT EXERCISE 12

What should be the major responsibilities of head of physics unit in a school set up?

3.4.2 Some roles of the Head of physics unit

* **Formation of Unit timetable** – The head of physics unit joins his/her colleagues in other science units to work on the general school timetable and come up with their different unit's timetable to be display it in their different unit laboratory.

* **Provision of the Unit information on the Notice Board** – The head of physics unit should be responsible for the provision of up-to-date information on the unit notice board as an aid to proper communication. This notice board should be divided into sections and labelled using section headings and different colours (e.g. red colour for urgent or emergency information). Some of the headings could be:

    School timetable
    Science department timetable
    Physics laboratory timetable
    Physics teachers timetable
    Departmental notices
    Physics unit notices
    Science Club activities (e.g. JETS Club, Physics Club etc.)
    Today's Announcement
    Teacher's Centre information
    Emergency information.

* **Keeping Unit Records** – The head of physics unit should also be responsible for storage and retrieval of information by maintaining two separate filing cabinets or shelves. One of the files will be confidential files, which should contain examination information, students' records, and reports on students and staff members in the unit. The second file which is called "open-access" files should contain past question papers, physics

syllabus, career information, catalogues for books and physics equipment and safety information.

* **Running of the Unit** – The head of physics unit should on regular basis consult with other units' heads in the science department as regards the needs of the unit and department. The outcomes of the consultations are presented to the school head for either implementation or further directed to appropriate higher authorities. Sometimes, the consultation could be on estimates, which can be broken down into the following subheads:

    equipment cost
    running cost
    stationery
    books and audio-visual aids
    workshop/conference, seminar needs
    living organism funds
    replacement funds
    practical examination funds.

SELF ASSESSMENT EXERCISE 13

Apart from the teaching of physics, what other roles do you perform in your school as a physics teacher?

3.4.3 Other Roles Of The Physics Teacher In The Physics Laboratory

* **Preparation of materials, solutions and provision of equipment available** – It is the duty of the physics teacher to prepare all necessary materials or items for practical lesson and to take note of all the inadequacies.

* **Training of the laboratory assistants** – The physics teacher should be responsible for the training of the physics laboratory assistants. Since physics students learn a lot of things from them either directly or indirectly. So there is the need for them to continually improve their skills and knowledge on the physics laboratory organization and activities.

* **Stock control, requisition and receipt of supplies** – As a physics teacher, you should ensure that you take proper records of all the incoming and outgoing stock from the physics storeroom. You should also have a requisition book for your

request and always issue a receipt or sign for supplies made to the storeroom.

* **Recording breakages/damages** – There could be breakages especially with glass wares and damages of equipment in physics laboratory. These breakages and damages should be recorded by the physics teacher for replacement.

* **Proper storage and distribution of materials/equipment** – The physics teacher should ensure that physics equipment are stored according to their nature and the storage procedure should be simple for safety and ease of retrieval. All optical mirrors and lens should be stored together.

* **Implementation of safety regulations** – One of the major duties of the physics teacher is to make physics students and other supporting staffs in the physics unit keep to the safety regulations in the physics laboratory.

* **Supervision and control of laboratory assistants** – It is one of the responsibilities of the physics teacher to highlight the duties of the laboratory assistants and paste it where it can easily be referenced to. Copies of such duties could also be made available to each of the laboratory assistants for them to study, keep and use as required. There is the real need to have a close supervision and control of the laboratory assistants at all times to ensure safety of life and materials in the physics laboratory.

SELF ASSESSMENT EXERCISE 14

Do you have physics laboratory technician in your school?

3.4.4 Roles of physics laboratory technicians/assistants

Qualified laboratory technicians are sometimes rare to come by in our schools but most science departments usually employ the services of the laboratory attendants and train them on the job to play both roles. But their work reduces to that of errand boys when they are not well trained.

The primary duty of physics laboratory technicians is to maintain and repair damaged physics equipment. Apart from this, the physics laboratory technicians also perform the following tasks:

Keeping the physics materials/equipment clean and tidy;
Setting up or dismantling demonstration equipment;
Ordering of physics equipment;
Storing of physics equipment in accordance with a regular order;

Keeping adequate records of purchases and damages;
Make minor repairs of physics equipment;
Experienced technicians or attendants also serve as physics resource person to physics students.

4.0 CONCLUSION

In this unit, you learnt about the physics laboratory, its design and safety. The organisation and management of physics laboratory with respect to head of physics unit, and his roles as well as roles of physics teachers and physics technicians/attendants were also discussed.

5.0 SUMMARY

In this unit, you learnt that:

- the layout of the physics laboratory should be flexible
- modern physics laboratory design should have the following:

  preparation room
  central storage room
  resource room
  detached room
  staff offices
  provision for ventilation, water, light, heat services etc.

- Safety should be the first thing to know in teaching physics and other science subjects.
- The ten safety rules must be adequately observed by the students in the physics laboratory.
- The facilities required for services in physics laboratory are:
  water gas
  electricity

The management of physics laboratory involves:

the head of physics unit
the physics teacher
the physics laboratory technicians/attendants.

6.0 TUTOR-MARKED ASSIGNMENT

1. Itemize and discuss the use of laboratory exercise in teaching physics at senior secondary level.

2. What are the advantages of using laboratory method in teaching physics at senior secondary level?

7.0 REFERENCES/FURTHER READINGS

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UNIT 5 EVALUATION OF SCIENCE TEACHING AND LEARNING WITH REFERENCE TO PHYSICS

CONTENTS

1.0 INTRODUCTION

One of your main duties as a physics teacher is to promote the learning of the fundamental facts and principles of physics and to develop in the physics students' abilities and skills needed to engage in scientific processes. However, as the acquisition of scientific knowledge is the ultimate criterion, it is imperative to regularly evaluate students' progress in their learning of physics. Your role as physics teacher in evaluation is very important and crucial. Thus, you should be well equipped for the performance of this task.

In this unit, you will be exposed to one of the commonly used methods of evaluation, which is teacher's test. The tests may take different forms. But the science teacher's concern is to monitor the progress of learning among his/her students. Therefore tests in physics class serve a variety of functions, which shall be discussed in this unit.

2.0 OBJECTIVES

After studying this unit, you should be able to:

Define test and assessment;
Discuss the functions of the classroom tests;
List and discuss the forms of assessment in science;
State the merits and demerits of all the forms of 'paper and pencil' tests;
Discuss the principles of test construction in science teaching with particular reference to physics;
Describe a marking scheme;
Describe how to prepare marking schemes for essay type, objective type and practical examinations.

3.0 MAIN CONTENT

3.1 Meaning of Test and Assessment

According to test experts (Obe, 1977 & Folagbade, 1988), teaching/learning processes are incomplete without clearly identifying the processes of determining students learning outcomes. The experts further said that the most reliable method available to practicing teachers for assessing students learning outcomes is the use of tests.

According to Obe (1977), a test is defined as a series of activities purposely designed to measure learners abilities in the area of recall of facts, recognition of facts, understanding of concepts, thinking capabilities and manipulative skills.

SELF ASSESSMENT EXERCISE 1

What will you consider as good suggestions by the test experts to the practicing teachers?

The test experts implored the practicing teachers and those educators involved in assessing learning outcomes to learn how to select test items, which are relevant and would give balanced representations of the traits to be assessed at a given time.

3.2 Functions of Tests

Findley (1963) categorized the functions of the classroom tests under three major groups which are:

instructional
guidance
administrative

3.2.1 Instructional functions of a test

- Testing of students' progress in the science class provides the science teacher with the information on the students' rate of learning. This will enable the teacher to provide more appropriate instructional guidance.

- Test construction reminds the science teacher of the objectives of the course. The process of test construction at times helps the science teacher to redefine the course objectives in clear terms.

3.2.2 Guidance functions of tests

- Information obtained from tests can be useful in the counselling process especially on matters relating to choice of career.
- Test can be used to discover pupils special abilities and aptitudes.

3.2.3 Administrative functions of tests

- Tests serve as a quality assurance for schools. Because it provides a mechanism not only for maintaining standard for a school system but also for individual standards.
- Tests assist in the grouping or placement of students for teaching/ learning processes. This is based on the ability as indicated by the scores of the students in the tests.

3.3 Forms of Assessment used in teaching/learning processes

There are different forms of assessment with great potential for determining students progress in teaching/learning processes.

These are:

Oral form
Written (essay and objective) form
Project form.

3.3.1 Oral form of assessment

SELF ASSESSMENT EXERCISE 2

What is the usefulness of this form of assessment in physics teaching?

This involves the student's ability to describe or narrate in his/her own words the steps involved in a given task. The confidence displayed in such situations by student in the presence of an expert, his/her communicative ability, his/her use of the appropriate expressions as well as the commanding presence give a clear picture of a good mastery of what has been learnt. Without any bias or sentiment, the assessor can easily classify the student as either excellent, good or average, below average or poor.

3.3.2 Written form of assessment

SELF ASSESSMENT EXERCISE 3

How often do you as a physics teacher encourage the use of this form of assessment when teaching physics?

This form of assessment is one that involves the students putting down in writing the processes taken such as observation, recordings, calculating and interpretation. Written assessment is usually in the form of "paper and pencil" test, which could be in anyone of the following kinds:

(i) essay type test
(ii) objective type test
(iii) performance (practicals) type test
(iv) problems (quantitative questions) type test.

3.3.3 Project form of assessment

SELF ASSESSMENT EXERCISE 4

What form of assessment will you as a physics teacher use in assessing your teaching?

There is a difference between the project form of assessment and any of the two forms of assessment earlier mentioned. In science class with particular reference to physics, theory or practical work are assessed by either of oral or written forms of assessment. In the case of project, what is to be assessed is real and there is a permanent end product which

can be physically displayed for all to see, appreciate, comment on and finally assessed.

3.4 Essay Type Test

This is used as a means of evaluating the qualitative aspects of verbal instruction. The test items require the student to compose a response of some length, usually by integrating materials from a variety of sources.

SELF ASSESSMENT EXERCISE 5

As a science teacher, when will you say the essay type test is required?

The essay type test is used especially when the test requires:

explanation, description and prediction of processes and structure;
description of instruments, apparatus, etc.
exposition of theoretical knowledge;
interpretation of experimental and numerical data;
discussion of results of experiments and solution of problems.

SELF ASSESSMENT EXERCISE 6

Construct four essay type questions in physics for SS1 students on concept of work.

3.4.1 Merits and Demerits of Essay Type Test

The merits of essay tests are:

It promotes better study habit;
It reduces the possibility of cheating;
It requires a high degree of thinking rather than rote learning;
It demands recall rather than identification

The demerits of essay tests are:

It is difficult to draw up good questions for the essay test;
It is difficult to score because it takes a great deal of the teacher's or scorer's time;
Scoring of essay test is highly subjective because the scorer tends to carry impressions from one paper to another;
The result of scoring is often less reliable because of the scorer's mood and its subjective ness.

3.5 Objective Type Test

An objective test is one in which the test item are so framed that there is only one correct answer to each question. The answer is predetermined and the test will give the same score for each item for any individual since the marks cannot be influenced by the biases and prejudices of the teacher.

SELF ASSESSMENT EXERCISE 7

List the forms of objective test

In objective test, subjectivity in scoring or marking is eliminated. The answers to the questions can be marked by an individual who has no knowledge of the subject matter using the pre-prepared model answers marking scheme.

There are various forms of objective test and their classification depends on the type of response which is being sought. There are four classes of objective test that are commonly used in the school setting. These are:

short answer items or completion test
multiple choice items
matching items
true false items.

3.5.1 Short answer items or completion test

This test is not like other types of objective tests. Completion test items are not objective enough to allow anybody working solely from a key or a machine to score the test. It has the advantage that it reduces guessing to a minimal level and demands recall rather than recognition.

Some of the demerits of this type of test are:

it encourages rote learning;
it is more difficult to construct;
scoring is relatively more tedious.

SELF ASSESSMENT EXERCISE 8

Construct five short answer items on a chosen topic in physics for SS1 class.

In this type of objective test, the students supply answers which are always in short sentences:

1. The S.I unit of work done is ……
2. The concept of energy means ……..
3. Rest energy is associated with …….
4. The two forms of mechanical energy are …… and ……
5. Anything that has weight and occupied space is called …….
6. The rate of doing work is referred to as ……...
7. Large amount of power could be measured in …….. and ……
8. Kinetic energy is associated with …….
9. Large amount of work could be measured in …… and …….
10. Energy possessed by an object moving linearly from one place to another is called ……..

3.5.2 Multiple choice items

This is the most widely used objective test because of its adaptability and wide application. In the multiple choice test, each test item may start with an introductory question or an incomplete statement together with a number of alternative answers of which one is correct and the remainders are incorrect.

SELF ASSESSMENT EXERCISE 9

What are the merits and demerits of this type of test?

This type of test often requires the students to select response, which is correct for a particular question from a given list of options. The merits of this type of test that may convince science teachers of the versatility of this type of objective test are:

it allows for a large sample of test items
there is complete objectivity in scoring
it reduces the factor of chance success
it can be used with a wide variety of material

Some of the demerits of multiple-choice tests are:

it is prone to cheating
it aids recognition rather than recall
it is generally difficult to construct.

Examples of multiple choice test on physics are:

1. Work done is ……..

A. the sum of force and distance moved in the direction of force.
B. the sum of force and distance moved in opposite direction of force.
C. the product of force and distance moved in the direction of force.
D. the product of force and distance moved in opposite direction of force.
E. the product of force and distance.

2. Principle of conservation of energy states that:

A. energy can neither be created nor destroyed during a transformation.
B. energy can be created during a transformation.
C. energy can be destroyed during a transformation.
D. energy can either be created or destroyed during a transformation.
E. none of the above.

3. Which of the following is NOT an example of Vector quantity?

A. Acceleration
B. Velocity
C. Energy
D. Force
E. Displacement

4. What is the velocity of a 2.5 kg. object when its kinetic energy is 10J?

A. 2.83 ms^{-1}
B. 28.3 ms^{-1}
C. 283 ms^{-1}
D. 283.3 ms^{-1}
E. 283.33 ms^{-1}

3.5.3 Matching items

This type of objective test is essentially a series of multiple choice items, each item in the first column is to be paired with an alternative in the second column. Every test item is made up of two parallel lists: One containing stimulus (words or phrases), the other containing response

alternative. The students are required to match the items on the two lists.

SELF ASSESSMENT EXERCISE 10

When are the matching items useful in teaching / learning process?

When the learning of a particular physics concept requires the association of two things in the student's mind, this type of test items comes into play. In physics, matching items are used to gain knowledge of terms, definitions, laws, tools and their uses, illustrations, charts and diagrams.

Instruction: Match items on Column A against statements in Column B.

A	B
Work done in springs or elastic strings	A measure of amount of work done in bringing the moving object to rest.
Power	The product of average stretching force and extension.
Rest Energy	The product of force and velocity
Kinetic Energy	The energy which a body has by virtue of its mass alone.

3.5.4 True – False Items

Of all types of objective items, true/false item is the most susceptible to guessing. It is worthy of note that, this type of testing has become less useful as a means of assessing students' learning outcomes. This type of test is usually used for testing factual recall and definitions of terms. An inherent weakness of this testing technique is that it is difficult to find good true/false items as it is not easy to find many statements, which are true or false.

Examples of true/false items on physics are:

T F - The work done in pulling a stone on ground is given by this expression $W = T \sin \theta$ X distance moved

T F - Work is a scalar quantity

T F - The more energy an object has the less work it can do

T F - Power could be measured in horsepower

T F - The basic unit of all matter is the atom.

3.6 Principles of test construction in science teaching

Beside the expertise advise given by the test experts at the beginning of this unit, it is also important to take note of the following points when constructing objective tests in science subjects.

Identification of major concepts to be tested.
Identification of the different cognitive levels at which the concepts are to be tested.
Decision on the number of test items to be included in the test.
Preparation of a table of specification to guide you as a science teacher on the selection of test items to be used.

Table 1: Table of specification for a physics multiple choice test

Physics Concepts Tested	COGNITIVE LEVELS TESTED						TOTAL
	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation	
Work	2	2	1	1	0	0	6
Energy	3	2	2	0	1	0	8
Power	3	1	1	1	0	0	6
Machines	4	3	2	0	1	0	10
Total	**12**	**8**	**6**	**2**	**2**	**0**	**30**

Table 1 illustrates the specifications required in terms of physics concepts and cognitive levels. The table shows that 4 physics concepts are to be tested across 6 cognitive levels as proposed by Bloom (1956). The number of items to be selected from each concept is indicated while the items per concepts are spread proportionately across the cognitive levels.

SELF ASSESSMENT EXERCISE 11

Give detailed interpretation of the table of specification shown in table 1.

In all, a total of 30 items are generated to cover all the 4 physics concepts listed. The 30 items are also spread according to the cognitive levels required in all the concepts. It is observed that no item was

distributed in each of the physics concepts to the evaluation levels of cognition. This is because at the senior secondary level of physics learning, students might have not attained such level of cognition. In the 4 concepts to be tested no items are distributed to analysis, synthesis and evaluation because it is believed that these concepts are usually considered abstract by students. With reference to the National Curriculum on Physics, the document recommended that items to be tested should cover the first two cognitive levels (i.e. knowledge and comprehension) for the first year of senior secondary level while the first three levels (i.e. knowledge, comprehension and application) are recommended for the third year of senior secondary level.

3.7 Basic Guidelines for Preparing Practical Examination in Science

Practical examinations in science are tasks meant to assess science mainly in the psychomotor domain of learning. For the purpose of balanced assessment of students' learning outcomes in science, most practical examinations also test cognitive as well as affective domain of learning.

SELF ASSESSMENT EXERCISE 12

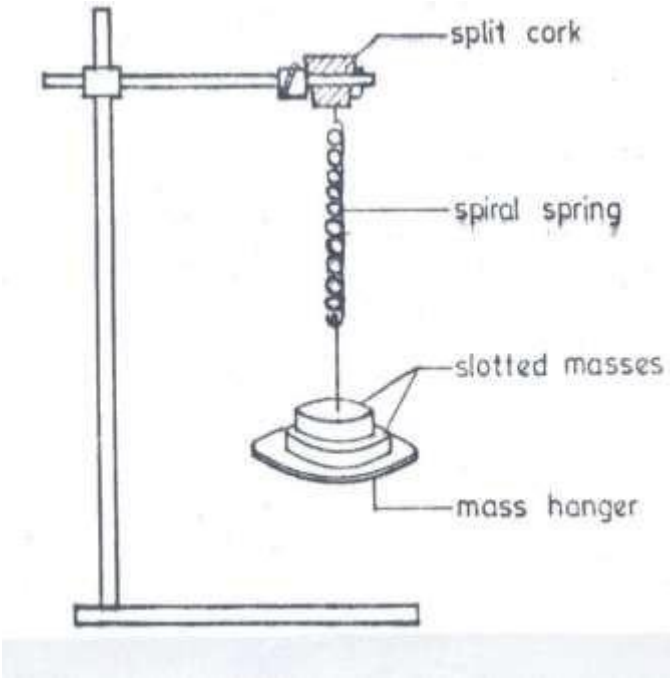
What are the usefulness of practical examinations to the students?

Practical examinations are viable and reliable methods of assessing science students' learning outcomes in the sense that:

* students are encouraged to demonstrate their practical skills in science.
* students are encouraged to apply theories learnt to practical applications rather than relying on rote memory of scientific facts.
* students are afforded the opportunity to observe, classify, record, interpret instructions and report observation made.

Constructing practical examinations in science does not constitute any problem because many standard science practical textbooks are available in the schools to guide practicing science teachers.

An example of a typical practical physics examination is given below as guidance.



You have been provided with a retort stand, clamp and boss, a set of masses, a spiral spring, stop watch, split cork and other necessary apparatus.

Using the diagram above as a guide, carryout the following instructions:

(i) Suspend the spiral spring vertically as shown in the diagram;
(ii) Suspend a mass hanger on the free end of the spiral spring and add a mass, m = 50.0g to the hanger;
(iii) Pull the hanger gently downward and release to set it into vertical oscillations.
(iv) Determine the time, t, for 20 complete oscillations;
(v) Evaluate the period, T, of the oscillation. Also evaluate T^2.
(vi) Repeat the procedure for four other values of m= 70, 90, 110 and 130g. In each case, determine t and evaluate T and T^2.
(vii) Plot a graph of T^2 on the vertical axis against m on the horizontal axis;
(viii) Determine the slope, s, of the graph and the intercept, I, on the vertical axis.

3.8 Marking schemes for grading essay type, objective type and practical examinations in science

SELF ASSESSMENT EXERCISE 13

What is a marking scheme?

A marking scheme is a model solution prepared by an examiner with marks distributed proportionately across the different sections of test items in the cases of essay type and practical examinations in the case of objective test, the marking scheme required correct responses. All correct responses carry equal marks despite the varying degrees of difficulty associated with different test items.

SELF ASSESSMENT EXERCISE 14

List the factors that can make the marking of essay type questions subjective.

In preparing a marking scheme for essay type questions, the examiners are expected to provide solutions to the questions posed section-by-section. For instance, if a typical essay type question attempts to test knowledge, understanding and application of a given scientific concepts, in preparing the marking scheme for such an essay question, solution provided must reflect knowledge, understanding and application of the concepts tested.

SELF ASSESSMENT EXERCISE 15

How will you carryout the mark distribution for an essay type question on physics concepts that attempts to test the first three cognitive levels?

In distributing marks to the different levels of cognition tested applications of concepts are expected to carry more weight (i.e. more marks) than comprehension (i.e. understanding) while knowledge of facts in most situations should carry least marks.

3.9 Guideline for preparing marking schemes for practical examinations on physics practical

In preparing marking schemes for practical examinations, the following criteria are to be allotted marks proportionately: observation, readings recorded, graphs plotted (if any) deductions, precautions reported, result and conclusions drawn.

Penalties may be earned in the different criteria mentioned above. For instance, missing units attract loss of ½ mark, systematic errors attract a loss of 1 mark and faulty scales used for graphing attract loss of marks depending on the deficiencies observed.

Example of hypothetical marks allotted to different sections of physics practical questions:

Observations	-	7 marks
Readings Recorded	-	1 mark
Reasonable Graph	-	6 marks
Slope	-	2 marks
Deductions from Graph	-	2 marks
Calculations (if any)	-	1 mark
Accuracy	-	3 marks
Precautions	-	3 marks
Results	-	3 marks
Conclusion	-	2marks
Total marks obtainable	**-**	**30marks**

To use this format of marks, practicing physics teachers are implored to use their discretion to modify the marks according to the emphasis required from the practical examinations.

4.0 CONCLUSION

In this unit, you noticed that evaluation in teaching/learning processes should be a continuous process and an integral part of curriculum development and classroom instruction. As a science teacher, you need to pay more attention to assessment of science students' learning outcomes in both theory and practical examinations.

5.0 SUMMARY

In this unit, you learnt that:

- the most reliable method for assessing students' learning outcomes is the use of tests
- test is a series of activities purposely designed to measure learners abilities in the area of cognition and psychomotor
- assessment is the process or method of finding out about students progress

- the three major functions of tests are:

Instructional

Guidance
Administrative

- the three forms of assessment in teaching/learning processes are:

  oral form
  written (essay and objective) form
  project form

- the forms of objective type test used in school setting are:

  short answer items
  multiple choice items
  matching items
  true false items

- steps to consider while constructing objective tests in science:

  identification of major concepts to be tested
  identification of the different cognitive levels at which the concepts are to be tested.
  decision on the number of test items to be included in the test
  preparation of a table of specification to guide you on the selection of test items to be used.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is item analysis in science tests?
2. How would you ensure content validity of physics test set for first year students of senior secondary level?
3. List the characteristics of a good physics test items.

7.0 REFERENCES/FURTHER READINGS

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