NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF EDUCATION

COURSE CODE: SED 831

COURSE TITLE: ADVANCED CURRICULUM TRENDS IN SCIENCE EDUCATION

COURSE DEVELOPMENT

SED 831

ADVANCED CURRICULUM TRENDS IN SCIENCE EDUCATION

COURSE GUIDE

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1.0 INTRODUCTION

SED 831: Advanced Curriculum Trends in Science Education is a three credit unit and 800 level course prepared for Ph.D Science Education students.

This course will expose you to understanding the various curriculum reforms in science education both in Nigeria and in other countries of the world. You will also learn about the historical, philosophical and psychological foundations of science education curriculum development and the various reforms that had taken place in science education in Nigeria and other countries such as United Kingdom, United States of America, Japan, Netherlands, Ghana and South Africa. Finally, this course will further expose you to modern approaches and strategies for science teaching.

2.0 WHAT YOU WILL LEARN IN THIS COURSE

SED 831 is a follow up to SED 731 i.e. Curriculum Development in Science Education which you have offered at masters level. Its an advanced form of curriculum trends in science education and it will give you a better understanding of the various reforms that took place in science education in Nigeria and in other countries.

3.0 COURSE AIMS

The aim of the course can be summarized as follows:

- introduce you to the historical, philosophical and psychological foundations of science education curriculum development;
- acquaint you with the historical background of science education curriculum reforms in Nigeria;
- expose you to the various curriculum reforms in science education in other countries of the world;
- Introduce you to current approaches and strategies of teaching science.

4.0 COURSE OBJECTIVES

In order to achieve the above stated aims, the course sets overall objectives. Each unit also has specific objectives. The unit objectives are always included at the beginning of a unit. You should read them before you start working through the unit. You may want to refer to them during your study of the unit to check on your progress.

You should always look at the unit objectives after completing a unit. In doing so, you will be sue that you have followed the instructions in the unit.

Below are the 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) Trace the historical foundations of science education curriculum development;
(2) Highlight the philosophical foundations of science education curriculum development,
(3) Discuss some of the psychologists that have contributed to science education curriculum development,
(4) Trace the history of science education in Nigeria highlighting the main features;
(5) Discuss the nature of science education curriculum development in the United Kingdom, United States of America, Japan, Netherlands, Ghana and South Africa,
(6) Discuss the nature of science education reforms in the United Kingdom, United States of America, Japan, Netherlands, Ghana and South Africa,
(7) State and discuss the modern approaches and strategies for science teaching,
(8) State the advantages and disadvantages of each of the modern approaches and strategies of teaching science,
(9) Describe how you will use concept mapping in teaching some selected concepts in your area of specialization,
(10) Describe how you will use v-diagram in teaching a chosen topic in your area of specialization,
(11) Compare and contrast some of the modern approaches and strategies of teaching science.

5.0 WORKING THROUGH THIS COURSE

To complete this course, you are required to read the study units, read set books and read other materials provided by the National Open University of Nigeria (NOUN). Each unit contains self-assessment exercises, and at a point in the course, you are required to submit assignments for assessment purposes. At the end of the course, is a final examination. The course should take you about 16 – 17 weeks in total 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 successfully on time.

6.0 COURSE MATERIALS

Major components of the course are:

- Course Guide
- Study Units
- References
- Assignment
- Presentation Schedule

7.0 STUDY UNITS

The study units in this course are as follows:

Module 1 Foundations of Science Education Curriculum Development

Unit 1: Historical Foundations of Science Education Curriculum Development (I),
Unit 2: Historical Foundations of Science Education Curriculum Development (II)
Unit 3: The Philosophical Foundations of Science Education Curriculum Development,
Unit 4: Psychological Foundations of Science Education Curriculum Development (I),
Unit 5: Psychological Foundations of Science Education Curriculum Development (II)

Module 2 Science Education Curriculum Reforms in Nigeria

Unit 1: The Early Secular Curriculum in Nigeria,
Unit 2: Impacts of Phelps-Stokes Commission on Curriculum Development in Nigeria,
Unit 3: Patterns of Curriculum Shift in Science Education in Nigeria,
Unit 4: Curriculum Reformations in Science Education in Nigeria

Module 3 Science Education Curriculum Reforms in Other Countries

Unit 1: Science Education Curriculum Reforms in the United Kingdom (England),
Unit 2: Science Education Curriculum Reforms in the United States of America (USA),
Unit 3: Science Education Curriculum Reforms in Japan,
Unit 4: Science Education Curriculum Reforms in the Netherlands,
Unit 5: Science Education Curriculum Reforms in South Africa
Unit 6: Science Education Curriculum Reforms in Ghana

Module 4 Modern Science Curriculum Trends and Reforms

Unit 1 Trends in Research in Science Education from Behaviorism to social Constructivism
Unit 2 The Constructivist Approach to Learning Science through Hands-on, Minds-on and Authentic Learning Experience
Unit 3 Constructivist Approach to Learning through Cooperative Learning
Unit 4 Concept Mapping
Unit 5 Vee-Diagram
Unit 6 Essential Teaching Skills in Science Classroom

: The first module comprises of five units and it talks about the foundations of science education curriculum development. The second module comprises of four units and it talks about science education curriculum reforms in Nigeria. The third module is made up of six units and it talks about science education curriculum reforms in other countries. The last module is made up of six units and it talks about modern science curriculum trends and reforms.

8.0 ASSIGNMENT FILES

There are TWELF (12) assignments in this course. The course assignment which cover all the topics in the course material are there to guide you to have proper understanding and grasp of the course.

9.0 PRESENTATION SCHEDULE

The presentation schedule included in your course materials gives you the important dates for this year for the completion of tutor-marked assignments and attending tutorials. Remember, you are required to submit all your assignments by the due date. You should guard against falling behind in your work.

10.0 ASSESSMENT

There are three aspects to the assessment of the course: first are self-assessment exercises, second, are the tutor-marked assignments; and third, there is a written examination.

In tackling the assignments, you are advised to be sincere in attempting the exercises; you are expected to apply information, knowledge and techniques gathered during the course. The assignments must be submitted to your tutor for formal assessment in accordance with the deadlines stated in the ***Presentation Schedule*** and the ***Assignment File***. The work you submit to your tutor for assessment will count for 50% of your total Course mark.

At the end of the course, you will need to sit for a final written examination of ‘three hours’ duration. This examination will also count for 50% of your total course mark.

11.0 TUTOR-MARKED ASSIGNMENT (TMAs)

There are several tutor-marked assignments in this course. You only need to submit five of the assignments. You are encouraged, however, to submit at most five assignments in which case the highest four of the five marks will be counted. Each assignment counts 10% towards your total course mark.

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, references and study units. However, it is desirable in all degree level education to demonstrate that you have read and researched more widely than the required minimum. Using other references will give you a broader viewpoint and may provide a deeper understanding of the subject.

When you have completed each assignment, send it together with a TMA (tutor marked assignment) form, to your tutor. Make sure that each assignment reaches your tutor 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 tutor before the assignment is due to discuss the possibility of an extension. Extensions will not be granted after the due date unless there are exceptional circumstances.

12.0 FINAL EXAMINATION AND GRADING

The final examination for SED 831 will be of three hours' duration and have a value of 50% of the total course grade. The examination will consist of questions, which reflect the types of self-testing, practice exercise and tutor-marked problems you have previously encountered. All areas of the course will be assessed.

Use the time between finishing the last unit and sitting for the examination to revise the entire course. You might find it useful to review your self-tests, tutor-marked assignments and comments on them before the examination. The final examination covers information from all parts of the course.

13.0 COURSE MARKING SCHEME

Total Course Marking Scheme

ASSESSMENT	MARKS
Assignment 1 – 12	twelve assignments, best five marks of the nine count @ 10% each = 50% of course marks
Final Examination	50% of overall course marks
Total	**100% of course marks**

14.0 COURSE OVERVIEW

This table brings together the units, the number of weeks you should take to complete them and the assignment that follow them.

Unit	Title of work	Weeks activity	Assessment (end of unit)
Module 1	**Foundations of Science Education Curriculum Development**		
1	Historical Foundations of Science Education Curriculum Development (I)	1	Assignment 1
2	Historical Foundations of Science Education Curriculum Development (II)	1	Assignment 2
3	The Philosophical Foundations of Science Education Curriculum Development	1	
4	Psychological Foundations of Science Education Curriculum Development (I)	1	Assignment 3
5	Psychological Foundations of Science Education Curriculum Development (II)	1	Assignment 4
Module 2	**Science Education Curriculum Reforms in Nigeria**		
1	The Early Secular Curriculum in Nigeria	1	
2	Impacts of Phelps-Stokes Commission on	1	

	Curriculum Development in Nigeria		
3	Patterns of Curriculum Shift in Science Education in Nigeria	1	Assignment 5
4	Curriculum Reformations in Science Education in Nigeria	1	
Module 3	**Science Education Curriculum Reforms in Other Countries**		
1	Science Education Curriculum Reforms in the United Kingdom (England)	1	Assignment 6
2	Science Education Curriculum Reforms in the United States of America (USA)	1	
3	Science Education Curriculum Reforms in Japan	1	Assignment 7
4	Science Education Curriculum Reforms in the Netherlands	1	Assignment 8
5	Science Education Curriculum Reforms in South Africa	1	
6	Science Education Curriculum Reforms in Ghana	1	Assignment 9
Module 4	**Modern Science Curriculum Trends and Reforms**		
1	**Trends in Research in Science Education from Behaviorism to social Constructivism**	1	
2	**The Constructivist Approach to Learning Science through Hands-on, Minds-on and Authentic Learning Experience**	1	
3	**Constructivist Approach to Learnig through Cooperative Learnig**	1	Assignment 10
4	**Concept Mapping**	1	
5	**Vee-Diagram**	1	
6	Essential Teaching Skills in Science Classrooms	1	
	Total	12	

15.0 HOW TO GET THE MOST FROM THIS COURSE

In distance learning, the study units replace the university lecturer. This is one of the great 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 reading the lecture that a lecturer might set you some reading to do, the study unit will tell you when to read your other materials. Just as a lecturer might give you an in-class exercise, your study units provide exercises for you to do at appropriate points.

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 is a set of learning objectives. These objectives let you know what you should be able to do by the time you have completed the unit. You should use these objectives to guide your study. When you have finished the unit, you must go back and check whether you have achieved the objectives. If you make a habit of doing this, you will significantly improve your chances of passing the course.

The main body of the unit guides you through the required reading from other sources. This will usually be either from a ***Reading Section*** of some other sources.

Self-tests are interspersed throughout the end of units. Working through these tests will help you to achieve the objectives of the unit and prepare you for the assignments and the examination. You should do each self-test as you come to it in the study unit. There will also be numerous examples given in the study units, work through these when you come to them too.

The following is a practical strategy for working through the course. If you run into any trouble, telephone your tutor. Remember that your tutor's job is to help you. When you need help, don't hesitate to call and ask your tutor to provide it.

(1) Read this course guide thoroughly.

(2) Organize a study schedule. Refer to the course overview for more details. 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 will be made available. You need to gather all this information in 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 for working on each unit.

(3) Once you have created your own study schedule, do everything you can to stick to it. The major reason that students fail is that they get behind with their coursework. If you get into difficulties with your schedule, please let your tutor know before it is too late for help.

(4) Turn to unit 1 and read the introduction and the objectives for the unit.

(5) 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 references, on your desk at the same time.

(6) Work through the unit. The content of the unit itself has been arranged to provide a sequence for you to follow. As you work through the units, you will be instructed to read sections from your other sources. Use the unit to guide your reading.

(7) Well before the relevant due date, check your Assignment File and make sure you attend to the next required assignment. Keep in mind that you will learn a lot by doing the assignments carefully. They have been designed to help you meet the objectives of the course and, therefore, will help you pass the exam. Submit all assignments not later than the due date.

(8) Review of the objectives for each study unit confirms that you have achieved them. If you feel unsure about any of the objectives, review the study material or consult your tutor

(9) When you are confident that you have achieved a unit's objectives, you can then start on the next unit. Proceed unit by unit through the course and try to face your study so that you keep yourself on schedule.

(10) 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 written on the assignment. Consult your tutor as soon as possible if you have any questions or problems.

(11) 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).

16.0 TUTORS AND TUTORIALS

There are 17 hours of tutorials provided in support of this course. You will be notified of the dates, times and location of these tutorials, together with the names and phone numbers of your tutor, as soon as you are allocated a tutorial group.

Your tutor will mark and comment on your assignments, keep a close watch on your progress and on any difficulties you might encounter and provide assistance to you during the course. You must mail your tutor-marked assignments to your tutor well before the due date (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 tutor by telephone, e-mail, or discussion board if you need help. The following might be circumstances in which you would find help necessary.

Contact your tutor if:

- You do not understand any part of the study units or the assigned readings.
- You have difficulty with the self-test or exercise.
- You have a question or problem with an assignment with your tutor's comment on an assignment or with the grading of an assignment.

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

ADVANCED CURRENT TRENDS IN SCIENCE EDUCATION

MODULE ONE FOUNDATIONS OF SCIENCE EDUCATION CURRICULUM DEVELOPMENT.

UNIT 1 HISTORICAL FOUNDATIONS OF SCIENCE EDUCATION CURRICULUM DEVELOPMENT I

CONTENTS

1.0 INTRODUCTION

Science Education Curriculum Development can be traced back to the history of science and the history of science lies in the early human civilizations. In this unit, you will learn how the early human civilizations have contributed to the development of modern science education curriculum. You will also see how the early cultures have given rise to scientific revolutions.

2.0 OBJECTIVES

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

(i) mention some of the ancient cities and their civilizations;
(ii) relate how some of these cities have laid foundation for the development of modern science and technology;
(iii) discuss the role of each of the ancient cities in the reformation of science education curriculum.

3.0 MAIN CONTENT

3.1 Early Cultures and Scientific Revolutions

The beginning of scientific thinking and western science in particular lies in the human past. Civilization simply means the gradual process by which societies achieve organisation. A civilized society is a society in an advanced state of intellectual, social, cultural, level, political and religious development. The ancient civilization achieved highly developed techniques in terms of their perception of the universe. It should be noted that the achievements of the ancient civilization laid the foundation for the development of modern science and technology. Prominent among the ancient civilizations include Egypt, Mesopotamia, Greek, China, Maya, Indus River Valley and the Islamic civilization. The achievements of some of these cities will be discussed briefly below.

Self Assessment Exercise 1.1

What, in your own way, do you understand by the term 'civilization'?

3.2 Ancient Egyptian Civilizations

It is located in the present day Eastern North Africa. The civilization is concentrated along the lower banks of River Nile in what is now known as modern country of Egypt. The achievements of ancient Egypt are briefly listed as follows:

- **River Nile:**

The civilization of ancient Egypt was facilitated by the existence of River Nile which encouraged settlements and the practice of agriculture.

- **Transportation:**

Nile River also serves as a natural highway for transportation for the settlers.

- **Security:**

The presence of Nile River served as a natural barriers and security from external invaders. This natural barrier made Egypt to be conservative and independent.

The major achievements of ancient Egypt and their scientific implications can be seen in terms of architectural design, astronomy, mathematics, medicine and agriculture to mention but few.

(i) ***Architecture:*** They built magnificent buildings in form of pyramid using timbers and stones thus having strong houses.

(ii) ***Astronomy:*** They devised the four cardinal points to know the direction in the universe i.e. North, South, West and East. Their calendar had 29 and 30 days with a total of 365 days in a year.

(iii) ***Mathematics:*** They were good in counting addition, subtraction, multiplication and division thus laying the foundation for modern "BODMAS".

(iv) ***Medicine:*** They belief in the life after death hence practice mummification which made them to be conversant with human body and surgical operations.

(v) ***Agriculture:*** They were good in irrigation and animal rearing because of the presence of River Nile.

Self Assessment Exercise 1.2

Describe the process of mummification as practiced by the ancient Egyptians.

3.3 Ancient Mesopotamian Civilization

Ancient Mesopotamia is located between two Rivers. These are Rivers Tigris and Euphrates. It can be found today in the present modern Iraq and Eastern Syria. The achievements of Mesopotamia is briefly summarised as follows:

- ***Agriculture:*** The presence of Rivers Tigris and Euphrates gave ancient Mesopotamia an advantage to practice farming and rear animals and fishing activities. These attracted people to settle and develop on their own.

- ***Medicine:*** Ancient Mesopotamia's early medicine manifested itself in a combined form of magic and science. This is enshrined in their belief that ailments are caused by the gods hence they consult the gods before they administer any drug.

- ***Writing:*** They invented a form of writing known as "cunelform". This is a mode of writing using wedge shape strokes inscribed mainly on clays, stone, metal wax and other hard materials.

- ***Domestication of Animals:*** The presence of Rivers Tigris and Euphrates made it possible for the ancient Mesopotamians to identify, study, classify and domesticate different kinds of animals and plants. Hundreds of varieties of animals were identified and classified into fish, birds, serpent, four-legged animals and over two hundred and fifty (250) varieties of plants were identified.

- ***Building:*** They used sundry bricks, hardened by fire, in building their houses. Their houses are built in form of Temples known as “Ziggurates”.

- ***Map Making:*** They were the first to introduce the idea of map making.

Self Assessment Exercise 1.3

Describe the form of Mesopotamian writing.

3.4 Civilization of the Ancient Greece

The beginning of western science has been traditionally located among the philosophers of Greek city states located on the coast and island of the Eastern Mediterranean Sea. The early Greek philosophers were cosmologists who gave possible explanation to events in the universe. Prominent among the ancients Greek philosophers were Thales, Empedocles, Pythagoras, Plato, Socrates and Aristotle.

The ancient Greeks have achieved in the following areas:

- ***Mathematics:*** They were very vast in mathematics. Euclid was the first famous mathematician to invent a complete system of geometry. Pythagoras also invited the Pythagoras theorem which is being used in mathematics today all over the world.

- ***Science:*** The Greeks were the pioneers of some of the major branches of science that are being studied today, e.g. zoology, biology, physiology etc. In fact, Theophrastus is regarded as the father of Botany.

- ***Medicine:*** The Greek were the first to debunk the belief that sicknesses were caused by supernatural causes but that sicknesses were caused by diseases. Hippocratus is regarded as the father of medicine and modern medical doctors still honour his ideas up till today as it is expressed in the true Hippocratic oath.

- ***The Greek Language:*** The Greek language has greatly influence nomenclature in scientific disciplines today. Most concepts in science disciplines were derived from Greek languages, biology, geology, geography, physiology, zoology, etc.

Self Assessment Exercise 1.4

Explain why the Greeks are regarded as the major bedrock of modern science? If you have no done this, go back to the main content.

3.5 China, Maya and Indus Rivers Civilization

3.5.1 China

- China, like the Egyptians, developed an independent civilized society in the Far East because they were isolated from the rest of the world.

- Their way of writing is enshrined in their own brand of science in that they wrote on pieces of bone or tortoise shell and they later changed to bronze vessels.

- Chinese science was more pragmatic than theoretical and the use it to solve practical problems.

- In terms of mathematics, they use small rods to count numbers nd this can be used for addition, subtraction, multiplication and division.

- In terms of astronomy, they kept tract of the solar system by observing the heavens and the planet. They also devised a calendar which had 365¼ days.

- Their pure science were more practical than theory. They devised many practical methods in physics, chemistry, biology and mathematics.

Self Assessment Exercise 1.5

Describe the nature of mathematics in ancient China.

3.5.2 Maya

Maya is located in the middle America and in Western Mountain of South America.

- In terms of mathematics, Mayan counted their numbers in the units of twenty with each number going by a special name, but there was no formal mathematics.

- In astronomy, Mayan conception of the universe was primitive and superstitious. The earth was seen as the back of a giant lizard or crocodile lying in vast pond within water lilies and fish.

- The Mayan developed a complex system of hieroglyphic writing to read astronomical observations and calendar calculations.

- Their power of architecture can be seen from the way they build. They build massive store, pyramid, temples and sculpture.

3.5.3 Indus River Valley

The remains of Indus River Valley can be found in Pakistan, and Western India. They were very good in pottery, ceramic toys, beads, metal ornaments and stamp seals.

- Because the Indus River Valley was very fertile, it was used for agricultural purposes and this attracted settlement.

- There was intermingling of communities from both the West and the East.

- The major achievement of this civilization was in brick making. They were also good in town planning and the establishment of uniform standards of weights and measurements.

3.6 Islamic Civilization and Science

- Literature has shown that Islamic culture is very relevant to European science in that it is related to Judaism and Christianity.

- There was also cultural intermingling between Arabic speaking countries and Latin hence the early Arab leaders at Baghdad had the bulk of the Greek science translated into Arabic and their scholars advanced especially in mathematics, astronomy, optic chemistry, biology and medicine.

- In terms of mathematics, Arabian mathematician, Muhammed Al-Khwarizimi introduced Hindu-Arabic numerals which start from "zero". He also discovered algebra, a name derived from Arabic word "Al-jabr". He introduced Algorithm, which forms the backbone for our modern day computing.

- The Arabian scholars gave names to many of the brightest stars. Some of these include: Aldebaran, Altair and Denab.

- Arab chemists left their marks in some names used in chemistry today e.g. Alkali, Alchemy etc. They also developed methods of manufacturing metallic alloys and methods of testing the quality and purity of metals.

- The Arab scholars were also good in physics and other devices used in optics.

- In terms of medicine, the Arab scholars introduced numerous chemical treating substances for treatment of the sick. They were also good in the fields of ophthalmology and public hygiene.

4.0 CONCLUSION

It can be seen from the above that the ancient civilizations actually laid the foundation of modern science and technology. The achievements of the ancient cities discussed above served as a foundation stone for the development of modern science education curriculum.

5.0 SUMMARY

The foundation of modern science and technology, and the reformation in science curriculum was laid by the civilization of ancient cities such as Egypt, Mesopotamia, Greek, Maya, China civilization. In the next unit, you will learn about the second part of the historical foundations of science education curriculum development.

6.0 TUTOR MARKED ASSIGNMENT

1. Compare and contrast the achievement of ancient Egypt, Mesopotamia and Greek.

2. Explain how some of the achievement of each of the cities discussed in the text has laid the foundation of modern science and technology.

3. Discuss the role of each of the ancient cities in the reformation of science education curriculum.

4. Do you agree that without Rivers Nile, Tigris and Euphrates, there will be no Egypt and Mesopotamia respectively? Support your stance with relevant points.

7.0 REFERENCES/FURTHER READINGS

Bakker, C. and Clark, L. (1988). ***Explanation: An Introduction to the Philosophy of Science.*** Mountain View, California: May Field Publishing Company.

Butterfield, H. (1975). ***The Origins of Modern Science***. New York Free Press.

UNIT 2 HISTORICAL FOUNDATIONS OF SCIENCE EDUCATION CURRICULUM DEVELOPMENT II

CONTENTS

1.0 INTRODUCTION

In the previous unit, you started the historical foundations of science education curriculum development where you learnt about the achievements of the ancient civilizations and how they have served as foundation for the development of modern science curriculum.

In this unit, you will learn briefly about science in the Middle ages, scientific revolution and science in the 18th, 19th, 20th and 21st centuries.

2.0 OBJECTIVES

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

(i) explain the major development in science in the middle ages;

(ii) state the major achievements of the scientific revolution in the 16th and 17th centuries;

(iii) mention some of the scientists of the 18th, 19th, 20th and 21st centuries and their achievements.

3.0 MAIN CONTENT

3.1 Science in the Middle Ages

The development of science in the middle ages can be summarised as follows:

- It is generally agreed that the middle ages preserved for the use of later times the science of the ancients.

- Men in the dark ages did not find the parts of the western empire, which they occupied, a scientific tradition as rich as that which the Arabs inherited in the Eastern provinces.

- Scientific learning came to the western empire later, mostly in the 12^{th} and 13^{th} centuries from the Arabs and the Jews.

- The contribution of the middle ages to the development of modern science was so little that historians of science regard the middle ages as a period of pause in scientific thinking.

- The medieval men improved in their practical arts and added a little to their understanding of nature thus preparing the ground for scientific renaissance or revival.

- As a result of the revival, scientific knowledge became much richer than it had once been.

- As late as the early eleventh century, medieval mathematics were still confined to simple computations. But by the end of the thirteenth century, mathematicians were tackling advanced problems of the geometry of Pythagoras, approaching the solution of cubic equations by the intersections of cones, trigonometry and calculus.

- Medieval alchemists had stumbled across some new facts about the properties of metals and gases.

- On the whole, the middle ages witnessed the beginning of the re-birth in science which is called the renaissance though the progress was very slow.

Self Assessment Exercise 2.1

What are the major achievements of science in the middle ages?

3.1.1 Factors Responsible for the Slow Progress of Science in the Middle Ages

The factors responsible for slow progress of science in the middle ages are as follows:

(i) Absence of scientific incentives;
(ii) Treatment of technical methods in science with mysteries and secrecy;
(iii) Great emphasis on theology and faith;
(iv) Medieval mathematics were confined to simple computations and mathematics was not regarded as a complement of science;
(v) Lack of scientific societies where scholars of like minds can interact.

- However, by the late middle ages, there was a positive change in intellectual climate because theology and religion could no longer solve man's problems

- Again, there was disagreements and controversies in medieval learning.

- This disagreement brought about intellectual curiosity and willingness to re-open questions about the dogmas of the Greek philosophers.

- All the above factors contributed to the re-birth of science called the renaissance.

Self Assessment Exercise 2.2

List and explain some factors that led to the slow pace of science in the middle ages.

3.2 Scientific Revolution in the 16th and 17th Centuries

- The renaissance which was cultural movement that encompasses a rebellion of learning based on intellectual transformation can be viewed as a bridge between the middle ages and the modern era. This was a movement that affected European intellectual life. Renaissance was a period of revival in classical learning in Europe which was brought about partly by contact with other civilization. The scientific revolution which is also called renaissance positively affected the rapid development of science in Europe in the 16th and 17th centuries.

- The 16th and 17th centuries produced the intellectual basis for modern western technology, particularly in Europe.

- The period witnessed a drastic emergence of able bodied men of science who discovered almost all aspects of science and technology.

- Significant transformations were made in the field of astronomy, physics and mathematics.

- The change from only thinking and speculations about things to investigating them experimentally is one of the major changes that gave rise to modern science.

- In the 16th and 17th centuries, it was possible and convenient to borrow scientific instruments from other walks of life.

- The period also witnessed the designing of scientific instruments for specific purposes.

- Scientific instruments were used on a really big scale for the first time in history and this opened room for discovery of new things in nature.

Self Assessment Exercise 2.2

What is the significance of 16th and 17th centuries in the history of science?

3.2.1 Factors that led to Revolutionary Upsurge in Science in the 16th and 17th Centuries

1. Quickening cultural, political and economic changes taking place and the receptive of new ideas by the society;

2. Formation of societies and organisations to promote, publicise and encourage science;

3. Emergence of able bodied and devoted men of science;

4. Use of well formulated problem and pursuit of answers to such problems;
5. Use of improved experimental instruments such as telescope, microscope, etc;

6. Marriage of mathematics with science which make precision in science possible;

7. Free communication among scientists.

3.3 Science in the 18th and 19th Centuries

- The 18th and 19th centuries witnessed the industrial revolution.

- Industrial revolution is the change from the cottage system of industry to the factors system of industry in Europe.

- The revolution was as a result of application of a science for practical purposes. For instance, goods that were traditionally manufactured at home or in small workshops now began to be manufactured in the factory.

- The revolution began in Great Britain during the last half of the 18th century; it later spread to regions of Europe and to the United States of America during the following centuries.

- The industrial revolution is called a revolution because it changed the European society both significantly and rapidly.

- Some of the factors that aided industrial revolution in Britain are as follows:

  1. geometric increase in population as a result of rural-urban migration;
  2. introduction of machines and establishment of factories to reduce manual labour;
  3. soft loans from banks to factory owners which encouraged more people to establish factories;
  4. availability of raw materials to feed the factories e.g. coal, iron, ore, wool, etc.
  5. availability of water transport which facilitated the transportation of manufactured goods.

Self Assessment Exercise 2.3

What is industrial revolution? What are the benefits of industrial revolution to the whole world?

3.4 Science in the 20th and 21st Centuries

- The 20th and 21st centuries witnessed a great advancement in science and technology and it formed the basis of modern science.

- It was a continuation of the developments in the 16^{th}, 17^{th}, 18^{th} and 19^{th} centuries.

- Science became highly professionalized.

- Investigations were centred purely on laboratory experiments with the use of scientific methods.

- Spectacular achievements were made in the fields of genetics, evolution, medicine, social sciences, technology and physics.

- In physics, Albert Einstein postulated the theory of relativity to resolve certain theoretical experimental anomalies in Newtonian physics.

- A great advancement was made in genetics. For instance, Gregor Mendel's work in genetics was revisited in the 20^{th} century.

- James Watson and Francis Crick established the structure of DNA in 1953.

- It was also discovered during these centuries that diseases cannot only be caused by micro organism but also by deficiency of certain substances called vitamins. Alexander Flamming discovered penicillin in 1928.

- Cure, treatment and prevention of diseases that affected human beings were discovered. Improved drugs and development of new tools for surgical operations were discovered.

- An Australian physician, Sigmund Freud founded the practice of psychoanalysis. There was also dramatic discovery.

- There was marriage of science with mathematics.

- Lastly, science today has so much affected the development of all nations. No historical events of the past have influenced the world and lives of men like science. No nation today can achieve the first rank position without an advancement in science and technology.

Self Assessment Exercise 2.4

Discuss the side effects of science and technology on living things.

4.0 CONCLUSION

From the above discussion, it can be concluded that the development of modern science and technology started within renaissance. Renaissance brought about the emergence of able bodied men and women of science. It also led to the industrial revolution in Britain in the 18^{th} and 19^{th} centuries.

Today, more discoveries are being made as a result of post-renaissance research. This has led to improvements in agriculture, transportation, medicine and telecommunication, to mention but few.

5.0 SUMMARY

In this unit, you have learnt about the evolution of science from the middle ages up till the present century. You have also seen how science and technology has influenced the overall development of the world.

In the next unit, you will learn about the philosophical foundations of science education curriculum development.

6.0 TUTOR MARKED ASSIGNMENT

1. Discuss the significance of renaissance in he birth of modern science.

2. Do you agree with the assertion that 'modern science is a double edged sword? Butress your stand with the aid of relevant points.

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UNIT 3 THE PHILOSOPHICAL FOUNDATIONS OF SCIENCE EDUCATION CURRICULUM DEVELOPMENT

CONTENTS

1.0 INTRODUCTION

In the last unit, you have seen how the ancient cities have laid the foundations for the development of modern science and technology.

In this unit, you will see how the branches of philosophy have contributed to knowledge of science. You will also see some of the contributions of Greek philosophers to the development of modern science and technology.

2.0 OBJECTIVES

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

(i) define the term ‘philosophy’;

(ii) list and describe some branches of philosophy you know;

(iii) state some of the Greek philosophers and their contributions to the development of modern science and technology.

3.0 MAIN CONTENT

3.1 Meaning of Philosophy

The word 'philosophy' literally means love and pursuit of wisdom. It is the systematic critical examination of the way in which we judge, evaluate and act, with the aim of making ourselves wiser and more self-reflective. The term philosophy originates from a Greek word "Philosophia" meaning "love of wisdom". It is used today to signify the critical evaluation of the facts of experience. The earliest philosophers in ancient times gave possible explanations to events in the universe. They sought rational solutions to certain fundamental problems of mankind asking questions about the nature of the universe and the meaning of human experience.

The great philosophers such as Socrates, Plato and Aristotle among others attempted to solve specific problems from their individual point of view and in most cases; they speculate ideas about the universe. The history of philosophy throughout ancient, medieval and modern times has generally followed the precedent of system-building initiated by Plato and Aristotle. The ideas of the ancient philosophers laid the foundation of modern science curriculum.

Self Assessment Exercise 3.1

What, in your own word, is philosophy?

3.2 Philosophy and Science Education Curriculum

Until about 200 years ago, science as we know it today was known as natural philosophy and there was no distinction between science and philosophy. Today, natural philosophy has been changed to science which means the investigation of nature by the use of experiment and observation. Science today has so many branches and divisions. Science can be divided generally into pure and applied sciences. As earlier on discussed, philosophy is love of wisdom. It tends to give explanation to events in the universe. This leads to a branch of philosophy known as epistemology.

3.2.1 Epistemology

Epistemologists have attempted to clarify not only the meaning of explanation but also the meaning and relationships of concepts such as knowing, truth, validity and the likes. In fact, epistemology today is recognised as the philosophy of science. This is because science tend to give explanation to events in the universe while epistemology does the same thing. Other branches of philosophy include: logic, metaphysics, ethics, etc.

3.2.2 Logic

Simply put, logic is the study of methods for evaluating arguments and reasoning. This is the study of the principles for distinguishing correct from incorrect reasoning. It can be said to be the science of reasoning or better still, the science of rational reasoning. Logic is a technique for evaluating philosophical claims and arguments. Philosophical arguments are sets of statements in which one or more of the statements attempt to provide reasons or evidences for the truth of another statement. For every logical argument, there must be a premise and conclusion. A premise is a statement in an argument that serves to provide evidence for the truth of a claim. The conclusion, on the other hand, is the statement in an argument that the premises are claimed to support or imply. The following is a simple logical argument:

1. All living things have life;
2. A goat is a living thing;
3. Therefore, a goat has life.

The above is an example of a valid argument. The first and second statements are called premises while the third statement is the conclusion.

In a valid argument, the truth of the conclusion must logically follow from the premises. A valid argument is also called a sound argument. An invalid argument is a situation whereby the premises did not support the conclusion.

Self Assessment Exercise 3.2

Construct a valid and an invalid argument based on your area of specialisation.

Logical argument could be deductive or inductive. In deductive argument, the conclusion follows the premises while in inductive argument, the premises follows the conclusion.

Implication of Logic for Science Education Curriculum Development

Most scientific statements today are based on either inductive or deductive argument. For instance, for any drug to be released in the market today, it will first be tested using other lower animals such as: Albino rats, monkey etc. Smaller group may also be used to test the efficacy of the drug before a conclusion can be reached that the drug is safe for human being. Adequate testing provides a strong inductive argument that the drug is safe. Also, the scientific methods used in carrying out investigation today are derived from the deductive method of reasoning.

Self Assessment Exercise 3.3

State a logical argument based on your area of specialisation.

3.2.3 Metaphysics

The term ‘metaphysics’ is that area of philosophy that deals with the nature of reality. It contains some of the most difficult, profound and abstract theories produced by the human mind. It should be noted that at the dawn of western philosophy in ancient Greece, the early philosophers began to examine the nature of reality for themselves and began to think critically about the traditional stories that explains the universe prior to the development of philosophy and science. The Greeks were concerned with the problem of permanence and change. To them, everything seems to be changing. For instance, the daylight comes and go, darkness comes and go, seasons rotate, the planets shift their position including earth, etc. Again, some constants seem to remain permanent throughout these changes. The metaphysicist tend to ask questions about the nature of permanence and changes. They tend to ask what things are permanent and what things are real. Plato, a Greek philosopher was regarded as the father of metaphysics. According to him, reality is that which we dare not misunderstand if we are to be truly fulfilled persons.

Implications of metaphysics to science education curriculum

Since metaphysics talks about reality, science also talks about reality. Whatever cannot be perceived by all the human senses is not real and it is not scientific. All the disciplines of science today such as: physics, chemistry, biology etc. use scientific methods to investigate the realities of life.

Self Assessment Exercise 3.4

Differentiate between metaphysics and science.

3.2.4 Ethics

Ethics ordinarily seeks to establish and prescribe norms, standards or principles for evaluating our actual practices. Ethics seek to establish principles that prescribe what we ought or ought not to do. Ethics and religion are similar. Ethical theory seeks to identify and set forth the nature of moral value and moral obligation. It tends to talk about goodness or rightness and bad. Ethical theories talk about actions, motives, consequence and character and subject these factors to moral evaluation.

Self Assessment Exercise 3.5

In your own words, define ethics.

3.3 Greek Philosophers and their Contributions to Science Education

There are several Greek philosophers but you will learn about the five famous Greek philosophers. They are as follows:

Thales (636 – 546 BC)
Pythagoras (562 – 500 BC)
Socrates (470 – 399 BC)
Plato (427 – 347 BC)
Aristotle (384 – 322 BC)

3.3.1 Thales

- Thales was a mathematician, astronomer and a philosopher.

- The scientific traditions of the Greek started with Thales.

- He was considered to be the first “physiologist” or philosopher of nature.

- Thales tried to show that he was superior to ordinary practical man due to his scientific knowledge.

- He believed that water is the material cause of all things and that the universe is merely a modification of water.

- As a mathematician, he demonstrated that a circle is bisected by a diameter and that the base angles of an isosceles (i.e. a triangle with two equal sides) are equal.

- Thales could predict solar and lunar eclipses, devise methods to measure the height of a building from a distance and determine the distance of a ship from the shore.

- He found a way to find the distance of a ship from the shore using simple geometry.

Self Assessment Exercise 3.6

In just one or two words, state the major achievement of Thales.

3.3.2 Pythagoras

Below is the summary of Pythagoras’ achievements:

- He was born on the island of Somos.

- He was against book-writing but emphasised a teacher-disciple mode of learning in which his disciplies followed him on his travels.

- Pythagoras’ phillsophy and practices created a brotherhood called Pythagoreans meaning people who follow the doctrines of Pythagoras.

- He noticed the mathematical relationship between the length of a vibrating string and the notes of the musical scale.

- This mathematical relationship, along with the other relationships, he observed in geometry and astronomy, led him to believe that all things consist of numbers and a particular shape.

- Numbers, called “arithmos”, were divided into categories. Odd numbers were associated with feminine characteristics while even numbers were associated with masculine characteristics thus given rise to the concept of arithmetic.

- He polarized the famous pythagoras’ theorem which states that “in a right-angle triangle, the square of the length of the hypotenuse is equal to the square of the length of the base plus the square of the perpendicular.

- He believed that the universe is made up of five different geometric shapes, mathematically.
- He also believed that the earth is made from a cube, fire from a triangular pyramid, air from a octahedron, water from the icosahedrons and earthier from a dodecahedron.
- Pythagoras and the Pythagorean brotherhood formulated principles in religion, science, and the occult that influenced the later Greek philosophers.

Self Assessment Exercise 3.7

State the major achievement of Pythagoras.

3.3.3 Socrates

- Socrates, like Pythagoras, did not write books but most of our knowledge about him comes from Plato's book 'dialogues'.
- In Socratic philosophy, a healthy discourse was considered as the best way to know truth even the truth that is described in arithmetic, geometry and astronomy.
- Socrates considered observational science especially observational astronomy as a waste of time.
- He used a distinctive method of questioning in finding truth. This is known as Socratic method.
- Socratic methods usually demanded critical thinking to arrive at the correct answer.
- The uniqueness of this method is that the answer of a question is a question.
- Socratic method is a popular tool in teaching and learning process today.

Self Assessment Exercise 3.8

State the major achievements of Socrates.

3.3.4 Plato

- Plato's main works are in his books: Timaeus, Dialogues and the Republic.
- He was not so fond of experimental observation especially in astronomy.
- He believed that astronomers do not need to practice traditional stargazing.
- He is of the opinion that with the help of mathematics and geometry, one can easily deduce heavenly motions. Mathematics can be used to learn the physical universe.

- He believed that mathematics was the best science of all because mathematics help to gain knowledge about the external world.

- Geometry was more theoretical and not practical in the eyes of Plato.

- He founded a school known as Academy which became a centre of learning. This school was later closed down by the Emperor on the ground that Plato's Academy had many scholars who followed the pagan religion where forces of nature are worshipped.

- He visited Egypt to obtain knowledge in science, religion, rites and manners.

Self Assessment Exercise 3.9

What will Plato be remembered for?

3.3.5 Aristotle

Below is the summary of Aristotole's achievements:

- Like Plato, Aristotle also founded his own school called Lyceum where he conducted the classes under trees or in gardens.

- The main contributions of Aristotle's school are in biology, philosophy and history.

- Aristotle believed that the earth and the heavens follow two different sets of natural laws.

- The Arabs became fond of Aristotle's philosophy and preserved his works.

- He has also contributed greatly to geometry.

- He was the first to notice that sea urchins lay larger eggs during a full moon. He also observed that male cat fishes look after the eggs laid by their females. He observed that placental dog fish release fully developed babies and not eggs.

- The above observations by Aristotle were later confirmed by other scientists to be true.

4.0 CONCLUSION

From what you have learnt above, you will agree with us that the works of the Greek philosophers actually laid the bedrock of modern science disciplines. However, it should be noted that the Greek philosophers were only speculative in their studies about nature. They did not carry out any experiment to buttress their claims about nature.

5.0 SUMMARY

Can you now see how the various branches of philosophy such as: epistemology, logic, metaphysics, and ethics have contributed to the development of scientific knowledge? You have also seen how some Greek philosophers have laid the foundation of modern science curriculum development. In the next unit, you will learn the psychological foundations of science education curriculum development. You will see how some psychologists have related cognitive development to the learning of science.

6.0 TUTOR MARKED ASSIGNMENT

1. With the aid of specific example, define logic and put up a logical argument.

2. Why are the Greek philosophers important in the philosophical foundations of science education curriculum development?

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UNIT 4 PSYCHOLOGICAL FOUNDATIONS FOR SCIENCE EDUCATION CURRICULUM

CONTENTS

1.0 INTRODUCTION

In the last unit, you learnt about the philosophical foundations of science curriculum development. In the unit, you shave seen how the ideas of Greek philosophers laid the foundation for modern science education curriculum. In this unit, you will study into the psychological foundations for science education curriculum. Specifically, you will see how Jean Piaget's developmental theory has affected the teaching and learning of science.

2.0 OBJECTIVES

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

(i) explain the concept of cognitive development;
(ii) describe the stages of Jean Piaget's work;
(iii) state the implications of the findings of these various psychologists listed in (ii) above to science teaching;
(iv) describe Les Vygotsky's work and its implication to science teaching.

3.0 MAIN CONTENT

3.1 Cognition and Cognitive Development

Cognition, simply put, is the acquisition of knowledge through thought and perception. It deals with how we gain information about the world, how such information is represented and transformed as knowledge, how it is stored and how that knowledge is used to direct our attention and behaviour. Science teaching and curriculum development involves series of psychological processes ranging from sensation to perception, pattern recognition, attention, learning, memory, concept formation, thinking, remembering, language and other developmental processes. Many psychologists have worked on the process of science teaching and learning processes. Prominent among them includes: Jean Piaget, David Ausubel, Jerome Brunner and Robert Gagne to mention but few. In the subsequent discussion, you will study the works of these psychologists and the implications of their findings to the teaching and learning of science.

3.2 Jean Piaget and his Development Stages

Jean Piaget, a Swiss psychologist worked on development stages of a child right from birth to maturity. From his work, he discovered that the thought processes of a child change in response to the demands made on them during his long and varied interaction with the physical and social development. The critical feature of Piaget's view point is that thinking actually changes in an orderly fashion as individuals' progress from helpless infants to mature adults. Piaget classified the cognitive development of a child into four (4) stages and he identified some of the characteristics of each stage. The stages are:

(i)	Sensory motor stage	0 – 2 years
(ii)	Pre-operational stage	2 – 7 years
(iii)	Concrete operational stage	7 – 11 years
(iv)	Formal operational stage	11 years and upward.

3.2.1 Characteristics of Each Stage

Sensory Motor Stage:

- Inter-coordination of schemes into successively more complex and integrated ones;

- Reflex responses are innate and involuntary but this later develops into voluntary actions;

- For instance, sucking, looking and grasping, which were initially reflex actions later graduates into voluntary actions. This is when a child can grasp and look simultaneously. The child here can now look at something with a view to grasp it. This is known as secondary schemes;

- The next scheme is the tertiary scheme at which point the child can do several things with an object. He can pick up an object, squeeze it and bite it;

- The next level is one of final inter-coordination, with a resulting qualitative shift in intellectual functioning; activating of schemes by objects not present i.e. from memory;

- Differentiates self from objects;

- The process of interrogation marks the end of the sensor motor period. It's a period of intellectual functioning which has integration and inter-coordination as its basis.

Pre-occuational Stage:

- Here, the child's behaviour shifts from dependence on action to utilization of mental representations of these actions;

- The capacity for representation makes possible a number of significant new abilities;

- There is a primitive kind of insight learning in which the child can merely look at a problem and solve it without having to perform any overt actions. This means that he can figure out the answer in his head and realize the correct solution;

- The capacity for representation makes possible the child's use of language which may comprised of symbols or words that stand for objects and events;

- Although the child shows signs of thinking he does not yet possess the ability to coordinate different thoughts in an integrated and systematic way;

- This general limitation manifests itself in several important behaviours i.e. egocentrism, concatenative thinking and anthropomorphism;

- Concatenative thinking is the tendency to string ideas together as they come to mind, with little regard for overall unity and little concern for adhering to a central integrating theme or idea;

- Here, the child cannot coordinate individual ideas or thoughts into an integrated, controlled sequence;

- The child can represent simple images and thoughts but the ideas remain isolated from each other and not integrated into a system;

- Anthropomorphism means endowing inanimate objects with human characteristics;

- The child at this level appears unable to distinguish clearly between human beings and objects;

- The pre-operational child has less control over how his thoughts are organised and will thus tend to get human and non-human characteristics mixed up;

- Children learn to use language and to represent objects.

Concrete Operational Stage:

- This stage witnesses the transformation of the thought structures of the pre-occupational child into those of the concrete-operational child;

- The process of transformation involves advances in three important domains of intellectual growth;

- These are conservation, classification and seriation/transivity;

- Conservation is the ability to see invariance in the face of apparent variance;

- Conservation permits the child to ignore the perceptual changes or variations occurring in the world and to appreciate the underlying continuity or invariance of the quantity;

- The child can think logically about objects and events;

- The concept of reversibility develop. This means that interiorized transformation that is reversible develops;

- The operation is interiorized in the sense that the child can carry out actions by imagining;

- For instance, if you give a child at this level two identical containers with the same dimensions, one higher and narrower while the other is lower, but wider and you pour coke (soft drink) of the same measurement into the two containers and ask a child at this level to pick one out of the two. The child at this level will know that the two containers contain the same quantity of coke (soft drink);

- The concrete operational child focuses not on state but on the transformation that occurs as the liquid is poured. He then puts that together with his knowledge about the height and width of the containers.

Classification:

- This is the ability to classify or group objects;

- A child at concrete operational stage can demonstrate a classification ability called the addition of classes;

- The child here can perform advanced transformation, reversibility and interiorization.

Seriation/Transitivity

- Seriation refers to the ability to string together a series of elements according to some underlying relation;

- Transitivity, on the other hand, is related to seriation ability;

- A pre-occupational child asked to order several sticks according to their length will be able to do so in a limited fashion. Most often ordering two sticks correctly but not aligning the third stick with the first two. However, a child at concrete operation stage can perform a complete seriation task;

- Generally, the child is limited to coordinating concrete things in an actual situation.

Formal Operational Stage:

- At this level, the child possesses the ability to coordinate the different concrete-operational systems effectively;

- The child, here progresses towards greater integration and coordination of previously isolated concrete-operation systems;

- The child develops an integrating systems of thought;

- Child can think logically about abstract proposition, hypothesis systematically;

- The child can carry out systematic experimentation;

- He/she can carry out hypothetical and abstract thinking;

- He/she can work with different dimension into a higher-order thinking. Unlike the concrete operational child who can only work on one dimension;

- He/she can coordinate previously isolated systems of concrete operation;

- The child at this level has evolved from the simple reflexes of the new born to the sophisticated thoughts of the adolescents and adult.

3.3 Challenges of Piagetian Theory

Recent researchers have come up with ideas that tend to criticize Piaget's work. Some focus on minor aspects of Piaget methodology but others are directed towards the substance of his theory. Some of the criticisms are as follows:

1. Attention can affect a child's ability to perform Piagetian task especially in conservation, classification and transitivity;

2. It has also been suggested that the poor performance of very young children on Piagetian tasks may result more from memory deficits than from deficient logical operations;

3. Familiarity of concepts and environmental factors can affect cognitive development of children hence, Piaget's categorization may not be universally practicable;

4. Other scholars have examined Piaget's claims about the processes underlying transitivity (Trabasso, 1977; Riley et. al., 1977). Those studies provide a serious challenge to Piaget's claims about the processes that underlie certain abilities. Contrary to Piaget's claim, it has been discovered that transitive inferences may be made not by the application of a sequential logic pattern but by the use of mental imagery;

5. Piaget's methodology was largely clinical. The exclusive use of natural-observational methodology may have limited the validity of the conclusion reached by Piaget;

6. Many theorists question Piaget's fundamental assumption that development occurs in a discontinuous stages. They believe that development is continuous (Brainend, 1978; Chen and Siegler, 2000 and Siegler, 1998);

7. Scholars have questioned Piaget's estimate of the ages at which particular accomplishments can first be made. This is because research has shown that some children can do things earlier than Piaget had thought (Baillargeon, 2002; Gelman and Baillargeon, 1983).

3.4 Implications of Piaget's Theory on Science Teaching

1. Science teachers should prepare their curriculum in a spiral form following Piaget's classification;

2. Science teachers should use relevant and varieties of teaching aids when teaching;

3. Hands-on activities and mind-on activity should be employed by science teachers especially at the primary and lower secondary school levels;

4. Science teachers are to encourage children to make enquiries and ask questions about their environment.

3.5 Alternative Theory of Cognitive Development of Lev Vygotsky

Alternative theory of cognitive development is a Neo-Piagetian theory. Piaget's theory of cognitive development was partly accepted by some scholars, some modified it and others built on it. One of the scholars that developed an alternative theory of cognitive development is Lev Vygotsky, a Russian psychologist. His ideas are based mainly on internationalization and the zone of proximal development.

Internalization:

While Piaget emphasised the biological and maturational aspects of development, Vygotsky emphasised the role of the environment in children's intellectual development.

- According to Vygotsky, development proceeds from the outside in, in a process known as internalization;

- The process of internalization implies that social rather than biological influences are paramount in this theory;

- Vygotsky is of the view that a child's learning occurs through interactions within an environment and this determines what the child internalizes;

- The child listens and watches what people say, how they say it, what they do at home, school, church, etc. on the basis of what they saw from their interaction, they now internalizes by making it their own;

The Zone of Proximal Development

- The zone of proximal development, according to Vygotsky, is the range between the developed abilities that a child clearly shows and the abilities that the child might acquire, if given the appropriate environment;

- The zone of proximal development tend to measure the latent capacity between the ability that a child develop through interaction of heredity and environment and what the child's potential would be if he was free from the confines of an environment that is never truly optimal;

- He argued that in order to test this latent capacity, we need to test children in a static assessment environment in which an examiner asks a series of questions neither helping nor revealing whatever the test taker has answered them correctly or otherwise;

- In a dynamic assessment environment when the child gives a wrong answer, the examiner offers a sequence of guided hints to facilitate problem solving;

- In this scenario, the examiner serves as both the teacher and tester and he is particularly interested in the child's ability to use hints;

- This ability is the basis for measuring the zone of proximal development because it indicates the extent to which the child can expand beyond the observable abilities at the time of testing;

- The zone of proximal development is one of the more exciting concepts in cognitive development psychology because it enables the teacher to see beyond a child's observed performance.

Self Assessment Exercise

Compare and contrast Piaget's theory of cognitive development and Vygotsky ideas.

3.6 Implications of Alternative Theory of Cognitive Development to Science Training

1. The power of Piaget and Vygotsky's work lies in their interest in probing beneath the surface to try to understand why children behave and respond the way they do hence science teachers should take this into consideration when teaching;

2. Science teachers should also encourage students to internalize by giving them activities that will expose the students to their environment;

3. Children should be allowed to interact among themselves by introducing group activities and discussion methods.

3.7 Challenges of Vygotsky's Theory

The over-emphasis on the role of language in thinking has been criticized by some scholars. Also, emphasis on collaboration and guidance in the teaching – learning procedure can make some children become lazy and over-dependent on others.

4.0 CONCLUSION

It can be concluded from the above that Piaget's approach to cognitive development through a categorization structure is central to the school of cognitive theory known as constructivism. While the works of Vygotsky was an alternative theory of cognitive development because, unlike Piaget's work, it emphasises on cultural mediation, internalization and language as a tool for cognitive development.

5.0 SUMMARY

In this unit, you have seen how Jean Piaget categorized cognitive development of children in stages. You have also seen the characteristics of each stage. Again, you have perused the works of Vygotsky where he emphasises the cognitive role of tools of mediation and notion of internalization of knowledge. In the next unit, you will see how other psychologists such as: Brunner, Gagne and Ausubel have laid more emphasis on the process of learning.

6.0 TUTOR MARKED ASSIGNMENT

1. Explain the concept of cognitive development in your own words.
2. Describe briefly the cognitive developmental stages of Jean Piaget.
3. What are the implications of Piaget's work on the teaching and learning of science?
4. Explain briefly the main points of Vygotsky's cognitive development.

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UNIT 5 PSYCHOLOGICAL FOUNDATIONS OF SCIENCE EDUCATION CURRICULUM DEVELOPMENT II

CONTENTS

1.0 INTRODUCTION

In the last unit, you have learnt about the works of Jean Piaget and Lev Vygotsky on cognitive development. You have also seen the implication of their findings to the teaching learning of science. In this unit, you will learn about other psychologists that have worked on child development. You will also see the implication of their findings on science teaching.

2.0 OBJECTIVES

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

(i) state some psychologists that have worked on child development;
(ii) explain Jerome Bruner's learning theory and its implication to science teaching;
(iii) describe Robert Gagne's conditions of learning and its implication to science teaching;
(iv) highlight David Ausubel's theory and its implication for science teaching;
(v) compare and contrast Jerome Bruner's work with that of David Ausubel.

3.0 MAIN CONTENT

3.1 Jerome Bruner's Learning Theory

Jerome Seymour Bruner is an American psychologist that has worked on cognitive psychology and cognitive learning theory in educational psychology. His findings have implications for science teaching. Below are briefs from his finding:

- He is of the view that any subject can be taught to any child at any stage of his development in some intellectual honest form;

- That learning is an active process in which learners construct new ideas or concepts based upon their current or past experiences;

- That in a learning process, the learner selects and transforms information;

- That interest in the material to be learnt is the best stimulus to the learner, rather than external goals such as grade or other reinforcements;

- According to Bruner, a theory of instruction should address four major aspects. These are:

  (i) predisposition towards learning;
  (ii) the ways in which a body of knowledge can be grasped by the learner;
  (iii) the most effective sequences in which to present material;
  (iv) the nature and pacing of rewards and punishment.

- In his research on the development of children, Bruner proposed three modes of representation. These are:

- enactive representation (action-based);
- iconic representation (image-based);
- symbolic representation (language-based);

- The above modes of representation are not neatly delineated but are integrated and only loosely sequential as they translate into each other;

- Bruner identified two types of discovery. These are spontaneous and non-spontaneous discovery.

- According to Bruner, knowledge acquired through discovery learning and problem solving has the highest retention.

Implications of Bruner's Work:

1. Bruner's work suggests that a learner regardless of his age is capable of learning any material so long as the instruction is organised appropriately. This implies that science teachers should organise their syllabus, scheme of work and lessons in a spiral curriculum form, so that the students continuously builds upon what they have learnt;

2. Science materials should also be presented to learners from known to unknown and from simple to complex;

3. Discovery method of teaching should be employed in teaching science and hands-on-activities. Science teachers should encourage students to discover principles by themselves rather than telling them.

Self Assessment Exercise 5.1

Differentiate between the two types of discovery as identified by Bruner.

3.2 Robert Gagne's Conditions of Learning

Robert Gagne's work is on conditions of learning and learning hierarchy. He is of the view that there are different levels of learning and each different type requires different types of instruction. Gagne identified five major classes of learning. These are:

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i. verbal information
ii. intellectual skills
iii. cognitive strategies
iv. motor skills
v. attitudinal skills.

According to Gagne, each of the above classes of learning has different internal and external conditions. He also identified eight types of learning tasks for intellectual skills. These are as follows:

i. stimulus recognition or signal learning;
ii. response generation or stimulus-response learning;
iii. procedure following or chain learning;
iv. use of terminology or verbal association;
v. discrimination or multiple discrimination;
vi. concept formation or concept learning;
vii. rule application or rule learning; and
viii. problem solving.

Gagne believes that learning structure which results from task analysis is a system of learning hierarchy of intellectual operation. Gagne's theory focused mainly on intellectual skills. His theory outlines nine instructional events and corresponding cognitive processes.

Table I shows Gagne's nine instructional events and corresponding cognitive processes

S/N	Instructional Events	Corresponding Cognitive Processes
1.	Gaining attention	Reception
2.	Informing learners of the objective	Expectancy
3.	Stimulating re-coin of prior learning	Retrieval
4.	Presenting the stimulus	Selective perception
5.	Providing learning guidance	Semantic encoding
6.	Eliciting performance	Responding
7.	Providing feedback	Re-inforcement
8.	Assessing performance	Retrieval
9.	Enhancing retention and transfer	Generalization

Source: Gagne, R. (1985). The conditions of learning (4th ed.)

The following table illustrates a teaching sequence corresponding to the nine instructional events for the objective using: "Characteristics of living things" as a topic.

Table II showing teaching sequence and corresponding instructional events

S/N	Instructional Events	Teaching Sequence
1.	Gain attention	Show a video documentary on living things (i.e. animal and plant)
2.	Identify objective	Pose questions e.g. what are living things
3.	Recall prior learning	Review characteristics of living things
4.	Present stimulus	Describe one characteristic of living thing
5.	Guide learning	Show examples of both plants and animals
6.	Elicit performance	Ask students to show other examples of plants and animals
7.	Provide feedback	Check all examples as correct/incorrect
8.	Assess performance	Provide scores and correction or remediation
9.	Enhance retention/transfer	Show pictures and diagrams of different plants and animals and ask students to identify them

The above tables imply the following:

(a) that different instruction is required for different learning outcomes;

(b) events of learning operate on the learner in ways that constitute the conditions of learning;

(c) the specific operations that constitute instructional events are different for each different type of learning outcomes;

(d) learning hierarchies define what intellectual skills are to be learned and a sequence of instruction.

Implication of Gagne's Theory to Science Teaching:

1. Science teachers should prepare their learning materials in an hierarchical form from simple to complex, known to unknown;

2. Science teachers should use different techniques and strategies in teaching science;

3. Science teachers should use varieties of teaching aids in disseminating information to students;

4. Science teachers should encourage students to be involved in problem-solving activities in the science classroom.

Self Assessment Exercise 5.2

Using Robert Gagne's nine instructional events, identify a topic in your area of specialisation and state the teaching sequence in a higher tabular form.

3.3 David Ausubel's Meaningful Verbal Learning and Subsumption Theory

David Ausubel was a developmental psychologist whose theory was based on meaningful verbal learning and subsumption theory. Like Jerome Bruner, Ausubel's work agrees with the hierarchical nature of knowledge. He gave more emphasis to the verbal learning methods of speech, reading and writing, unlike Bruner who focused on discovery process of learning. Bruner's ideas are summarised in the following points:

- Meaningful learning is created through some form of representational equivalence between language and context;

- There are two processes involved. These are reception, which is employed in meaningful verbal learning and discovery which is involve din concept formation and problem-solving;

- Subsumption theory on the other hand occurs when information is organised hierarchically into the learner's cognitive structure;

- To subsume is to incorporate new material into the learner's cognitive structure;

- There are two ways by which new material is subsumed into the learner's cognitive structure:

1. when the existing structure provides a framework which the new learning is related, hierarchically, to the previous information or concept in the individual cognitive structure. In this case, meaningful learning would take place;

2. when one encounters completely new unfamiliar learning that is not related to the previous information or concepts in the individual's cognitive structure. When this happens, there will be no meaningful learning, but Rote learning. However, this rote learning may eventually contribute to the construction of a new cognitive structure which can later be used in meaningful learning.

- Ausubel proposes didactic, expository methods of teaching. This method, according to him, is a verbal learning approach which encourages rapid learning and retention;

- Ausubel was also a strong proponent of advanced organizers. It is a tool that aid meaningful learning. It helps students to integrate new information with existing knowledge thereby leading to meaningful learning as opposed to rote learning or memorization;

- Advanced organizer is a means of preparing the learner's cognitive structure for the learning experience that is about to take place;

- Ausubel believed that it was important for science teachers to provide a review of information to be learned. This can be done by providing a brief introduction about the way that information that is going to be presented are structured.

Implication of Ausubel's Theory to Science Teaching

1. Science teachers should encourage meaningful learning by linking new learning with the previous knowledge of the learners;

2. Science teachers should combine didactic expository methods of teaching with activity oriented method so that rapid learning and retention can be encouraged;

3. Advanced organizers in learner should be encouraged by science teachers through integration of new information with the existing knowledge.

Self Assessment Exercise 5.3

What, in your own word, do you understand by "Advanced organizer"?

4.0 CONCLUSION

From the above discussion, you will agree with me that the works of Jerome Bruner, Robert Gagne and David Ausubel are all geared towards developmental psychology and cognitive development. While Bruner was of the view that any subject can be taught to any child in an intellectual honest form at any stage of his/her development, Robert Gagne categorized learning into hierarchy while David Ausubel focused on meaningful learning.

5.0 SUMMARY

In this unit, you have seen the psychological foundations for science education curriculum development. You have also seen how the findings of the various psychologist discussed can influence the teaching and learning of science in schools.

In the next module, you will go into science education curriculum reforms in Nigeria.

6.0 TUTOR MARKED ASSIGNMENT

1. State the psychologist that have worked on child development and highlight briefly their findings.

2. Discuss separately the implications of Bruner, Gagne and Ausubel's works on the teaching and learning of science.

3. Compare and contrast Jerome Bruner's work with that of David Ausubel.

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MODULE TWO SCIENCE EDUCATION CURRICULUM REFORMS IN NIGERIA

UNIT 1 THE EARLY SECULAR CURRICULUM IN NIGERIA

CONTENTS

1.0 INTRODUCTION

In the last module, you have studied the historical, philosophical and psychological foundations of Science Education Curriculum. In this module, you will see the various reforms that have taken place in Science Education Curriculum in Nigeria. Specifically in this unit, you will learn about the early Secular Curriculum in Nigeria.

2.0 OBJECTIVES

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

(i) define the concept of curriculum;
(ii) state the impact of missionaries on the curriculum development in Nigeria;
(iii) state the role of British Examining Bodies on the curriculum reforms in Nigeria.

3.0 MAIN CONTENT

3.1 Meaning of Curriculum

Simply put, curriculum can be defined as an integrated group of courses and planned activities which pupils or students have under the guidance of the school or college and the instruction of a number of teachers. According to Good (1959), curriculum is a group of courses or planned experiences which a student has under the guidance of the school or college. It is the decision about what a school should teach. It is the sum total of all the subjects taught in a school, college or university, for instance, English, mathematics, physics, chemistry and biology to mention but few.

It should be noted that the term curriculum does not apply to only the academic activities of the school. It also includes other non-academic activities being carried out in the school set-up. Curriculum is also considered to be more than just the syllabus of a subject; it embodies other strategies of teaching and learning. Curriculum is really the entire programme of the school's work. It is everything that the student and their teachers do.

In Nigeria, the first school curriculum was brought/drawn by the missionaries. Let us now look at the activities of the missionaries in Nigeria.

3.2 Activities of Missionaries and their impact on Curriculum Development in Nigeria

The activities of the missionaries are summarised in the following points:

- The coming of the missionaries to Nigeria towards the end of the first half of the 19th century marked the establishment of missionary schools where the Four R's were taught to new converts i.e. reading, writing, arithmetic and religion.

- Since their arrival, they opened, maintained and controlled schools in Nigeria.

- They determined the content, objectives and methods of teaching the subjects in the curriculum.

- The first sets of primary schools in Nigeria were opened by the missionaries in Badagry, Abeokuta and Lagos (Osiyale, 1972).

- With the joint efforts of the local communities and Christian missionaries, other primary schools were opened in Ogbomoso, Ibadan, Ijaiye and across the River Niger in Calabar.

- The major aim of opening these schools was to give new converts in Christianity basic instructions in English language and to train loy-readers and catechists so that they will be useful in the missionary works.

- Later on and due to agitations from various Christian denominations, the missionaries decided to establish secondary grammar schools and the first of such school was Church Missionary Society (CMS) Grammar School, Lagos and subsequently, the Methodist Boys' High School, the Methodist Girls' High School and the Baptist Academy.

- The curriculum of these schools was sorely controlled by the missionaries. The subjects offered included:

    (i) English Grammar and Composition
    (ii) History

(iii) Geography
(iv) Book-keeping
(v) Euclid's Elements
(vi) Latin and Greek Grammar
(vii) Natural Philosophy
(viii) Chemistry
(ix) Physiology
(x) Geology
(xi) Botany, (Ajayi, 1963)

- The above subjects were some of the subjects offered in British Grammar Schools at that time and the British literary tradition was strictly followed.

- Very little consideration was given to the future needs of Nigerian pupils because the curriculum was mainly based on white-collar job grammar school leavers.

- Pupils in these schools were prepared for various certificates of the Colleges of Preceptors of London. The first-class certificate of the college of preceptors was the highest qualification available for highly paid jobs in the civil service and in churches.

3.3 Impact of British Examining Bodies on Curriculum Reforms in Nigeria

- By 1882, the British Government began to show interest in the curriculum development in Nigeria when it passed an Education Act.

- The 1882 Education Act provided for a Board of Education to control the development of education at all levels in English speaking West African countries.

- By 1887, the first Nigerian Education Act was passed and a separate Board of Education was constituted for Nigeria.

- The Act provided for Assisted and Non-Assisted Schools and invested in the Nigerian Board of Education, the authority to control and direct the development of education in Nigeria.

- All assisted schools were given some grants by the government worked out on the principle of "payment by results" and subject to favourable inspection reports.

- The principle of payment by results implies that most of the schools started employing qualified staff so that they can get good results and be qualified for grants. This has yielded positive results.

- As at 1909, the only examination body available to Nigerian Grammar School candidates was the College of Preceptors of London.

- By 1910, the University of Cambridge Local Examination Syndicate (UCLES) opened a Centre for its local examinations in Lagos, one year after the establishment of the first Government Secondary School i.e. King's College, Lagos.

- It should be noted that King's College was the first school to present candidates for Cambridge Local Examinations in Nigeria.

- Later on, other Grammar Schools in Nigeria started presenting candidates for Cambridge Examinations.

- The implication of this development on Nigerian Curriculum was that the Cambridge Local Examination Syndicate usually prepare their pupils for subjects normally examined by that body.

- The subjects covered by UCLES, were more in quantity and in detail that those taught in most Secondary Grammar Schools in Nigeria at that time.

- Most of the Grammar Schools at that time had primary departments.

- Another development was the establishment of Teacher Training institutions which combined academic curriculum with pedagogical training. The Teachers' Colleges established were:

    (i) The Hope Waddel Training Institute, Calabar;
    (ii) St. Andrew's College, Oyo;
    (iii) Wesley College, Ibadan.

- These schools provided instructions in domestic duties; in fact care and Teacher Education.

- The Primary School pupils in Teacher Training Colleges were locally examined at the end of their courses while the Secondary School pupils were consistently externally examined.

- By 1923, the UCLES became School Certificate Examinations.

- This new nomenclature had a wide implication for the development of the curriculum of the senior classes of Nigerian Grammar Schools because new subject at he Senior Local School Certificate Examinations were introduced.

- Some of the new subjects included Applied Mathematics, Experimental Science, Botany, Natural History of Animals and Hygiene were included in the Nigerian Grammar School Curriculum.

- It should also be noted that changes in the syllabi of the senior local school certificate examinations subjects affected the content of these subjects in the senior classes of the Grammar Schools.

- The implication of all these changes on curriculum development in Nigeria is that there was a linkage between external examinations and subject offerings in the Grammar Schools.

- Apart from the UCLES, the University of London Schools Examinations Council also influenced the content of the schools and colleges curricula in Nigeria.

Self Assessment Exercise

Discuss the roles of UCLES in the reformation of Secondary Grammar School Curriculum in Nigeria.

4.0 CONCLUSION

From the above discussion, you will agree with us that the secondary grammar school curriculum was clearly one of complete dependence on the guidance and direction of British Examining Boards. It should also be noted that most of the science subjects taught at that time used foreign examples and there was no activity (ies) for pupils hence the nature of science taught at that time was foreign to Nigerian students.

5.0 SUMMARY

In this unit, you have learnt about the activities of the missionaries as it affected curriculum reform in Nigeria. You have also seen the impact of British Examining Bodies as it influenced curriculum development in Nigerian schools.

In the next unit, you will see the impact of Phelps-Stokes Commission on the curriculum development of Science Education.

6.0 TUTOR MARKED ASSIGNMENT

1. Discuss the impact of missionary activities on the curriculum reform and development in Nigeria.

2. What are the roles of British Examining Bodies on the reformation of curriculum in Nigeria Education system?

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UNIT 2 IMPACTS OF PHELPS-STOKES COMMISSION ON CURRICULUM DEVELOPMENT IN NIGERIA

CONTENTS

1.0 INTRODUCTION

In unit of this module, you have seen how the activities of the missionaries and the British Examining Bodies have influenced curriculum reformation in science and other subjects. In this unit, you will see how a Commission was set up to look into the possibility of adapting academic curriculum of Nigerian education to the needs of Nigerians. That Commission was called Phelps-Stokes Commission. You will also see curriculum development in Nigeria from 1953 – 1960.

2.0 OBJECTIVES

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

(i) narrate the activities of Phelps-Stokes Commission to the development of curriculum in Nigeria;
(ii) state some of the recommendations of the commission;
(iii) highlight the main curriculum reforms that took place in Nigeria between 1952 and 1960 and post-independence.

3.0 MAIN CONTENT

3.1 Phelps-Strokes Commission and its impacts on Curriculum Development

In the last unit, when we discussed about the activities of the missionaries and their impact on curriculum development, you will notice that the curriculum was mainly academic. Most of the examples used in the various subjects were drawn from Britain. The curriculum was not patterned towards the needs of Nigerian environment and the type of knowledge passed into Nigerian children was non-functional, but pattern towards “white collar job”. It was against this background that the Phelps-Stokes Commission was set up.

The aim of setting up the Commission was to study the education system and curriculum in existence at that time and make appropriate recommendations on how the curriculum can be useful to the needs of Nigerian people (Lewis, 1962). The activities and recommendations of the Commission are summarised below:

- The Commission recommended that education in Nigeria should be adapted to the real needs of the people. Emphasis should be laid on African countries in terms of content and examples instead of European countries.

- Attempt should also be made to train masses on the one hand and local lenders on the other.

- In the same vein, the Advisory Committee on Native Education in British Tropical Africa made a similar observation and recommended that the content and methods of teaching various subjects in the school curriculum should be adapted to suit African life and surroundings.

- In another development, the Education Ordinance of 1926 provided for the rapid growth of the schools' curricula through regular inspection of the subjects taught in the schools and registration of teachers.

- In 1930, the federal government directed that in every subject offered in Nigerian secondary schools:

  (i) Form I should attain a standard equivalent to that required for a pass in the Cambridge University Preliminary Local Examination;
  (ii) Form II should attain a standard equivalent to that required for a pass in the Cambridge Junior School Certificate Examination;
  (iii) Form IV should attain a standard equivalent to that required of the Cambridge School Certificate or London Matriculation Examination;
  (iv) For VI should attain a standard equivalent to that required of the Cambridge Higher School Certificate Examination;

- It should be noted that in spite of all the above, the content of formal education in Nigeria was still closely patterned along the British line as the British Examining Bodies continue to exert considerable influence on the Grammar School curriculum.

- Again, both the UCLES and University of London continued to make its local examinations available to school candidates in Nigeria throughout this period. This made most Grammar Schools added more subjects and adopted the policy of preparing their pupils for the Cambridge School Certificate Examination.

Self Assessment Exercise 2.1

What is the significance Education Ordinance of 1926 in the development of curriculum in Nigeria?

3.2 Pre-independence Curriculum Development (i.e. 1952 – 1960)

- In March, 1952, following the recommendation of Dr. G.B. Jeffrey, the then Director of the Institute of Education, University of London, the West African Examinations Council (WAEC) was established. The Lagos Office of the Council was opened at Yaba, Lagos in September, 1953.

- The main role of WAEC was to inspect schools for the purpose of approving and accepting their pupils as private candidates for Cambridge Overseas School Certificate Examination. This later became West African School Certificate.

- The establishment of WAEC encouraged the Grammar Schools to teach the various subjects normally examined by the West African Examinations Council.

- Other factors that influenced development of school curricula in Nigeria was the activities of the various regional Ministers of Education who revised their primary and secondary school curriculum. This was in preparation for independence.

- At the national level, efforts were made to review the whole education system and new courses were introduced as the country prepared for political independence.

- In 1959, the government set up the Ashby Commission. The report of the Commission was submitted in 1960 which made several recommendations on how to improve the standard of education in Nigeria.

3.3 Curriculum Development from Independence and Post-independence till-date

- With the submission of Ashby Commission's report in 1960, the following recommendations were made by the Commission amongst other things:

  (i) introduction of obligatory manual projects into secondary schools;
  (ii) provision of different types of secondary school curricula including commercial, vocational and agricultural courses;
  (iii) both the pre-service and in-service training of teachers should be intensified;
  (iv) introduction of Advanced Teachers' Colleges to be associated with Universities;

- On the basis of the Commission's recommendation, some Advanced Teachers' Colleges (now known as Federal Colleges of Education) were established at Zaria, Kano, Ondo, Abraka, Owerri, etc.

- Other factors that influenced curriculum development in Nigeria since independence apart from Ashby's report are as follows:

  (i) in the Western region, both Banjo Report of 1961 and Taiwo Report of 1968 recommended the revision of the school syllabi and the introduction of a new structure of education. Banjo report recommended the introduction of junior and senior secondary schools. Taiwo report also recommended that the primary school curriculum should be overhauled and new syllabi be prepared in subjects like mathematics and social studies;

(ii) the Nigerian Educational Research Council (NERC) which is a body established to coordinate research activities in Nigeria organised a National Curriculum Conference in 1969. The conference called for a well defined philosophy of Education for Nigeria. The conference then suggested the principle that should guide the formulation of the objectives and curricula of primary, secondary, teacher and higher education in Nigeria (Adaralegbe, 1972). The proceedings of the conference provided the basis for the National Policy on Education in 1977 which advocated a 6:3:3:4 system of education;

(iii) the West African Examinations Council (WAEC) immediately after independence undertook a gradual revision of the school certificate syllabi especially in science subjects and other arts subjects i.e. physics, chemistry, biology, mathematics, English language, etc. with a view to localising it to suit Nigerian culture. This led to a swing of candidates from the traditional subjects to the new ones since there are now better qualified teachers with better equipment for teaching them.

Self Assessment Exercise 2.2

Highlight the major features of curriculum reform in Nigeria since independence to date.

4.0 CONCLUSION

The curriculum reformation in Nigeria initially started with the activities of the missionaries. Later the Nigerian government gradually involved itself especially after independence. This was done by the establishment of Examination and Research Councils to regularise the school curriculum and to advise it on curricula innovation.

The efforts of both NERC and WAEC led to the overhauling of some of the subjects and the introduction of more Nigerian-based curricula for both science and arts subjects. This led to the introduction of more qualified teachers and the use of more reliable equipment. This innovation which started vigorously after independence is still going on till date.

5.0 SUMMARY

In this unit, you have seen how the recommendations of Phelps-Stokes Commission have helped in curriculum innovations in Nigeria. You have also seen how other factors at both pre-independence and post-independence has contributed to the development and reformation of curriculum in Nigeria.

In the next unit, you will learn about the current status of education in Nigeria.

6.0 TUTOR MARKED ASSIGNMENT

1. Enumerate with the aid of specific examples, the major impact of Phelps-Stokes Commission in curriculum development in Nigeria.

2. What are the major curriculum innovations that took place in Nigeria between 1952 and 1960?

7.0 REFERENCES/FURTHER READINGS

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UNIT 3 PATTERNS OF CURRICULA SHIFT IN SCIENCE EDUCATION IN NIGEIRA

CONTENTS

1.0 INTRODUCTION

In unit 2, you have seen how the various agencies led by the government have made significant influence on the curriculum reform in education generally in Nigeria. In this unit, you will study the current status of education in Nigeria with specific reference to the pre-primary education, primary education, secondary education and tertiary education in Nigeria.

2.0 OBJECTIVES

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

(i) enumerate the status of pre-primary education in Nigeria;
(ii) discuss the nature of primary and secondary education in Nigeria;
(iii) highlight the nature of tertiary education in Nigeria.

3.0 MAIN CONTENT

3.1 Current Status of Education in Nigeria

The current status of education in Nigeria can be found in the National Policy on Education, 4th Edition, 2004. In the policy statement, the current status of education is discussed for pre-primary, primary, secondary and higher education. Below is a brief discussion of each of the levels.

3.1.1 Pre-Primary Education

According to Section 2 of the National Policy on Education (2004), pre-primary education is “the education given in an educational institution to children prior to their entering the primary school". This means that pre-primary education prepares the child for primary education. It includes the crèche, the nursery and the kindergarten. The main aim of this level of education is to introduce the child to the rudiments of the numbers which include counting and identification of numbers, introduce them to identification of letters, colours, shapes, forms, etc. through play way method. There is no clear cut age limit to put a child into this type of education as it depends on the social class of the parent.

This type of education is good for working class women and some parents put their children in pre-primary education as early as one month old.

Self Assessment Exercise 3.1

What are the benefits of pre-primary education?

3.1.2 Primary Education

Primary education begins at the age of six for the majority of Nigerians. Section 4 of the NPE (2004) defines primary education as "the type of education given in institutions for children aged 6 to 11 plus". Students spend six years in primary school and graduate with a School Leaving Certificate. Subjects taught at the primary level include: mathematics, English language, basic science, one of the three main native languages (i.e. Hausa, Yoruba and Ibo), physical and health education, religious knowledge, agriculture/home economics, cultural and creative arts and computer education. Primary school students are required to take a common entrance examination to qualify for admission into the Federal and State Government Schools. The mode of teaching as recommended by the policy shall be by practical, exploratory and experimental methods. On the whole, the purpose of primary education is to prepare the pupils for the junior secondary school.

Self Assessment Exercise 3.2

Make a list of some of the subjects offered at the primary school level in Nigeria.

3.1.3 Secondary Education

Section 5 (20) of the Policy (NPE, 2004) defines secondary education as "the education children received after primary education and before the tertiary stage". The main aim is to prepare the individual for useful living within the society and higher education. Secondary education in Nigeria is divided into two. The first three years is for junior secondary school while the other three years is for the senior secondary school. At the end of the first three years, they take the junior secondary school examination (i.e. JSS exam) which is a qualifying exam for the senior secondary school. The senior secondary exam is taken in the last year of the high school (i.e. SSS 3). The secondary schools in Nigeria are managed by the Federal government, State governments and private organisations. Each of the 36 States and the Federal Capital Territory has at least one Federal Government College and the Schools are funded and managed directly by the Federal Government through the Ministry of Education. Admission into these schools is based on merit, determined by the National Common Entrance Examination taken by all final year primary school pupils.

State-owned schools are funded by each state government and are not comparable to the Federal Government Colleges. Many of the states adopt the system of free tuition or very low tuition but students are required to purchase books and uniforms in other states.

Private secondary schools in Nigeria tend to be quite expensive than the government-owned secondary schools. This might be due to smaller classes, modern teaching equipment and a better learning environment and employment of more qualified teachers.

The junior secondary school curriculum is made up of both the prevocational and academic subjects. The subjects are grouped into core subjects, pre-vocational electives and non-prevocational electives.

The senior secondary school is more comprehensive with a core curriculum designed to broaden pupils' knowledge. The curriculum is grouped into core subjects, vocational electives and non-vocational electives. Every senior secondary school is expected to take all the six core subjects and a minimum of one or a maximum of two from the list of electives to give a minimum of seven and a maximum of eight subjects which will be examined at senior secondary school certificate examinations.

Self Assessment Exercise 3.3

What is the nature of junior secondary school curriculum in Nigeria?

3.1.4 Tertiary / Higher Education

Section 8 (58) of the NPE (2004) define tertiary education as "the education given after secondary education in universities, colleges of education, polytechnics, monotechnics including those institutions offering correspondence courses". Tertiary institutions in Nigeria are managed by the Federal government, state governments and private organisations.

Below is a list of tertiary institutions in Nigeria:

Table 1: Nigerian Universities

S/N	UNIVERSITIES	YEAR FOUNDED
1.	Abubakar Tafawa Balewa University, Bauchi	1988
2.	Ahmadu Bello University, Zaria	1962
3.	Bayero University, Kano	1975
4.	Fed. Univ. of Petroleum Resources, Effurun	2007
5.	Federal University of Technology Yola.	1988
6.	Federal University of Technology, Akure	1981
7.	Federal University of Technology, Minna	1982
8.	Federal University of Technology, Owerri	1980

9.	Micheal Okpara University of Agriculture, Umudike	1992
10.	National Open University of Nigeria, Lagos	2002
11.	Nigerian Defence Academy, Kaduna	1985
12.	Nnamdi Azikiwe University, Awka	1992
13.	Obafemi Awolowo University, Ile-Ife	1962
14.	University of Abuja, Gwagwalada	1988
15.	University of Agriculture, Abeokuta	1988
16.	University of Agriculture, Makurdi	1988
17.	University of Benin, Benin	1970
18.	University of Calabar, Calabar	1975
19.	University of Ibadan, Ibadan	1948
20.	University of Ilorin, Ilorin	1975
21.	University of Jos, Jos	1975
22.	University of Lagos, Lagos	1962
23.	University of Maiduguri, Maiduguri	1975
24.	University of Nigeria, Nsukka	1960
25.	University of Port-Harcourt, Port-Harcourt	1975
26.	University of Uyo, Uyo	1991
27.	Usumanu Danfodiyo University, Sokoto	1975
28.	Abia State University, Uturu	1980
29.	Adamawa State University, Mubi	2002
30.	Adekunle Ajasin University, Akungba Akoko, Ondo State	1999
31.	Akwa Ibom State University of Technology, Uyo	2004
32.	Ambrose Alli University, Ekpoma, Edo State	1980
33.	Anambra State University of Science & Technology, Uli	2000
34.	Benue State University, Makurdi.	1992
35.	Bukar Abba Ibrahim University, Damaturu., Yobe State	2006
36.	Cross River State University of Science &Technology, Calabar	2004
37.	Delta State University Abraka	1992
38.	Ebonyi State University, Abakaliki	2000
39.	Enugu State University of Science and Technology, Enugu	1981
40.	Gombe State Univeristy, Gombe	2004
41.	Ibrahim Badamasi Babangida University, Lapai, Niger State	2005
42.	Imo State University, Owerri	1992
43.	Kaduna State University, Kaduna	2004
43.	Kano University of Science & Technology, Wudil	2000
44.	Katsina State University, Katsina	2006
45.	Kebbi State University, Kebbi	2006
46.	Kogi State University Anyigba	1999
47.	Kwara State University, Ilorin	2009
48.	Ladoke Akintola University of Technology, Ogbomoso, Oyo State	1990
49.	Lagos State University Ojo, Lagos	1983

50.	Nasarawa State University, Keffi	2002
51.	Niger Delta Unversity, Yenagoa	2000
52.	Olabisi Onabanjo University Ago-Iwoye, Ogun State	1982
53.	Ondo State University of Science & Technology, Okitipupa	2008
54.	Osun State University, Oshogbo	2006
55.	Plateau State University, Bokkos	2005
56.	Rivers State University of Science & Technology	1979
57.	Tai Solarin Univ. of Education, Ijebu-Ode, Ogun State	2005
58.	Taraba State University, Jalingo	2008
59.	University of Ado-Ekiti, Ekiti State	1988
60.	University of Education, Ikere Ekiti, Ekiti State	2008
61.	Abti-American University, Yola	2003
62.	Achievers University, Owo	2007
63.	African University of Science & Technology, Abuja	2007
64.	Ajayi Crowther University, Ibadan	2005
65.	Al-Hikmah University, Ilorin	2005
66.	Babcock University, Ilishan-Remo	1999
67.	Bells University of Technology, Otta	2005
68.	Benson Idahosa University, Benin City	2002
69.	Bingham University, New Karu	2005
70.	Bowen University, Iwo	2001
71.	Caleb University, Lagos	2007
72.	Caritas University, Enugu	2005
73.	CETEP City University, Ibadan	2005
74.	Covenant University Ota	2002
75.	Crawford University Igbesa	2005
76.	Crescent University,	2005
77.	Fountain University, Oshogbo	2007
78.	Igbinedion University Okada	1999
79.	Joseph Ayo Babalola University, Ikeji-Arakeji	2006
80.	Katsina University, Katsina	2005
81.	Lead City University, Ibadan	2005
82.	Madonna University, Okija	1999
83.	Novena University, Ogume	2005
84.	Obong University, Obong Ntak	2007
85.	Pan African University, Lagos	2002
86.	Redeemer's University, Mowe	2005
87.	Renaissance University, Enugu	2005
88.	Salem University, Lokoja	2007
89.	Tansian University, Umunya	2007
90.	University of Mkar, Mkar	2005
91.	Veritas University	2007
92.	Wesley University of Science & Technology, Ondo	2007

93.	Western Delta University, Oghara	2007
94.	Wukari Jubilee University, Wukari	2005

Source: NUC website 2010.

Table 2: Colleges of Education in Nigeria

S/N	COLLEGE	TYPE	LOCATION
1	Federal College of Education (Technical), Asaba	Federal College of Education	Asaba, Delta State.
2	Federal College of Education, Kano	Federal College of Education	Kano City, Kano State.
3	Federal College of Education (Special), Oyo	Federal College of Education	Oyo, Oyo State.
4	College of Education, Gindiri	State College of Education	Gindiri, Plateau State.
5	Adamawa State College of Education, Hong	State College of Education	Yola, Adamawa State.
6	Tai Solarin College of Education, Ijebu-Ode	State College of Education	Ijebu-Ode, Ogun State.
7	College of Education, Ikere-Ekiti	State College of Education	Ikere-Ekiti, Ekiti State.
8	Ebonyi State College of Education, Ikwo	State College of Education	Ikwo, Ebonyi State.
9	Colege of Education, Warri	State College of Education	Warri, Delta State.
10	FCT College of Education, Zuba	State College of Education	Zuba, Garki, FCT Abuja.
11	Institute of Ecumenical Education, (Thinkers Corner), Enugu	Private College of Education	Enugu, Enugu State.
12	Osisatech College of Education, Enugu	State College of Education	Enugu, Enugu State.
13	Delar College of Education	Private College of Education	Agodi Gate, Ibadan, Oyo State
14	Federal College of Education, Abeokuta	Federal College of Education	Abeokuta, Ogun State
15	Federal College of Education, Eha-Amufu	Federal College of Education	Eha Amufu, Enugu State.
16	Federal College of Education (Technical), Gombe	Federal College of Education	Gombe, Gombe State.
17	Federal College of Education, Kontagora	Federal College of Education	Kontagora, Niger State.
18	Federal College of Education, Okene	Federal College of Education	Okene, Kogi State.
19	Federal College of Education (Technical), Omoku	Federal College of Education	OMoku, Rivers State.
20	Federal College of Education (Tech), Potiskum	Federal College of Education	Potiskum, Yobe State
21	Nasarrawa State College of Education, Akwanga	State College of Education	Akwanga, Nassarawa State.
22	Isa Kaita College of Education, Dutsin-Ma	State College of Education	Dutsin-Ma, Katsina State.
23	College of Education, Ekiadolor-Benin	State College of Education	Ekiadolor-Benin, Edo State
24	College of Education, Gashua, Damaturu	State College of Education	Gashua, Yobe state.
25	Kaduna State College of Education, Gidan-Waya, Kafanchan	State College of Education	Kafanchan, Kaduna State.
26	Osun State College of Education, Ilesa	State College of Education	Ilesa, Osun State.
27	Kwara State College of Education, Ilorin	State College of Education	Ilorin, Kwara State.
28	Kwara State College of Education	State College of Education	Oro, Kwara State.
29	College of Education, katsina-Ala	State College of Education	Katsina-Ala, Benue State.
30	Kano State College of Education, Kumbotso	State College of Education	Kumbotso, Kano State.
31	College of Education (Technical), Lafiagi	State College of Education	Lafiagi, Kwara State.
32	Nwafor Orizu College of Education, Nsugbe	State College of Education	Nsugbe, Anambra State.
33	Adeniran Ogunsanya College of Education, Otto/Ijanikin	State College of Education	Otto/Ijanikin, Lagos State.

34	Alvan Ikoku College of Education, Owerri	Federal College of Education	Owerri, Imo State.
35	Oyo State College of Education, Oyo	State College of Education	Oyo, Oyo State.
36	College of Education, Waka BIU	State College of Education	Waka Biu, Borno State.
37	St. Augustine College of Education (Project Time), Lagos	State College of Education	Yaba, Lagos State.
38	City College of Education, Mararaba, Gurku	Private College of Education	Mararaba, Gurku, Nasarawa State
39	Federal College of Education (Technical), Akoka	Federal College of Education	Akoka, Lagos State.
40	Federal College of Education (Technical), Bichi	Federal College of Education	Bichi, Kano State
41	Federal College of Education (Technical), Gusau	Federal College of Education	Gusau, Zamfara State.
42	Federal College of Education, Katsina	Federal College of Education	Katsina, Katsina State.
43	Federal College of Education, Obudu	Federal College of Education	Obudu, Cross River State.
44	Adeyemi College of Education, Ondo	Federal College of Education	Ondo, Ondo State.
45	Federal College of Education, Pankshin	Federal College of Education	Pankshin, Plateau State.
46	Federal College of Education, Yola	Federal College of Education	Yola, Yola State.
47	Delta State College of Education, Agbor	State College of Education	Agbor, Delta State
48	Federal College of Education, Zaria10.	Federal College of Education	Zaria, Kaduna State.
49	Akwa Ibom State College of Education, Afahansit	State College of Education	Afahansit, Akwa Ibom State.
50	Kogi State College of Education, Ankpa	State College of Education	Ankpa, Kogi state.
51	Adamu Augie College of Education, Argungu	State College of Education	Argungu, Kebbi State.
52	College of Education, Azare	State College of Education	Azare, Bauchi State
53	Umar Ibn Ibrahim El-Kanemi College of Education, Science and Technology, Bama	State College of Education	Bama, Borno State.
54	Nigerian Army School of Education (NASE), Ilorin	Federal College of Education	Ilorin, Kwara State.
55	College of Education, Jalingo	State College of Education	Jalingo, Taraba State.
56	Zamfara State College of Education, Maru	State College of Education	Maru, Zamfara State.
57	Jigawa State College of Education, Gumel	State College of Education	Gumel, Jigawa State.
58	Niger State College of Education, Minna	State College of Education	Minna, Niger State.
59	Rivers College of Education, Rumuolumeni	State College of Education	Port Harcourt, Rivers State.
60	Shehu shagari College of Education, Sokoto	State College of Education	Sokoto, Sokoto State.
61	Jama'Atu College of Education (JACE), Kaduna	State College of Education	Kaduna, Kaduna State.
62	Ansar-Ud-Deen College of Education, Isolo	Private College of Education	Oshodi, Isolo, Lagos State.
63	Yewa Central College of Education, Ayetoro	State College of Education	Ayetoro, Ogun State

Source: NCCE Website, 2010

Table 3: Polytechnics in Nigeria

APPROVED FEDERAL POLYTECHNICS IN NIGERIA

1.	Akanu Ibiam Federal Polytechnic, Unwana-Afikpo, Ebonyi State.
2.	Auchi Polytechnic, Auchi Edo State
3.	Federal Polytechnic, Ado-Ekiti.
4.	Federal Polytechnic, Bauchi, Bauchi.
5.	Federal Polytechnic, Bida, Niger State.
6.	Federal Polytechnic, Damaturu, Yobe State.

7.	Federal Polytechnic, Ede, Osun State.
8.	Federal Polytechnic, Idah, Kogi State.
9.	Federal Polytechnic, Ilaro, Ogun State.
10.	Federal Polytechnic, Kaura Namoda, Zamfara State.
11.	Federal Polytechnic, Mubi, Adamawa State.
12.	Federal Polytechnic, Nasarawa, Nassarawa.
13.	Federal Polytechnic, Nekede-Owerri, Imo State.
14.	Federal Polytechnic, Offa, Kwara State.
15.	Federal Polytechnic, Oko, Anambra State.
16.	Hussaini Adamu Federal Polytechnic, Kazaure, Jigawa State.
17.	Kaduna Polytechnic, Kaduna.
18.	Waziri Umaru Federal Polytechnic, B/Kebbi, Kebbi State.
19.	Yaba College of Technology, Yaba, Lagos.
20.	*Federal Polytechnic, Bali, Taraba State
21.	*Federal Polytechnic, Ekowe, Bayelsa State

APPROVED STATE POLYTECHNICS IN NIGERIA

1.	Abdu Gusau Polytechnic, Talata-Mafara, Zamfara State.
2.	Abia State Polytechnic, Aba, Abia State.
3.	Abubakar Tatari Ali Polytechnic, Bauchi.
4.	Adamawa State Polytechnic, Yola.
5.	Akwa-Ibom State College of Art and Science, Numkum
6.	Akwa-Ibom State Polytechnic, Ikot-Osurua
7.	Benue State Polytechnic, Ugbokolo
8.	Delta State Polytechnic, Ogharra
9.	Delta State Polytechnic, Ozoro
10.	Delta State Polytechnic, Ugwashi-Uku
11.	Edo State Institute of Management and Technology, Usen
12.	Gateway ICT Institute, Itori, Ewekoro, Ogun State.
13.	Gateway ICT Polytechnic, Igbesa, Ogun State.
14.	Gateway ICT Polytechnic, Saapade, Ogun State.
15.	Hassan Usman Katsina Polytechnic, Katsina.
16.	Imo State Polytechnic, Umuagwo
17.	Institute of Management. & Technology, Enugu.
18.	Jigawa State Polytechnic, Dutse
19.	Kano State Polytechnic, Kano.
20.	Kogi State Polytechnic, Lokoja.
21.	Kwara State Polytechnic, Ilorin.
22.	Lagos State Polytechnic, Ikorodu.
23.	Moshood Abiola Polytechnic, Abeokuta, Ogun State.
24.	Nasarawa State Polytechnic, Lafia.
25.	Niger State Polytechnic, Zungeru.
26.	Nuhu Bamalli Polytechnic, Zaria, Kaduna State.

27.	Osun State College of Technology, Esa-Oke.
28.	Osun State Polytechnic, Iree.
29.	Plateau State Polytechnic, Barkin Ladi.
30.	Ramat Polytechnic, Maiduguri, Borno State.
31.	Rivers State Polytechnic, Bori.
32.	Rivers State College of Arts and Science, Rumola, Port Harcourt.
33.	Rufus Giwa Polytechnic, Owo, Ondo State.
34.	Sokoto State Polytechnic, Sokoto.
35.	Taraba State Polytechnic, Jalingo.
36.	The Polytechnic, Ibadan, Oyo State.
37.	The Polytechnic, Ijebu Igbo
38.	Yobe State Polytechnic, Geidam.

PRIVATE POLYTECHNICS

1.	Allover Central Polytechnic, Sango-Ota, Ogun State.
2.	Crown Polytechnic, Ado-Ekiti
3.	Dorben Polytechnic, Bwari, FCT.
4.	Fidei Polytechnic, Gboko, Benue State.
5.	Grace Polytechnic, Surulere, Lagos State.
6.	Interlink Polytechnic
7.	Lagos City Polytechnic, Ikeja.
8.	Lighthouse Polytechnic,
9.	Our Saviour Institute of Science Agric and Technology, Enugu.
10.	Ronik Polytechnic, Lagos.
11.	Universal College of Technology, Ile-Ife, Osun State.
12.	Wolex Polytechnic, Ikeja, Lagos State.

Table 4: Monotechnics in Nigeria

FEDERAL COLLEGES OF AGRICULTURE

1.	College of Agriculture (DAC), Kabba, Kogi State.
2..	Federal College of Agriculture Akure, Ondo State.
3.	Federal College of Agriculture, Dadinkowa, Gombe State.
4.	Federal College of Agriculture, Ibadan, Oyo State.
5.	Federal College of Agriculture Ishiagu, Ebonyi State.
6.	Federal College of Animal Health and Production Technology, Ibadan, Oyo State.
7.	Federal College of Animal Health and Production Technology, Vom, Plateau State.
8.	Federal College of Fisheries and Marine Technology, Lagos.
9.	Federal College of Freshwater Fisheries Technology, Baga, Borno State.
10.	Federal College of Freshwater Fisheries Technology, New Bussa, Niger State.
11.	Federal College of Forestry Mechanisation, Afaka, Kaduna State.
12.	Federal College of Land Resources Technology, Kuru, Jos, Plateau State.
13.	Federal College of Land Resources Technology, Owerri Imo State.
14.	Federal College of Wildlife Management, New Bussa, Niger State.

15.	Federal College of Forestry, Ibadan, Oyo State.
16.	Federal College of Forestry, Jos, Plateau State.
17.	Samaru College of Agriculture (DAC), Zaria Kaduna State.

STATE COLLEGES OF AGRICULTURE

1.	Adamawa State College of Agriculture, Mubi.
2.	Akperan Orshi College of Agriculture, Yandev Gboko.
3.	Akwa Ibom State College of Agriculture, Obio-Akpa.
4.	Anambra State College of Agriculture, Igbariam.
5.	Audu Bako School of Agriculture, Danbatta, Kano State.
6.	College of Agriculture, Jalingo, Taraba State.
7.	College of Agriculture, Lafia, Nassarawa State.
8.	College of Agriculture, Zuru, Kebbi State.
9.	Edo State College of Agriculture, Iguariakhi.
10.	Jigawa State College of Agriculture, Hadejia
11.	Mohamet Lawan College of Agriculture Maiduguri, Borno State.
12.	Niger State College of Agriculture, Mokwa.
13.	Oyo State College of Agriculture, Oyo.
14.	Plateau State College of Agriculture, Garkawa.
15.	Regional Agricultural Training School, Maiduguri, Borno State.
16.	Rivers State Institute of Agricultural Research and Training, Onne.
17.	School of Agriculture, Ikorodu, Lagos State.
18.	Yobe State College of Agriculture, Gujba.
19.	Zamfara State College of Agriculture, Bakura.

FEDERAL MONOTECHNICS/SPECIALISED INSTITUTIONS

1.	Air-Force Institute of Technology, NAF, Mando, Kaduna.
2.	Federal College of Chemical & Leather Technology, Zaria, Kaduna State
3.	Federal Cooperative College Ibadan, Oyo State.
4.	Federal Cooperative College Kaduna.
5.	Federal Cooperative College, Oji River, Enugu State.
6.	Federal College of Statistics, Enugu
7.	Federal College of Statistics, Ibadan, Oyo State
8.	Federal College of Statistics, Kaduna
9.	Federal School of Mines, Jos, Plateau State.
10.	Federal School of Survey, Oyo.
11.	Federal Training Centre, Calabar
12.	Federal Training Centre, Enugu
13.	Federal Training Centre, Kaduna
14.	Federal Training Centre, Maiduguri
15.	Maritime Academy of Nigeria, Oron, Akwa Ibom State.
16.	Metallurgical Training Institute, Onitsha, Anambra State.
17.	National Water Resources Institute, Mando, Kaduna.

18.	Nigerian Army School of Engineering, Makurdi, Benue State.
19.	Nigerian Army School of Finance, Administration, Apapa, Lagos State.
20.	Nigerian Army School of Signals Apapa, Lagos State.
21.	Nigerian Naval Engineering College, Sapele, Delta State.
22.	NITEL Training School, Oshodi, Lagos State.
23.	Petroleum Training Institute, Effurun, Delta State.

STATE MONOTECHNICS

1.	College of Administration and Business Studies, Konduga, Borno State.
2.	College of Administration and Business Studies, Potiskum, Yobe State.

PRIVATE MONOTECHNICS/SPECIALISED INSTITUTIONS

1.	Nigerian Institute of Journalism (NIJ), Lagos State
2.	Wavecrest College of Catering, Surulere-Lagos

FEDERAL COLLEGES OF HEALTH TECHNOLOGY & ALLIED INSTITUTIONS

1.	ABU Teaching Hospital, Department of Community Medicine (CHO), Shika, Zaria, Kaduna State.
2.	Aminu Kano University Teaching Hospital, Kano
3.	Federal College of Dental Technology, Enugu
4.	Institute of Public Health College of Health Sciences, (OAU) Ile- Ife.
5.	National Orthopaedic Centre, Igbobi, Lagos State
6.	Nigerian Army Medical Corps and Schools, Ojo, Lagos State.
5.	Othman Dan-Fodio University Teaching Hospital, Sokoto
7.	University of Calabar Teaching Hospital Calabar, Cross River State.
8.	University College Hospital, Ibadan, Oyo State.
9.	University Teaching Hospital, Lagos.

STATE COLLEGES OF HEALTH TECHNOLOGY & ALLIED INSTITUTIONS

1.	Anambra State School of Health Technology, Obosi.
2.	Bauchi State School of Health Technology, Ningi.
3.	Imo State School of Health Technology, Amaigbo.
4.	Imo State School of Public Health Nursing/CHO, Owerri Imo State.
5.	Lagos State School of Public Health Nursing/CHO, Awolowo Road, Lagos.
6.	Rivers State College of Health Sciences and Technology, Port Harcourt.
7.	School of Health Technology, Aba, Abia State.
8.	School of Health Technology, Akure, Ondo State.
9.	School of Health Technology, Alushi Via, Akwanga, Nasarawa State.
10.	School of Health Technology, Benin-City, Edo State.
11.	School of Health Technology, Calabar, Cross River State.
12.	School of Health Technology, Daura, Katsina State.
13.	School of Health Technology, Elesa Osun State.
14.	School of Health Technology, Etinan, Akwa-Ibom State.

15.	School of Health Technology, Idah, Kogi State.
16.	School of Health Technology, Ijero-Elati, Ekiti State.
17.	School of Health Technology, Ilese, Ijebu-Ode, Ogun State.
18.	School of Health Technology, Inyi, Enugu State.
19.	School of Health Technology, Jahun, Jigawa State.
20.	School of Health Technology, Jega, Kebbi State.
21.	School of Health Technology, Kaltungo, Gombe State.
22.	School of Health Technology, Kankia, Katsina State.
23.	School of Health Technology, Kano.
24.	School of Health Technology, Maiduguri, Borno State.
25.	School of Health Technology, Makurdi, Benue State.
26.	School of Health Technology, Minna, Niger State.
27.	School of Health Technology, Mubi, Adamawa State.
28.	School of Health Technology, Offa, Kwara State.
29.	School of Health Technology, Ofuoma, Ughelli Delta State.
30.	School of Health Technology, Oji River, Enugu State.
31.	School of Health Technology, Pankshin, Plateau State.
32.	School of Health Technology, Takum, Taraba State.
33.	School of Health Technology, Tungar Magajiya, Kontagora, Niger State
34.	School of Health Technology, Yaba, Lagos State.
35.	School of Health Technology, Zawan-Jos, Plateau State.
36.	School of Hygiene, Eleyele, Ibadan, Oyo State.
37.	School of Hygiene, Kano.
38.	School of Public Health Nursing Nsukka, Enugu.
39.	Shehu Idris College of Health Sciences and Technology, Makarfi, Kaduna State.
40.	Sultan Abdur-Rahman School of Health Technology, Gwadabawa, Sokoto State.

PRIVATE COLLEGES OF HEALTH TECHNOLOGY & ALLIED INSTITUTIONS

1.	NKST College of Health Technology, Mkar, Gboko, Benue State.

Source: NBTE, 2010

Entry into tertiary institutions in Nigeria today is based on ordinary level requirement of minimum five (5) credit passes. Apart from this, a candidate must pass a minimum cut-off mark in Joint Admissions and Matriculation Board (JAMB) Examination which is now uniform for all the tertiary institutions in Nigeria. Again, each university usually conducts an interview for a candidate to be qualified for admission. Duration of programme in tertiary institutions depend on programme of study.

Self Assessment Exercise 3.4

State the number of universities, colleges of education and polytechnics in Nigeria.

4.0 CONCLUSION

It can be deduced from the above discussion that education in Nigeria has improved compared with what was obtainable before Nigeria attained independence in 1960. As at today, the number of primary, secondary and tertiary institutions in Nigeria is growing sporadically. As the number is growing so also the curriculum undergoing review so as to meet the needs of Nigerians and discourage brain drain.

5.0 SUMMARY

Now that you have seen the current status of education in Nigeria, let us now look at patterns of curriculum shift in science education in Nigeria and the nature of science, technology and the society. All these will be discussed in our next unit.

6.0 TUTOR MARKED ASSIGNMENT

1. Describe the primary school curriculum in Nigeria.

2. What is the nature of secondary school education in Nigeria?

7.0 REFERENCES/FURTHER READINGS

Federal Republic of Nigeria (2004). National Policy on Education, 4th Edition, Federal Government Press.

http://en.wikipedia.org/wiki/Education-in-Nigeria.

UNIT 4 CURRICULUM REFORMATIION IN SCIENCE EDUCATION IN NIGERIA

CONTENTS

1.0 INTRODUCTION

Now that you have studied the nature of education generally in Nigeria in the last unit, let us now look at the curriculum reformation in science education. In this unit, you will study the patterns of curricula shift in science education in Nigeria.

2.0 OBJECTIVES

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

(i) highlight the pattern of curricula shift in science education in Nigeria;
(ii) mention some of the science programmes introduce in Nigeria after 1960;
(iii) state the relevance of National Policy on Education on the development of science education in Nigeria.

3.0 MAIN CONTENT

3.1 Patterns of Curricula Shift in Science Education in Nigeria

The history of science education in Nigeria today is closely linked with the activities of the missionaries as you have learnt in module one of this material. Science education gained wide acceptance in government-control schools only after the report of the Phelps-Stokes Commission. Before the commission report, science education was introduce as part of general education mostly in mission schools between 1859 and 1920. The type of science that was introduced at that time was just rudimentary and it did not relate to the immediate environment of the child. Subjects like rural science, hygiene and general science that contained mainly facts and principles which had very little ways of applications to Nigerian culture were introduced. Foreign examples were used and no references were made to suit Nigerian locality.

The Phelps-Stokes Commission observed that education in Nigeria was not adapted to the needs of the people (Lewis, 1962). The Commission, in canvassing for the invasion of science subjects in the school curriculum further observed thus:

> "*the great achievements of modern times are largely in the realm of the physical sciences. Physics, chemistry and biology have revolutionized many of the industrial and social activities of mankind. No phase of secondary education is more vital than the instruction of the pupils in the elements of these sciences. It is of utmost importance that the pupils should gain power to Apply the facts and principles of science and to interpret natural phenomena*" (Jones, 1922).

Another major activity that spurred science curriculum reform in Nigeria was the sputnik programme. The programme which emanated from the United States of America and the United Kingdom affected science education reforms in Nigeria by expansion. The reforms followed closely what obtained in the developed countries and this gave rise to several science programmes specifically in Nigeria and in Africa as a whole. Some of these programmes include the following:

(i) African Primary Science Programme (APSP);
(ii) Basic Science for Nigerian Secondary Schools (BSNSS);
(iii) The Ife Yoruba Six Year Primary Project (YSPP);
(iv) the Midwest Primary Science Project (MPSP);
(v) Primary Education Improvement Project (PEIP);
(vi) Nigerian Secondary Schools Science Project (NSSSP);
(vii) Nigerian Integrated Science Project (NISP), (George, 1988; Jegede, 1988).

Bozimo (1985), Jegede (1982) and Osiyale (1975), in their separate findings observed that even though the above programmes departed significantly from the factual/expository method of teaching science to a more progressive one, of teaching the learner what science is and how the scientists works, only minimal changes have been noticed in the learner and the system as a whole. It was also observed that a lot of what goes on as science teaching in Nigerian classroom relates to the teaching of mainly the facts and principles of science.

Jegede, Okebukola and Adeniyi (1987) summarised the scenario at that time in the following statement:

> "*by and large, the teaching of science has been by the didactic practice essentially on the 'new' concepts on which some practical laboratory hours were spent undertaking, presumably, confirmatory trips, dictated by the teacher. This is in spite of the daily sermon on the advantages of the inquiry/discovery and process approach to teaching over the traditional rote learning method*".

The prevailing climate of political independence of Nigeria in 1960, coupled with the experience some members of the Nigerian scientific community gained by their sojourn abroad in search of further education and the introduction of several other programmes in science teaching were some of the factors that led to the improvement of science teaching in Nigeria till today. Again, the Nigerian Policy on Education appears to project the modern aims and objectives of science education right from the early childhood/pre-primary education to tertiary education. For instance, Section 2 (13)(e) of NPE (2004) 4th Edition states as follows:

> "*The purpose of pre-primary education shall be to inculcate in the child the spirit of inquiry and creativity through the exploration of nature, the environment…*"

Section 4 (18)(b) states as follows:

> "*The goals of primary education is to lay a sound basis for scientific and reflective thinking*"

and Section 5 (22)(g) states that:

> "s*econdary education shall raise a generation of people who can think for themselves, respect the views and feelings of others….*"

All the above aims of education as stated in the National Policy on Education implies that science teaching should inculcate in the child the spirit of scientific inquiry and scientific attitudes.

Self Assessment Exercise

State some of the science programmes introduced in Nigeria after Nigeria got her independence.

4.0 CONCLUSION

It can be concluded from the above that a mirror of the trends in science education curriculum and science teaching that dominated the pre-1960 era was as a result of the apparent dysfunctionality of the inherited educational programmes that were largely imported into Nigeria through colonialism. However, this has passed through several reformations and today, it appears we are moving towards a stable science education curriculum.

5.0 SUMMARY

In this unit, you have studied the patterns of curricula shift in science education in Nigeria. In the next unit, you will study the nature of curriculum innovation in science education in other countries.

6.0 TUTOR MARKED ASSIGNMENT

1. Discuss the pattern of curricula shift in science education in Nigeria highlighting the important points.

2. How does the National Policy on Education encouraged science education curriculum in Nigeria.

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MODULE 3 SCIENCE EDUCATION CURRICULUM REFORMS IN OTHER COUNTRIES

UNIT 1 SCIENCE EDUCATION CURRICULUM REFORMS IN THE UNITED KINGDOM (ENGLAND)

CONTENTS

1.0 INTRODUCTION

In the last unit, you have studied the historical background of science education curriculum in Nigeria. In this unit, you will study science education curriculum reforms in the United Kingdom.

2.0 OBJECTIVES

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

- define the term 'science education';
- briefly describe the historical background of science education curriculum in the United Kingdom;
- highlight the nature of science education curriculum in England.
- State the challenges of science education in England and measures taken to improve the teaching of science.

3.0 MAIN CONTENT

3.1 Historical Background of Science Education Curriculum in the United Kingdom

Science education can be defined as a discipline that is concerned with sharing science content and processes with individuals that are not traditionally considered as part of scientific community. It is a general education in science, and the target individuals may be children, college students, or adults within the general public. The field of science education comprises science content, some social sciences and some teaching pedagogy or methodology. In the United Kingdom, the traditional subjects in science education are physical sciences, life sciences, earth sciences and space sciences.

The historical background of science education in the United Kingdom secondary schools began around 1870 (Jenkins, 1985). The first step came when the British Academy for the Advancement of Science (BAAS) published a report in 1867 which was based on promoting teaching of pure science and training of the scientific habit of mind (Layton, 1981). The idea of mental training through the sciences was supported by the Progressive Education Movement of the United Kingdom. BAAS emphasised separately the pre-professional training in secondary science education. However, the initial development of science teaching was slowed by the lack of qualified teachers. One key development in the United Kingdom at that time was the founding of the first London School Board in 1870, which discussed the school curriculum and suggested ways of reforming it. There was also the initiation of curses to supply the country with trained science teachers. Thomas Henry Huxley and John Tyndall’s contributions to the development of science education curriculum in the United Kingdom were very critical in arresting the situation.

In England and Wales, school science is generally taught as a single subject science until age 14 – 16 when it is splitted into subject specific ‘A’ level courses of Physics, Chemistry and Biology. In Scotland, the science subjects split into chemistry, physics and biology at the age of 13 – 15 for standard grades in these subjects. In September, 2006, a new science programme of study known as 21st Century Science was introduced in the United Kingdom and designed to give all 14 to 16 year olds a worthwhile and inspiring experience of science.

Self Assessment Exercise

At what age limit does a child in England and Scotland study physics, chemistry and biology?

3.2 Nature of Science Education Curriculum in England

Compulsory education in England is divided into four stages. These are:

- Key stage 1 = Ages 5 – 7
- Key stage 2 = Ages 7 – 11
- Key stage 3 = Ages 11 – 14
- Key stage 4 = Ages 14 – 16

There are three core subjects in compulsory education. These are mathematics, science and English. The science curriculum covers physics, chemistry, biology, astronomy and earth sciences. Technology is a separate subject. The science curriculum in England, apart from satisfying children's curiosity and providing them with knowledge about their environment, also stimulates and excites pupils' curiosity about natural phenomena and events taking place in the world around them. Scientific method was used to spur the children's critical and creative thought through experimental evidence and modelling.

The statutory document that guided science education curriculum in England was the National Curriculum. The curriculum specifies the contents and processes of science through four programmes of study. These are scientific enquiry, life and living processes, materials and physical processes. It should be noted that even though the National Curriculum is written centrally by a government body, schools are required to write programmes of study to implement it. Regional structures provide support to schools in executing the curriculum, while government inspectors monitor the implementation. Below are other characteristics of science education curriculum in England:

- The teaching of science at the primary level must take place for at least one hour per week;

- At secondary level, the teaching of science must take place up to 12 – 15% of curriculum time for the 11 – 14 age group and 15 – 20% for pupils aged 14 – 16;

- During primary education, science lessons normally take place in the regular classroom;

- For secondary pupils, science lessons are taught in specialised science laboratories with a capacity of thirty pupils;

- There are national tests at age 7, 11 and 14 of which the results for ages 11 and 14 are made known to the press;

- The terminal examination takes place at age 16 and its aligned with the National Curriculum. The results are also published in the National Press;

- Following compulsory education after age 16, pupils may continue to study five chosen subjects at secondary school for one year and each subject is examined. Three of these subjects may then be studied for a further year, after which there is another terminal examination which will determine entrance to higher education.

3.3 Support for Science Teaching in England Schools

Support for science teaching is provided through advisory schemes written and distributed by the central government for working with pupils aged 7 – 11 and 11 – 14. Limited advice is also offered on professional development. Commercial publishers produce a wide range of textbooks and support materials. Teaching materials are also supplied by industrial and charitable organisations. Further benefits are derived from an active and healthy science teacher organisation and network of regional advisers.

3.4 Challenges of Science Education in England

Although science education in England appears to be successful, it was also faced with some challenges, some of which include
:

1. The general public has a profound distrust of science, fearing that unbridled research of science will one day result in an irreversible scientific calamity. This attitude can account for a certain reluctance on the part of secondary students to pursue a scientific career;

2. There was also the failure to assess practical scientific skills. This is probably because it is expensive to do so and the measurement procedures are sometimes lacking. Science teachers often conclude that assessing practical scientific skills are not important hence they ignored it.

3.5 Measures taken to Improve the Teaching of Science in England

1. Introduction of more contemporary science into the curriculum e.g. science and technology in society. This will serve as scientific literacy to the society.

2. Increase in out-of-school and informal sources of science teaching. One of these sources was the introduction of science centres that provides ‘hands-on’ activities for children.

3. The growth of science on the internet and a profusion of science-related television programmes on scientific activities are encouraging trends.

4. Employment of a more student-centred approaches to science teaching.

3.6 Roles and Responsibilities in Scientific and Technological Curriculum Development in the United Kingdom (England)

The following table shows the roles and responsibilities in scientific and technological curriculum development in England.

Table 1: Roles and Responsibilities in scientific and technological curriculum development in the United Kingdom (England)

S/N		Central Level	Regional/ Provincial Level	School Level
1.	Aims and objectives	Determined by an explicit National Curriculum produced by the Qualifications and Curriculum Authority, which is a government agency	No influence	Responsible for interpreting the curriculum and translating it into a programme of study
2.	Curriculum plan	Provides details of the material to be taught. Specified through four components for the Key Stages of	No influence	Responsible for the selection of textbooks, apparatus and the choice of courses to study from

		education: (a) Experimental and investigative science; (b) Process of life; (c) Materials; and (d) Physical processes.		age 14 – 16.
3.	Methods and approaches to teaching	No statutory influence. However, the Qualifications and Curriculum Authority now produce 'advisory' schemes of work for children in Key Stages 2 and 3. These contain recommended approaches to teaching	Local officials provide support for the implementation of the curriculum and approaches to teaching.	Selects teaching approaches, purchases equipment, appoints teachers.
4.	Materials	No teaching materials are produced by any government agencies other than the 'advisory' work schemes. Rather they are produced by independent publishers who then market them to schools.	No role	Responsible for the selection and purchase of materials.
5.	Evaluation and examination	Standards and criteria for examination courses are set by the Qualification and Curriculum Authority for the public examination. The examinations themselves are produced by four independent boards. Examinations are marked and the standards moderated by the examination board. Pupils are tested at age 11 and age 14 using exams produced by the Qualification and Curriculum Authority.	No role	Selects which examination board to use and pays a fee to each board for registering them. Schools are responsible for assessing the practical component of science (known as experimental and investigative science).

Source: Layton, D. (1981). The Schooling of Science in England.

The above table shows that the aims and objectives of science education are determined centrally by the government agency without any influence or interference by the regional or provincial government. The schools only interpret and translate the curriculum into a programme of study.

The curriculum plan provides details of the materials to be taught at central level without any influence from the regional government. The school is only responsible for the selection of textbooks, apparatus and choices of courses to study.

In terms of methods and approaches to teaching, the central government does not have any statutory influence but can give advice while the local officials provide support for the implementation of the curriculum and approaches to teaching at regional and provincial levels. The schools select teaching approaches, purchases equipment and appoint teachers. Science teaching materials are not produced by both the central and regional governments, it is the sole responsibility of the schools to select and purchase science teaching materials.

The evaluation and examination standards and criteria are set by the central government through the agency of a body known as Qualifications and Curriculum Authority for the public examinations. No interference from both the regional and provincial governments. The school on their own selects which examination board to use and pays a fee to each board for registering them.

4.0 CONCLUSION

From the brief historical background and nature of science education in the United Kingdom discussed above, it can be concluded that science education in the U.K. appears to be standardised and developed probably because of the involvement of the central government in selecting the aims and objectives, curriculum plan and evaluation and examinations for students. Nigerian system of education seems to follow the pattern of United Kingdom in terms of aims and objectives and curriculum plan.

5.0 SUMMARY

In this unit, you have studied the brief historical background and nature of science education, curriculum reforms in the United Kingdom. In the next unit, you will now study the science education curriculum reform in the United States of America (USA).

6.0 TUTOR MARKED ASSIGNMENT

1. Outline the major features of science education curriculum reform in England.

2. What are the major challenges facing science teaching in England?

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UNIT 2 SCIENCE EDUCATION CURRICULUM REFORMS IN THE UNITED STATES OF AMERICA (USA)

CONTENTS

1.0 INTRODUCTION

In unit one of this module, you studied the science education curriculum reforms in the United Kingdom. You also saw the nature of science education curriculum and challenges faced. In this unit, you will study science education curriculum reforms in the United States of America.

2.0 OBJECTIVES

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

- Outline a brief historical background of science education curriculum in the USA;
- Explain the nature of science education curriculum reforms in the USA;
- Describe the mode of science education reforms in the USA.

3.0 MAIN CONTENT

3.1 Historical Background of Science Education Curriculum in USA

According to Del Giorno (1969), the development of a science curriculum in the United States of America (USA) emerged gradually after extended debate between two ideologies. These are citizen science and pre-professional training. As a result of a conference involving 30 leading secondary and college educators in Florida, the National Education Association (NEA) appointed a committee of ten in 1892 which had authority to organise future meetings and appoint subject matter in the United States secondary schools. The committee was composed of ten educators and was chaired by Charles Eliot of Harvard University. This committee met and appointed nine conference committees out of which three conference committees were appointed for science. These were:

1. Physics, Astronomy and Chemistry Committees;
2. Natural History Committee; and
3. Geography Committee.

Each committee, appointed by the committee of ten, was composed of ten leading specialists from colleges and normal schools, and secondary schools. The three science committees met for three days at different locations in Chicago area. The committee reports were submitted to the committee of ten which also met for four days in New York to create a comprehensive report. In 1894, the NEA published the results of work on these conference committees.

Based on the committee reports, the committee of ten recommended that the goal of high school was to prepare all students to do well in life, contributing to their well-being and the good of society. Another goal was to prepare students to succeed in college. This committee also supported the citizen science approach focused on mental training and withheld performance in science studies from consideration for college entrance (Hurd, 1991).

Furthermore, on the basis of committee of ten recommendations, the United States of America adopted a curriculum which was characterised as follows:

1. that elementary science should focus on simple natural phenomena (Nature Study) by means of experiments carried out in the field;

2. that secondary science should focus on laboratory work which should involve experiments.

The movement to incorporate a humanistic approach to science, technology, society and environment education is growing and being implemented more broadly in the late 20th century (Aikenhead, 1994).

3.2 Nature of Science Curriculum Reform in the United States of America

Before now, science teachers of K-12 must adhere rigidly to standards of what content is to be taught and to what age group. This made science teachers struggle to cover the topics regardless of whether the students understood it or not. Also, the processes of science and hands-on-activities were overlooked. However, in 1996, the United States Marital Academy of Sciences produced the National Science Education Standards. It focused on inquiry-based science, based on the theory of constructivism rather than on direct instruction of facts. It also focused on standard-based assessment such as: Washington Assessment of Student Learning which emphasised devising experiments at early grades. It equally focused on eight categories of national science education standards. These categories are:

1. unifying concepts and processes;
2. science as inquiry;
3. physical science;

4. life science;
5. earth and space science;
6. science and technology;
7. science in personal and social perspectives; and
8. history and nature of science.

The USA became worried by the fear that American students may be lagging behind their peers in international rankings as a result of poor science education programme and low science standards. This was glaring by the successful launching of Sputnik Satellite in 1957 by the Soviet Union. The Sputnik effect made the USA to call for more emphasis on rapid science education reforms at all levels of American educational institutions.

3.3 Science Curriculum Reform in the USA

As a result of the Sputnik effect, the American government set up various committees within the educational system to advice on how to reform science education. Depending on the group publishing the report, the recommendations from each of the reports addressed the following issues:

1. updating the scientific and technological knowledge;
2. application of contemporary learning theories and teaching strategies;
3. improved approaches to achieve equity; and
4. better preparation of citizens for the workplace.

The science curriculum reforms cut across all levels of educational systems in the United States of America. In the late 1980s and early 1990s, several frameworks and projects aimed at curriculum reforms were established. These include:

- The American Association for the Advancement of Science (AAAS);
- Science for All Americas;
- The National Science Teachers Association (NSTA);
- The National Centre for Improving Science Education (NCISE); and
- National Science Education Standards Project.

The reports of these projects and organisations suggested a rapid improvement and reformation of science education curriculum in America. Let us discuss the above projects.

Self Assessment Exercise

State some of the recommendations of the various committee reports which came up as a result of the Sputnik effects.

3.3.1 Science for All Americans

- This project was established by James Rutherford in the 1980s and it was tagged “Project 2061”;

- The programme was designed for a long term aimed at large scale view of education reform in the sciences based on the goal of scientific literacy;

- The project is of the belief that scientific literacy which embraces science, mathematics and technology is a central goal of science education;

- The core of Science for All Americans consist of recommendations by a distinguished group of scientists and educators about what understanding and habits of mind are essential for all citizens in a scientifically literate society;

- In preparing its recommendations, project 2061, staff used the reports of the five independent scientific panels. The project also sought the advice of a large and diverse array of consultants and reviewers such as: scientists, engineers, mathematicians, historians and educators;

- The projects recommendations are presented in the form of basic learning goals for American students;

- Its recommendations addressed the basic dimensions of scientific literacy and it was also based on the premise that schools do not need to teach more, rather they should teach less so that the content can be taught better;

- The project covers several topics many of which are common in the school curriculum while some were entirely new. However, the treatment of such topics differs from traditional approaches;

- One difference is that boundaries between traditional subject matter categories are softened and connections were made between the subjects in an integrated form;

- Another difference is that the amount of detail that students are expected to learn is less than in traditional science, mathematics and technology courses;

- Key concepts and thinking skills are emphasised instead of specialised vocabulary and memorized procedures;

- Project 2061 released the draft document Benchmarks for scientific literacy. The Benchmarks consist of specific goals and objectives for science curriculum;

- Many local schools, districts and some national organisations have began to use the benchmarks for different models of science curriculum in America.

3.3.2 Project Scope Sequence and Coordination

- It’s a programme spearheaded by Bill Aldridge in 1989 of the National Science Teachers Association;

- Upon analysing of school programmes in America, he noticed some deficiencies;

- He further compared American secondary school programmes with science programmes in other countries such as: Commonwealth of Independent States and the Peoples Republic of China;

- The "Project on Scope, Sequence and Coordination of Secondary School Science" is an effort to restructure science teaching primarily at the secondary school level;

- The projects call for elimination of the tracking of students;

- It recommends that all students should study science on a yearly basis for six years and advocates the study of science as carefully, sequenced, well-coordinated instruction in physics, chemistry, biology and earth and space science;

- This was a contradiction to the traditional curriculum in which science is taught as separate disciplines;

- The project is of the view that students can learn and retain new materials better if they study it in spaced intervals rather than all at once;

- The scope, sequence and coordination reform effort also uses appropriate sequencing of instruction, taking into account how students learn;

- The third component of this project is the coordination of science concepts and topics. The project is of the view that biology, chemistry, physics, earth and space science have significant features and processes in common;

- Coordination among these disciplines leads to awareness of the interdependence of the sciences and how the discipline forms a body of knowledge.

3.3.3 National Centre for Improving Science Education

- This centre develops frameworks for curriculum, assessment and staff for the elementary, middle and secondary schools in the United States of America;

- The curriculum and instruction frameworks for middle school and high schools extend the center's proposed framework for the elementary years;

- The organising concepts detailed the technical report for the middle schools include cause and effects, change and conservation, diversity and variation, energy and matter, evolution and equilibrium, models and theories, probability and prediction, structure and function, systems and interaction and time and scale;

- The curriculum emphases should include scientific habits of mind, such as: willingness to modify explanations, cooperation in answering questions and solving problems, respect for reasons, reliance on data and skepticism;

- Content in the programme should relate to the life and world of the student and provide a context for presenting new knowledge, skills and attitudes;

- The focus of curriculum and instruction should be on the depth of study and not breadth of topics.

3.3.4 National Science Education Centre

- This project provides the qualitative criteria and framework for judging science programmes in terms of content teaching and assessment and the policies necessary to support them;

- The standards will define the understanding of science that all students regardless of their background, future aspirations or prior interest in science should develop;

- The standards also present criteria for judging science education content and programmes at the K-4, K-5-8 and K-9-12 levels;

- This will also include learning goals, design features, instructional approaches and assessment characteristics;

- It will also include all natural sciences and their interrelationships as well as natural science connections with technology, science and technology-related social challenges;

- The project also recommended standards for the preparation and continuing professional development of teachers including resources needed to enable teachers to meet the learning goals;

- The project recommends criteria for judging models, benchmarks, frameworks, curricula and learning experiences developed under the guidelines of ongoing national projects;

- It provides criteria for judging teaching, provision of opportunities to learning valued science including such resources as instructional materials, educational technologies and assessment methods of science education programmes at all levels.

4.0 CONCLUSION

From the above discussions, you will agree with me that the major factor that spurred the rapid development and reformation of science education curriculum in the United States of America was the launching of Sputnik Satellite by the Soviet Union in 1957. This poses a challenge to the Americans and it led to rapid reformation in their science education curriculum.

5.0 SUMMARY

In this unit, you have studied the science education curriculum reform in the United States of America. In the next unit, you will study science education curriculum reforms in Japan.

6.0 TUTOR MARKED ASSIGNMENT

1. Give a brief historical background of science education curriculum in the USA.

2. Mention and discuss the various frameworks that aided science education reforms in the USA.

3. Highlight the role of Sputnik Satellite in the development of science education in the USA.

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UNIT 3 SCIENCE EDUCATION CURRICULUM REFORMS IN JAPAN

CONTENTS

1.0 INTRODUCTION

In the last unit, you studied science education curriculum reforms in the United States of America. You have also seen how the launching of the Sputnik Satellite by the Soviet Union had challenged the Americans to intensify efforts in reforming her science education programmes. In this unit, you will study the status of science and technology education in Japan.

2.0 OBJECTIVES

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

- Describe the nature and status of science and technology education in Japan;
- Highlight the learning programme for science education in Japan;
- State and discuss the reformation mode in science education programmes in Japan.

3.0 MAIN CONTENT

3.1 Historical Background of Science Education Curriculum in Japan

The school curriculum, like every other countries discussed in this module, is being controlled by the government of Japan. The content of the curriculum is determined by the standard national curriculum set up by the Japan Ministry of Education. It is legally compulsory for schools to abide by the national curriculum standard throughout the whole country. This is to ensure uniformity and maintain standard of the curriculum. The course of study is periodically reviewed by the Ministry of Education every ten years. A curriculum council was set up to determine the course of study and the syllabus.

The science and technology syllabus is a selection of quintessential topics such as scientific phenomena commonly encountered by students in their day-to-day life. The aim of science education is to train students in the practical aspects of scientific learning through laboratory and other experiments and to develop their powers of observation and their ability to interpret and apply their knowledge (Miwa, 1996). The following are the characteristics of science education in Japan as identified by Miyake (1997):

(i) The emphasis is on the basics of science and on individuality;

(ii) Learning is based on science encountered in everyday life and applied technology;

(iii) The aim of science education is to enable the development of the basic capabilities and creative skills necessary to cope with a rapidly changing societal environment.

The specific aspects that helped to develop a scientific temperament in Japan are as follows:

- Observation, experiments and growing plants;
- Scientific perception of nature;
- Research activity and task study;
- Scientific assessment, judgement and clear self-expression;
- Computing skills and applications;
- Science education-oriented towards the protection of the environment.

Self Assessment Exercise

Who determines the course of study in Japan?

3.2 Nature of Science Curriculum Reform in Japan

Schools in Japan are categorized into elementary school, lower secondary school and upper secondary school. The students that graduated from upper secondary school move to tertiary institution. Japanese schools are graduated into grades. For instance, elementary school has grades 1 – 6, lower secondary school has grades 7 – 9 and upper secondary school has grades 10 – 12. Each level of the schools has specific science courses and learning programmes.

3.2.1 Learning Programme for Science Education in Japan

This includes 1st to 6th grades. Below are some of the science programmes:

- The course content is divided into three areas. These are: living things and their environment, matter and energy and the earth and the universe;

- The overall objectives for teaching science at this level is to help develop the child's ability to solve problems, foster love and sensitivity towards nature, and to inculcate a deeper understanding of the phenomena of nature utilising a variety of observations and experiments;

- The main aim of science education at this level is to nurture a more rational and logical thought process that helps to develop a scientific worldview.

3.2.2 Lower Secondary School Level

This is made up of 7th, 8th and 9th grades. Below is a summary of the characteristics of science programme at this level:

- Science content is divided into two fields;

- The first field deals with matters and phenomena related to substances and energy;

- The second field deals with living things, and natural matters and phenomena;

- The overall objectives are to enable students develop the capacity to undertake investigations in a scientific manner and to deepen their understanding of scientific phenomena;

- The aim of science education at this level is to strengthen students' capacity to study science, kindle a passion for science and encourage them to explore and comprehend nature more deeply.

3.2.3 Upper Secondary School Level

This includes the 10th, 11th and 12th grades. Below is the summary of the science programme at this level:

- Science at this level is not divided into fields;

- Subjects offered at this level include integrated science, physics, chemistry, biology and geology;

- The overall objectives are to arouse students' curiosity and interest in nature, foster the capability of scientific investigation through observation and experimentation and deepen their understanding of natural phenomena, thereby developing a scientific view of nature;

- Each of the science subjects are divided into two or three and allocated credit units.

3.3 Reform of Science Education Curriculum in Japan

Prior to the reformation of science education in the year 2002, science curriculum in Japan faced some challenges. Some of these challenges were as follows:

1. A substantial number of children do not fully understand the syllabus content;

2. Children's ability to study and judge by themselves and to express their opinions have yet to develop fully;

3. Children’s abilities to view things from different perspectives are not yet satisfactory;

4. Children are excessively challenged by comprehensive science problems, such as problems related to environment and the essence of science;

5. Children lack interest in science and its study.

The above were some of the challenges identified by the Third International Mathematics and Science Study (TIMSS). It was also observed that the percentage of students who demonstrated an interest in science has registered a worrying drop from 85 per cent in Grade IV to only 56 per cent by Grade VIII (Miyake, et. al. 1999). Other challenges also were observed with the entrance examinations into schools in Japan. Some of these include unhealthy competition in the entrance examinations and a social climate where disproportionate emphasis is placed on academic credential and the harmful effects of uniformity and rigidity in school education.

In view of the above mentioned challenges and due to rapid and wide-ranging social change taking place in Japan, there was the need to develop an educational system capable of accommodating these changes and remedy the challenges. As part of the effort to deal with these problems, the National Council on Educational Reform was set up and the Council recommended the following:

- the introduction of the principle of respect for the individual;
- the transition to a lifelong learning system;
- the internationalisation and the shift to an information-oriented society.

The reformation of science education started in Japan in the year 2002. Below is the summary of some of the reformations made:

- Introduction of the five-day school week and the consequent reduction of science class time as well as the reorganisation of science content in the new course of study;

- There was 30 per cent reduction of content and teaching time;

- Each school must develop an original curriculum and teaching materials according to their ingenuity and the conditions pertaining to their schools;

- Pre-service and in-service teacher education will now be given priority by the government;

- Standard National Curriculum was reviewed;

- Introduction of “new integrated study” to include moral education and special activity. A period for integrated study will be established to encourage each school to show ingenuity in providing interdisciplinary and comprehensive study;

- There were reforms in the course content of the elementary, lower secondary and upper secondary schools;

- Introduction of lifelong learning society;
- Introduction of interdisciplinary curriculum network which involve network of subjects.

Self Assessment Exercise

What are the challenges faced by science education system in Japan that led to reformation?

4.0 CONCLUSION

Japan, as at today, is one of the industrial and technological nations. It attained this position as a result of reformation made in its science and technological education. Therefore, the role of science and technology in the development of a nation cannot be overemphasised.

5.0 SUMMARY

In this unit, you have studied the development of science and technology in Japan. You have seen the nature of science education in Japan. You have also studied the various reformations in science education. In the next unit, you will study science education curriculum reform in another country.

6.0 TUTOR MARKED ASSIGNMENT

1. With the aid of specific examples, describe the nature of science and technology education in Japan.

2. Outline the learning programmes in Japanese science education programme.

3. Discuss the reformations made in science education in the year 2002 in Japan.

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UNIT 4 SCIENCE EDUCATION CURRICULUM REFORS IN THE NETHERLANDS

CONTENTS

1.0 INTRODUCTION

In unit 3, you have studied the science education curriculum in Japan. In this unit, you will study another country which is the Netherlands. You will see the various reformations that have taken place in their science education curriculum.

2.0 OBJECTIVES

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

- Describe the nature of science education in the Netherlands;
- State the methods of learning science activities in the Netherlands;
- Elucidate the various reformations and new trends in science education curriculum in the Netherlands.

3.0 MAIN CONTENT

3.1 Nature of Science Education Curriculum in the Netherlands

The Dutch Educational System is made up of primary, secondary and tertiary institutions. Primary education is given to children of age 4 to 11 years. The child enters secondary school at the age of 12 years. The secondary school curriculum is made up of four years of basic secondary education. In most schools, the basic secondary education is divided into four streams as follows:

- Pre-vocational;
- Junior secondary;
- Senior secondary;
- Pre-university.

Primary schools in the Netherlands are free to decide how to organise the timetable and how much time to spend on science under the supervision of inspectors. At the secondary school level, science lessons take fifty minutes and in upper secondary science lessons, some double periods are allowed for more extensive practical work. The government recommends a total number of lessons for mathematics, science, technology and health subjects, but schools are free to increase or decrease these numbers.

At the primary school level, integrated science is taught with emphasis on biology, physics and physical geography. At the basic secondary education, the curriculum contains subjects such as physics, chemistry, biology, home economics, information science and technology. These subjects are taught by specialists who are usually trained at university levels. It should be noted that in all senior secondary streams, physics, chemistry and biology are taught as optional courses.

Primary in general do little on physics, but focus mainly on biology and physical geography contents. The main reasons for this one-sided approach to science teaching in primary schools are:

- teachers are not well trained to teach physics topics;
- most primary textbooks have under-developed sections on physics;
- there is little or no external support for teaching physics in contrast with support given by various external agencies to biology and environmental education.

Self Assessment Exercise

What is the nature of primary school in the Netherlands?

3.2 Methods of Learning Science Activities

At the primary school level, observations, making drawings, discovery activities and investigations are used.

At the basic secondary school level, practical work is strongly recommended. Other methods used in teaching science include: studying science in daily life contexts, making use of the computer, developing general skills such as communication and decision making and relating science to a variety of vocations.

For biology, physics and chemistry, at the senior secondary schools, practical skills are required and examined in a school-based practical examination;

Field studies are not recommended in physics and chemistry curricula, but field studies are more common in biology.

Self Assessment Exercise

At what level of education was practical work emphasised?

3.3 Reformation and New Trends in Science Education Curriculum in the Netherlands

Several factors gave rise to science education reforms in the Netherlands, some of these factors include:

i. It is generally felt that teachers were not sufficiently trained for teaching primary science;

ii. All kinds of specific interest groups produce materials for primary science hence there is no uniformity;

iii. Examination results conducted by the Dutch Institute for Testing and Evaluation has shown that the level of performance in primary science is too low especially on the part of physics;

iv. Most schools lack laboratory staff, have faced difficulties in practicals.

In view of the above, the following reformations were made:

- In biology, physics and chemistry, emphasis was given to skills and applications in terms of contexts, practical work, role of computer and the connections of each of these science subjects to the other;

- This shift of emphasis is supported by many teachers and its reflected in nearly all new textbooks. Most textbooks offered more depth than required by the curriculum;

- The central government is now responsible for monitoring the quality of education in all schools while municipal authorities or school boards govern schools;

- Nearly all secondary schools have separate departments for physics, chemistry, biology and technology;

- The central government now finances all public and almost all private schools and financial power has now shifted towards the school authorities;

- Each school now has a budget for laboratory furnishings, apparatus, and libraries. Chemistry department tend to have the largest budgets followed by physics and biology;

- In primary schools, the school owns books while in secondary schools, parents buy textbooks;

- Emphasis was laid on the use of computers. All schools now have computer rooms and working within computers in mathematics and physics is now obligatory, as it has been decided at the national level to integrate computer skills as much as possible into the various subjects;

- In-service training of science teachers was emphasised by the government;

- Teachers' organisation take initiatives for projects, they publish materials and organise local and national meetings. the largest one is the Dutch Association for Science Education with over 4,000 members;

- Science education research was encouraged. This has affected curriculum structure and conceptual change in physics, chemistry and biology;

- Out-of-school resources such as: museum 2005 and field trips were incorporated into science teaching techniques;

- Science clubs and cultural associations were also introduced in schools;

- Finally, a strong trend in the Netherlands curriculum is that primary and secondary schools are offered more autonomy in decisions about budgets and personnel. Such autonomy offers the school the possibility for a large number of policy choices and for developing its own identity.

Self Assessment Exercise

Who is responsible for maintaining the quality of education in the Netherlands after the reformation?

4.0 CONCLUSION

On the whole, science education curriculum renovation started since 1991. In all science subjects, more attention is given to relating science to the world outside school, to practical work, to the use of computers, to open investigation and to modern development in the disciplines. These measures have made science teaching more attractive and educationally worthwhile for students.

5.0 SUMMARY

In this unit, you have learnt about the nature of science education in the Netherlands. You have also studied the various reformations that took place in the Netherlands science education curriculum. In the next unit, you will study science education curriculum reforms in Ghana.

6.0 TUTOR MARKED ASSIGNMENT

1. What are the main features of science education in the Netherlands?

2. Discuss the nature of science reformation and new trends in the Netherlands science education system.

3. What are the factors that led to reformation in science and technology in the Netherlands?

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UNIT 5 SCIENCE EDUCATION CURRICULUM REFORS IN GHANA

CONTENTS

1.0 INTRODUCTION

In this unit, you are going to learn about the approach used in teaching pre-tertiary science in Ghana. You are also going to be introduced to the actual art of pedagogy as it obtains in the classroom. You are going to learn about the reforms done in science education in Ghana.

2.0 OBJECTIVES

At the end of this unit, you will be able to:

- Describe the approach used in teaching science in Ghana at Primary, Junior Secondary School and Senior Secondary School levels in Ghana;
- Explain what happens at the Senior Secondary School levels;
- State what cultural practices affect teaching the teaching process;
- Explain the problems of teaching in Science in Ghana;
- Discuss the kind of reforms that took place in Ghana Science Education.

3.0 MAIN CONTENT

3.1 The Teaching Approach to Junior Secondary School Science

The Ghanaian science curriculum follows the “spiral approach”, treating the same themes at different times and in greater depth within each educational level. At the primary and junior secondary school levels are environmental studies and integrated science. This curriculum is the modern replacement of what used to be called “Nature Study”.

This is a generalist survey course which exposes the child to the universe. At this level, students would get the basic exposure to scientific ideas and learn about the history of science. They also learn the basic scientific vocabulary.

3.2 The Approach to Teaching Senior Secondary School Science

At the senior secondary school level, the science curriculum comprises integrated science. At this level, the students are exposed to the rudiments of physics, chemistry and biology. They follow the "Ghana Science Series" for three years, in which the students spiral through the following topics:

(a) The nature of things around us: Some properties of matter, measurement, the nature of matter;

(b) Some effects of energy: Energy, some effects of heat on matter, movements of living and non-living things, making work easy (machines);

(c) Life activities: New life from old life, seeding in plants and animals, uses of food in living things, getting rid of waste materials from the body;

(d) Humans and their environment, crop production, raising animals, food processing, a balanced diet, hygiene and health.

At this stage, students are prepared for one of five programmes at the senior secondary school level, endorsed by "Ghanaian Science Series". As science education is held in the highest esteem in Ghana, only the best students are admitted into the senior secondary school programme with the science concentration options (what we will call science students in Nigeria). All senior secondary school students, whether with science options or not, must take a minimum of integrated science (comprising general science, agricultural and environmental studies).

For those who qualify to enter the senior secondary school science option, their science curriculum includes the individual disciplines of physics, chemistry, biology and physical education. The agricultural science options curriculum includes general agriculture, crop husbandry, animal husbandry, physics and chemistry. The senior secondary school integrated science curriculum guide employs the "SSS Science" authored to seamlessly follow the JSS science book series. The curriculum outline is as follows:

Year I: **Introducing Science:**

Diversity of living and non-living things, the cell, matter and energy:

(i) air and water, matter and energy;
(ii) acids, bases and salts.

Year II: **Interactions in Nature:**

Life activities in man, matter and energy:

(iii) change and equilibrium.

Year III: **Variation:**

Inheritance and evolution, matter and energy:

(iv) some elements and their compounds, components of carbon, science and society, science and technology.

At the university level, students enter the science departments corresponding to the senior secondary school programme. The science curriculum is further delineated into zoology, botany and mathematics. The agricultural option is also into animal and crop sciences, agricultural economics and extension, agricultural engineering and soil science. Students have the option to concentrate in any of the more specific areas towards the final year of their programme.

Self Assessment Exercise

Study the Ghanaian science education programme. In what way is it comparable to Nigeria's? Do you think a Nigerian science student can survive in the Ghanaian educational system? Explain this in the light of what obtains presently in Nigeria.

3.3 The Art of Teaching Science and Science Teaching in Ghana

In spite of the impact of colonization, the cultural heritage of Ghana still persists. This is manifested by respect for elders including teachers. This is a culture in which the elder is regarded as the custodian of knowledge, and should not be challenged. This is an authoritarian kind of leadership characteristics. This cultural tradition seriously influences the classroom environment. The teacher embodies the proverbial "sage on stage". The general method of teaching is the lecture method, in which the teacher delivers knowledge into a supposedly "empty willing vessels". The use of this method is not surprising because the Ghanaian modern educational system began with the missionaries, whose aim was evangelism, and so the culture of obedience, memorization of materials, and the "direct delivery" approach was mainly part of the ecclesiastical scholasticism that Ghana inherited in the early missionary days of education and this has further buttress the authoritarian cultural tendency.

3.4 Methods of Science Teaching in Ghana

However, science teaching cannot be done strictly by lecture alone. It must also involve some amount of practical work. It is therefore normal to find the Ghanaian teacher doing demonstration or laboratory work, where the facilities are available, and employ the guided-discovery approach in teaching. Thus, you may sometimes find the science teacher taking students to the farm for practical agriculture, or going to streams to pick live specimen in biology.

Since the prevalent method of teaching is the lecture method, a good science teacher in Ghana incorporates into his teaching strategies the following: analogies, anecdotes and personal narratives, by employing the inherent rich, colourful language forms of African. This makes teaching interesting, motivating and makes the Ghanaian students to sit and listen longer than when the ordinary lecture method is employed. Thus, in the Ghanaian cultural milieu, the science teacher has the additional cherished facility, the students' "cognitive presence" for longer time, and he or she takes advantage of it.

3.5 Educational Reforms and Science Teaching in Ghana

This will be discussed under two sub-headings, namely: reasons for reform and the consequences of the needs for reform.

3.5.1 Reasons for Reform

During the seventies and 1980s, Ghana experienced serious economic problems, which led to what is called brain drain. Many teachers and lecturers in primary, secondary and university left the country to work in neighbouring countries. There was also the general feeling that the educational system was not responding to the realistic economic future needs of the students and the nation.

3.5.2 Consequences of the Needs for Reform

The above reasons led to a reorganisation of the educational system into what it is at the present. There was also the sense of failure of the prevalent educational processes and methodologies to create an understanding of the information taught. This also led to a new movement in methodologies, whereby 'best practices' are being viewed as the provision of more hands-on, minds-on experiences. This is a new phenomenon in Ghana and may have some counter-cultural implications. On June 18, 2007, a news item was released which highlighted the latest overhaul done by the Ghanaian government in science education (see attached).

Although it will take time for the 'all-wise' teachers to step down from their 'stages' and the students to move from their relatively "passive-assimilations of knowledge" roles to engage their teachers in science discussions, this new movement is a step in the right direction.

4.0 CONCLUSION

The science education in Ghana, like in many other parts of the world, is using the "spiral curriculum approach" whereby the lecture method in teaching interspersed with practical demonstration by the teacher and occasional practice by the students. However, there was the general dissatisfaction on the impact of this method on students and the economy, leading to the reform in the 1980s and the general overhaul of the science education system in 2007.

5.0 SUMMARY

- The Ghanaian educational system is divided into primary and junior secondary education, which involves the teaching of primary/integrated science using the spiral curriculum.
- At the end of the junior secondary school, the student enters the senior secondary school where he/she may enter into one of the five senior secondary school programmes.

- For those who will enter the science option, they will do the individual science programmes of physics, chemistry and biology. Those who will do agriculture will participate in general agriculture, crop husbandry, animal husbandry, physics and chemistry. Those who will not enter the science option will take a minimum of integrated science. This means everybody has a given knowledge of science.

- The main teaching method was formal lecture method, interspersed with practical demonstration by the teacher and occasional fieldwork.

- The trend today is that of involving the students in more of hands-on, minds-on experiences.

- As a matter of fact, the country's science education programme since 2007 has been undergoing a general overhauling process in which students at kindergarten and primary level will be taught science in local languages. At secondary school level, science teaching will be on innovation and problem-solving.

6.0 TUTOR MARKED ASSIGNMENT

As a science educator, do a critique of the science education programme in Ghana. Discuss its similarities and differences with other named developed country. Make suggestions on how to improve science education in Ghana.

7.0 REFERENCES/FURTHER READINGS

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UNIT 6 SCIENCE EDUCATION IN SOUHT AFRICA

CONTENTS

1.0 INTRODUCTION

This unit exposes you to the foundational set up of South African educational system. It will also highlight some of the problems faced by science education and educators and how they are being solved. It introduces the learner to the Academic of Science in South Africa, and explain what professional development means to science educators, and the effect this will have on learners and the nation's development in general.

2.0 OBJECTIVES

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

- Trace the history of education in South Africa;
- State the impetus for science teaching;
- Highlight the problems of science education;
- Discuss teachers' misconception of their problems;
- List the solution to the problems of science education;
- Explain the role of Academy of Science in South Africa.

3.0 MAIN CONTENT

3.1 Brief History of Education in South Africa

South Africa has an area of 1.2 kilometre square, a population of 49.3 million comprising of 79.7% black, 9.1% white, 8.8% coloured, and 2.2% Asian (2007 South African Census at http://www.statssa.gov).

In South Africa, ages 7 – 15 years are the period of compulsory education. The South African Schools Act (Act 84) passed by the Parliament in 1996 (Post-apartheid period) aims to achieve greater educational opportunities for black children. The Act mandated a single syllabus and more equitable funding for schools. This is necessary because, prior to this period, non-whites were not allowed to study science and mathematics above the most elementary levels. Due to the segregation, the quantity and quality of education varied significantly across racial groups. The whites had the better part of it while the non-whites suffered.

However, when in 1994 democracy was allowed to have its way in South Africa, the laws governing segregation apartheid was abolished, and the change process began. The challenge is to create a single non-discriminatory, non-racial system that offers the same standard of education to all people. This means giving equal opportunities to all peoples, irrespective of race, colour or settlement.

Another challenge was the need to improve and encourage science in South Africa. This is because world over, a greater number of science graduates results in a more skilled and therefore more productive workforce, which in turn contributes to an internationally more competitive nation and to redressing the balance of trade problems (Robettom D. Hart, 1993). This belief is repeated often, in South African White Paper on Science and Technology (1996:10) which states that science is considered to be among the requirements for creating wealth, and improving the quality of life.

3.1.1 Impetus for Science Teaching

The importance of science to development in any nation cannot be overemphasised. It is the realisation of this that has made Africa eager to develop its scientific human power to attain a measure of self-reliance in the production of goods and services by expanding its educational facilities and setting up curriculum development and research centres as well as developing policies on science education (Ogunniyi, 1996).

In line with this, South Africa has in recent times set up similar science development centres such as:

- the creation of a Ministry of Science, Technology and Culture which declared 1998 and 2000 as Years of Science and Technology;

- prioritising research in science, for example, by the National Research Foundation (NRF);

- increasing the focus towards science by universities of Venda, the North, of Cape Town and of Fort Hare;

- further Diploma in Education in Science Education (FDE), now the Advanced Certificate of Education (ACE), for retraining science teachers;

- the Department of Education (DoE) commissions to improve science education; scholarships for science teachers from, for example, ESKOM;

- manufacturing of science teaching equipment by, for example, the Somerset Educational;

- media interventions such as the SABC Education and Liberty Life programmes on science;

- creation of NGOs such as CASME and All Saints specifically for science education, and an increase in the awareness of traditional science;

- outreach programmes such as ZENNEX, and ABSA, equipping schools with Somerset Micro Science Kits;

- science centres, such as the Interactive Science Centre at Cape Town;

- research conferences on science education such as the South African Association for Research in Science and Mathematics Education (SAARMSE);

- programmes for upgrading science educators such as that by the North West DoE (EDUSOURCE DATA NEWS, March, 2000:25), and

- the SYSTEM initiative by the DoE aimed at increasing the number of scientists.

Such efforts have provided South Africa with world-class scientists and contributed towards science education.

Self Assessment Exercise

In your own opinion, what was the state of science education and what efforts is South Africa making to improve science education since democracy began in 1994? Is the effort yielding any positive result? How do you know?

3.2 Problems of Science Education

In spite of all these laudable interventions in South Africa in improving science and even in other parts of Africa, science education is still experiencing problems in Africa and South Africa in particular, that could lead to crisis. These problems are highlighted for Africa in the Dakar Declaration which indicates large socio-economic obstacles against efforts towards human capital development in the field of science and poor state of science education (Ogunniyi, 1996).

In South Africa, indications that there are problems are observed in the impoverished communities of the Eastern Cape Province that could not contribute to curriculum development, poor school resources and inadequate teacher training (MacDonald and Rogan, 1988:34). Also, Matriculation level (South African Broadcasting Corporation, PM Live Program, 10^{th} January, 2000) and occasional reports on the low international ranking of science education.

These problems, if not solved, can lead to a crisis in science education in South Africa, which will negate development efforts. This is worrisome because science knowledge is believed to be important for development.

Self Assessment Exercise

1. What are the indicators that there are problems in science education in Africa generally and South Africa in particular?

2. List and explain the problems of science education in South Africa.

Some of the problems are listed as follows:

- Teachers misconception of their problems;
- Problem in the science classroom;
- A drop in science education students;
- Inadequate finance to NGOs dealing with science education.

Source: Muwanga-Zaka, J.W.F. (2010).

3.2.1 Teachers' Misconception of their Problems

The teachers were found not to know exactly what problem they had. This is because teachers were found not to be conducting practicals and when asked, they claimed no equipment and laboratories. The fact is that the main reason why teachers do not conduct practicals is that they are deficient in practical skills and do not understand the science concepts they are supposed to teach. This is evidenced in the fact that, of the 21 schools that participated in a project called the ZENNEX, and was provided with the Somerset Micro Science Kits, in Butterworth, only five seemed to have attempted to use the science teaching equipment. The equipment were found either to be gathering dust or neatly stored in boxes that had never been opened in the remaining 16 schools. Similarly, visits to three Masifunde Project schools in the Free State Province during 2000 revealed an assortment of unused science teaching equipment. All the schools had expired chemicals and broken or poorly maintained physics equipment, some of which teachers could not identify.

Some teachers complained of principals who keep equipment in their offices instead of releasing them to the laboratories. Some teachers who enrolled for FDE in 1998 and some qualified teachers, who were interviewed, claimed that they were never taught much of the prescribed science practicals when they were learners at school or as teacher trainees at college of education or at university.

1. What is the reason for lack of teachers' understanding of school science concepts?

- It may be due to the fact that the teachers in their school days were never taught much of the prescribed science practicals;

- Practicals were contributing directly towards passing examinations like the Ordinary Level Cambridge Certificates;

- If practicals are believed to enhance understanding of science concepts, then the teachers' deficiency in understanding can be explained by the claim of having been taught without science practicals;

- The fact that the science teachers ranked lacked of equipment and laboratories as key problems which prevented them from teaching practical science instead of the fact that they were taught without practicals, showed a misconception of the problem they had. It also showed that they realised that practical science is the basis of scientific processes.

2. The second problem is that of classroom management, and environment. Such managerial problems as late coming, schools opening late in the year, and starting end-of-year examination by middle of October, reduce tuition time which, for science, might lead to ignoring practicals as teachers rush to complete the syllabus. Others have to do with the quality of teachers.

- Poor quality of teachers: According to Ogunniyi (1996), no education system is higher than the quality of its teachers. Thus, science standard may fall because of lack of properly trained science teachers. Deficiency in practical skills and conceptual understanding are passed on to the student teacher who becomes a teacher, from one generation to the next. This kind of cycle perpetuates incompetence which can lead to a deterioration of standards over time. Poor teacher education might be the reason for teachers' complete reliance on textbook notes and practical instruction (Muwanga-Zaka, 1998). The practice of chalkboard teaching observed by Jennings and Everett (1996), and the teachers' inability to use equipment. Other classroom problems includes: lack of clear objectives for practicals, school environment not conducive for learning, unusual science equipment.

3. Cultural Barriers – Science is not culture-neutral. Ogunniyi (1996) and Henderson and Wellington (1998) agree that the greatest cultural barrier in learning science is language. South Africa has developed science curricula and content upon western trends and teachers' science mainly in English or Afrikaans. While learners and teachers wish to communicate in their mother tongue, Xhosa rather than English, as English and Afrikaans are learnt as second languages.

4. Inability to produce the actual number of students in science education – Science and education are often offered separately, and science education is not offered as a major subject. Institutions are unable to give the actual number of science educators they have produced, so it is difficult to plan resources, and to access funding for training of science education teachers.

   The number of blacks in the fields of science is still below the proportion of Blacks in South Africa, and may not be increasing in concert with the increase in the black population. The number of Blacks Science educators is of particular importance, more are needed in the often Black, overcrowded classrooms, because of language and cultural issues. Thus, it is important that more teachers are trained so that more students can learn science better.

5. Inadequate funding to Science Education NGO's – Much of the hues and cries about the importance of science to a nation is not accompanied with funding, as it seems that much of the funding to NGOs was redirected through the DoE after 1994 electios. This is because NGOs which were conceived as vehicles towards improving education is disadvantaged as the government used to fund them well. The present government prefers 'holistic' interventions which normally include school management, English, mathematics and science. Holistic approaches distribute funds and resources equally among these different fields – i.e. science does not get the priority it should have. NGOs such as CASME are currently experiencing difficulty in obtaining funding for improving science education, while others such as the Primary Science Project (PSP), and All Saints College have closed.

   The funders i.e. government are not realistic as they have advised the NGOs like CASME to be innovative, and most of the Black communities are still too disadvantaged to sustain such projects. For instance, rural schools do not have science laboratories and equipment partly because of their low social economic standards. They cannot therefore raise the necessary resources, as do the white communities. In addition, they have difficulties in starting and maintaining resource centres. Funders do not seem to realise that it takes time and money to build capacity.

In view of that had been discussed, it is clear that funding is the main requirement for science education to take its rightful place.

3.3 Solutions to the Problems

The first thing to solve these problems is as follows:

- producing quality science educators who will then produce more students entering the tertiary field of sciences;

- the educators too must be willing to change from their old ways. The educator is important as a guide and a leader who has the potential to transform and enlarge the knowledge coast and understanding of learners (Griffith, 2000). Educators too are the primary initiators of their own development and so they must first be empowered by the authorities so that they can make the necessary changes required in the students;

- this means that they must be subjected to professional development. This refers to "activities to enhance career growth such activities as individual development continuing education, and in-service education, as well as curriculum writing, peer collaboration, study groups and peer coaching or mentoring (Ferraro, 2000).

Professional development can play a very important role in improving the teaching of mathematics and science. The schools in South Africa are undergoing reforms, and for educators to be able to cope, they need to update their skills and knowledge and totally transform their roles as educators. It is only through professional development that educators could learn new roles and new teaching strategies to improve students' achievement. Through in-service professional development programmes, educators have access to an expanding body of knowledge with respect to the content area, teaching techniques, and meaningful engaged learning for students (James, et. al. 2010). This increased access and engagement with information, along with the current focus on educational standards that emphasise in-depth learning experiences and problem-solving abilities in science has made it crucial for educators to be prepared to implement change in the classroom.

In the course of professional development, those responsible for organising it must find ways to strengthen and support activities within the social settings of individual educators. This is because many educators in South Africa believe that the physical environment of the classroom has great influence on what they can do in the classroom. The physical environment includes the number of learners, the sitting arrangements and the amount of space available to move around in the classroom amongst others. There is also the need to consider the social context. Teddie and Stangfield (1993) suggested that effective schools in different social class context displayed different characteristics depending on the socio-economic context in which they operated. In addition, professional knowledge bases include strong emphasis on content-specific pedagogical knowledge (Hammond-Darling, 2006). This is important with changes in science curriculum in South Africa where educators are required to teach new content that they have not encountered previously. Thus, effective professional development means building a culture of up-to-date learning for both educators and learners in a school.

Apart from professional training, what other solutions can improve science teaching in schools in South Africa?

- More resources should be allocated and deployed to science development;

- There should be special bursaries for science teachers. There must be an intensive in-service training;

- Science teachers must pass practicals and laboratory management must be part of teacher training;

- Allocate fewer periods to science teachers or pay science teachers higher salaries in form of laboratory allowance ;

- Create a database of science educators in service, in-training and those that graduate each year;

- Create an examination panel to manage and control examinations;

- Establish a minimum period of funding and intervention. Design realist project evaluation criteria. Funders should stick to their promises;

- Teachers should have obtained excellent results in science at school;

- Supply of science equipment must be followed by training on how to use them.

3.4 Role of Academy of Science in South Africa

This would be discussed under two separate sub-heads, namely: brief history and objectives of the academy of science in South Africa.

3.4.1 Brief History

The Academy of Science of South Africa (ASSAF) is the national science academy for that country. It started in 1996, and encompasses all fields of scientific work. The academy comprised two separate institutions, namely: The Royal Society (from UK) and the Suid-Afrikaanse Akademie van Wetenskap en Kuns (SAAWEK, a National Party institution.

SAAWEK had an Afrikaans-language focus and was heavily supported by South African businesses. It was the national academy, whose statute was passed in 1950 that is based in Pretoria. As the national academy, it was structured into two 'faculties': human and natural sciences with a journal for each. Though it still awards medals and prizes, it is no longer the national science academy of South Africa. With the dawn of democracy in the early 1990s, it was realised that a new model was required. The Foundation for Research and Development (now the National Research Foundation) invited the Royal Society of South Africa, SAAWEK and the Agricultural Economics Association of South Africa (AEASA) to plan a new Academy.

After a vigorous debate with South Africa's scientific community, a new academy was instituted which included all South Africa's leading academies. In 1994, a plan and a draft constitution were adopted.

In 1995, 100 founder members were elected and the Academy of Science of South Africa was launched in 1996, with then-President Nelson Mandela as Patron. Membership as at today is 338. The role of ASSAF is to provide professional, independent, evidence-based advice. With grant-in-aid from the Department of Science and Technology (DST), the Academy moved to central Pretoria. In 2001, the DST commissioned the academy's first journal.

In 2006, a report entitled 'A Strategic Approach to Research Publishing in South Africa was released. Their breakthrough came in 2004 when the African Science Academies Development Initiative (ASADI) led by the United States National Science Academies selected ASSAF as an intensive partner, guaranteeing funding and mentoring for 5 to 7 years. this led to the first symposium on evidence-based practice theory and best-practice.

This was followed by study on HIV/AIDS, TB and Nutrition, ASSAF's first self-initiated consensus study. The report was released in 2007.

Other studies currently in progress include:

- State of Humanities in South Africa;
- Ph.D Study: Enhancing the Production of Postgraduates in South Africa;
- Clinical Research and Related Training in South Africa;
- Improved Nutritional Assessment in South Africa;

- Low Carbon Cities.

3.4.2 Objectives of the Academy

The main objectives of the Academy is to promote and apply scientific thinking in the service of the society. To achieve this objective, the academy shall:

- use the common ground of scientific knowledge and activity to remove barriers between people and obstacles to full development of their intellectual capacity;

- endeavour in every possible way to inspire, promote and recognise excellence in scientific and technical practice;

- investigate and publicity report on various matters in its own discretion or at the request of government or organisations in civil society, in order to promote and apply scientific thinking in the service of the society;

- promote science education and a culture of science in the population at large;

- maintain strict independence while consulting other organisations and individuals in the widest manner possible;

- endeavour to establish and develop close relations with scientific organisations in South Africa and with similar academies in other countries; and

- take any other action that it may consider necessary towards the attainment of its key objective.

Is this objective related to the national objective?

From the ongoing, one can see that the strategic priorities of the academy are closely matched to those of the nation, focusing particularly on the need for the greatly enhanced availability of high-level human capital, and an increased use of the country's best intellectual expertise in generating evidence-based policy advice that is practically feasible.

The academy is aligned to national policy as dictated in the White Paper on Science and Technology and the National Research and Development Strategy. It also seeks to meet other national priorities, such as the accelerated and Shared Growth Initiative for South Africa, the Joint Initiative for Priority Skills Acquisition and the Grand Challenges of the Department of Science and Technology.

4.0 CONCLUSION

The ongoing shows a crisis situation in South Africa's science education, which has been as a result of the long standing apartheid policy of its government. However, with the inception of democracy in 1994, science education has began to receive a ray of light among the Blacks. It is hoped that the new reform which has just began will go a long way in improving the intellectual skill and conceptual learning and also the basic skills acquisition in science education among blacks in South Africa.

5.0 SUMMARY

This unit has:

- highlighted a brief history of South Africa and its science education system;
- stated the importance of science in any nation;
- listed the problems of science education in South Africa;
- discussed the solution given to these problems particularly as it related to teacher development;
- the role of the Academy of Science of South Africa was given (ASSAF);
- finally, the relevance of ASSAF to South Africa and science education were equally highlighted.

6.0 TUTOR-MARKED ASSIGNMENT

1. In your own understanding, how do you think ASSAF can be of help in developing science education in South Africa?

2. What do you understand by Professional Development? Do you think it can help the development of Science Educators in South Africa? Explain.

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MODULE 4 MODERN SCIENCE CURRICULUM TRENDS AND REFORMS

UNIT 1 TRENDS IN RESEARCH IN SCIENCE EDUCATION FROM BEHAVIOURISM TO SOCIAL CONSTRUCTIVISM

CONTENTS

1.0 INTRODUCTION

The traditional patterns of science education have remained largely unchanged for most of the last century. Very often science instruction has lacked a clear focus and has been provided by teachers ill-prepared to deal with science content. The national curiosity of children, eager to understand their surroundings, is often diminished by instruction that discourages inquiry and discovery. Under the new vision of science teaching and learning, teachers must alter significantly the types of instruction that they have used in the past.

This unit will therefore discuss the trends in research in science education from behavirousm to modern ways of learning science which is constructivism.

2.0 OBJECTIVES

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

(i) describe briefly, the behaviourist and the constructivist learning theories;

(ii) compare and contrast the behaviourist and the constructivist learning theories;
(iii) explain the constructivists perception of learning and the nature of the learner;
(iv) state the constructivists teaching strategies;
(v) state and explain some of the criticisms of constructivism.

3.0 MAIN CONTENT

3.1 Behaviourist Theory of Learning

Behaviourist theory of learning considers human beings to resemble machines, hence they belief that human behaviour is mechanical in nature. This means that human beings behaviour can be manipulated by reinforcement whether positive or negative. Other principles from behaviourist theory as it relates to teaching-learning process include:

- constant repetition of concepts by teachers will enable the learners to grasp and understand the concepts;
- learning task should be concrete and progressively arranged;
- positive and negative reinforcement should be used by teachers in the classroom;
- there should be consistency in the use of reinforcers during the teaching-learning process;
- habits and other undesirable responses can be broken by removing the positive reinforcers connected with them;
- immediate, consistent, and positive reinforcement increases the speed of learning;
- once an item is learned, intermittent reinforcement will promote retention.

The main summary of the behaviourist theory is based on stimulus-response learning. For many years, these behaviourist principles formed the basis of most of the learning theories applied in child rearing and in classrooms. However, modern educators have began to conduct researches which tend to replace the behaviourist theories. It was discovered that although stimulus-response does explain many human behaviours and that it has a legitimate place in instruction, behaviour alone was not sufficient to explain all the phenomena observed in learning situations. One of such modern theory of learning is constructivism.

Self Assessment Exercise

Discuss the main principles of behaviorist theory.

3.2 Constructivist Perception of Learning

The constructivists argue that human beings generate knowledge and meaning from an interaction between their experiences and their ideas. The theory therefore recommend a teaching method that will encourage interactive activities among the learners. One of the protagonists of this theory is Jean Piaget who argued that play way method of teaching is an important and necessary point of the students cognitive development and he provided scientific evidence for his views.

Jean Piaget articulated mechanisms by which knowledge is internalized by learners. He is of the view that through the process of accommodation and assimilation, individuals construct new knowledge from their experiences. According to him, incorporation of new experience into an already existing framework took place when individuals assimilate and this takes place without changing the existing framework. Assimilation may occur when individuals' experiences are aligned with their internal representations of the world and it may also occur as a failure to change a faulty understanding. For instance, an individual may not notice an event, he may misunderstand input from others, or he may decide that an event is a fluke and is therefore unimportant as information about the world. In contrast, when individuals' experiences contradict their internal representations, they may change their perceptions of the experiences to fit their internal representations.

Accommodation, on the other hand, is the process of refraining one's mental representation of the external world to fit new experiences. It can also be understood to be the mechanism by which failure leads to learning. According to constructivist theory, when we act on the expectation that the world operates in one way and it violates our expectations, we often fail, but by accommodating this new experience and refraining our model of the way the world works, we learn from the experience of failure, or of others failure.

On the whole, constructivist's perception of learning suggests that learners construct knowledge out of their experiences. Constructivism is often associated with pedagogic approaches that promote active learning or learning by doing.

Self Assessment Exercise

In your own opinion, do you consider constructivism to be a method or a strategy of teaching?

3.3 Constructivist Perception of Nature of the Learner

We list below the constructivist perception of nature of the learner as follows:

- The constructivists see the learner as a unique individual with unique needs and backgrounds. The learner is also seen as a complex individual hence he should be regarded as an integral part of the learning process.

- Social constructivism recognises the importance of the background and culture of the learner; thus they encourage the learners' social interaction with knowledgeable members of the society. This will enable the learner to acquire social meaning of important symbol systems and learn how to utilise them. The constructivists encourage young children to develop their thinking abilities by interacting with other children, adults and the physical world.

- It was also argued that the responsibility of learning should reside increasingly with the learner (Glasersfield, 1988). This means that learners should be actively involved in te learning process rather than being passive learners.

- According to Von Glasersfield (1989), sustaining motivation to learn is strongly dependent on the learner's confidence in his or her potential for learning. By experiencing the successful completion of challenging tasks, learners gain confidence and motivation to embark on more complex challenges. This view links up with Vygotsky's "zone of proximal development where learners are challenged within close proximity to yet slightly above their current level of development (Vygotsky, 1978).

- The social constructivist sees the role of the science teacher as a facilitator rather than a teacher. According to Gamoran et. al. (1998), a teacher strives a didactic lecture that covers the subject matter while a facilitator helps the learner to get to his or her own understanding of the content. In teacher scenario, the learners are very passive in the learning process while in the facilitator scenario; the learners are actively involved in the learning process.

- The constructivist sees learning as a social process where the learners interact among themselves thereby making learning meaningful. Again, the constructivist believes that there is dynamic interaction between the learning task, the instructor, and the learner. The role of the facilitator is to encourage the dynamic interaction. The above implies that the instructor and the learners are equally involved in learning from each other (Holt and Willard Holt, 2000).

3.4 Constructivist Teaching Strategies

The constructivist's teaching strategies are as follows:

- that learning is best accomplished using a hands-on approach;

- that learners learn by experimentation and not by being told what will happen;

- that learners should be left to make their own discoveries, inferences and conclusions;

- that teachers should commence their teaching by building upon the previous knowledge that the learner process;

- that teachers role is not only to observe and assess but to also engage the students while they are completing activities;

- teachers also are to intervene when there are conflicts that arise in the course of their learning. They should facilitate the students' resolution and self-regulation, with an emphasis on the conflict.

On the basis of the above assertions by the constructivist, the following teaching strategies or approaches are recommended:

- inquiry-based learning;
- problem-based learning;
- hands-on teaching approach;
- collaborative or group work;
- cooperative learning.

3.5 Criticism of Constructivists Theory

Several cognitive psychologists and educators have argued that constructivist theories are misleading and that they contradict known findings. Matthews (1993) attempts to sketch the influence of constructivism in current mathematics and science education aiming to indicate how pervasive Aristotle's empiricist epistemology is within it and what problems construction faces on that account.

Demetriou et. al. (1992) argued that since the Piagetian theories of cognitive development has maintained that learning at any age depends upon the processing and representational resources available, therefore, if the requirement of the concept to be understood exceeds the available processing efficiency and working memory resources then, the concept of constructivism is by definition not learnable. This implies that no matter how a child is anxious to learn, he or she must operate in a learning environment that meets the developmental and individual learning constraints that are characteristics for the child's age. If this condition is not met, then construction goes astray.

Again, the effectiveness of constructivism towards instructional design has been questioned by several educators (Mayer, 2004; Kirschner Sweller and Clark, 2006). While some constructivists argue that learning by doing enhances learning, critics of this instructional strategy argue that little empirical evidence exist to support this statement. Mayer (2004) reviewed the literature and found that fifty years of empirical data do not support using the constructivist teaching technique of pure discovery; rather guided discovery method should be used in these situations requiring pure discovery.

It was also argued by Mayer that not all teaching techniques based on constructivism are efficient or effective for all learners. He describes that inappropriate use of constructivism as the "constructivist teaching fallacy" because it equates active learning with active teaching. Mayer then proposes that learners should be "cognitively active" during learning.

In another development, constructivist teaching methods has been regarded as an "unguided methods of instruction". This assertion was made by Kirschner, et. al. (2006). They suggest more structured learning activities for learners with little reference to prior knowledge.

4.0 CONCLUSION

On the whole, constructivist theorists have extended the traditional focus on individual learning to address collaborative and social cohesion of learning. It is possible to see social constructivism as bringing together of aspects of the work of Piaget with that of Bruner and

Vygotsky. All these scholars are proponents of active participation of learners in the learning process.

5.0 SUMMARY

In this unit, you have studied about the behaviourist theory of learning. You have also studied the constructivists' perception of the learner and the learning process. You have studied the teaching strategies or approaches recommended by the constructivist. Finally, you have seen some of the critics of constructivism.

In the next unit, you will study one of the teaching approaches of constructivism i.e. hands-on, minds-on and authentic learning strategies.

6.0 TUTOR MARKED ASSIGNMENT

1. Make a brief comparison between the constructivists and the behaviourists learning theories highlighting the major points of agreement or otherwise.

2. Describe how you will use two of the constructivists teaching strategies in teaching a topic in your area of specialisation.

3. Explain Mayer's (2004) argument against constructivism.

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UNIT 2 THE CONSTRUCTIVIST APPROACH TO SCIENCE TEACHING THROUGH HANDS-ON, MINDS-ON AND AUTHENTIC LEARNING EXPERIENCE

CONTENTS

1.0 INTRODUCTION

In the last unit, you studied the trends in research in science teaching from behaviourism to social constructivism.

In this unit, you will study the constructivist approach to science teaching through hands-on, minds-on and authentic learning experience.

2.0 OBJECTIVES

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

(i) describe the constructivist's approach to science teaching;
(ii) give brief explanation of hands-on, minds-on and authentic learning experience;
(iii) describe how you will use the strategy in teaching a topic in your area of specialisation;
(iv) state the advantages and challenges of the strategy.

3.0 MAIN CONTENT

3.1 Hands-on, Minds-on and Authentic Learning Experiences in Science

This is a teaching strategy that enables students to participate fully in the teaching and learning process such that the teacher is no longer the only source of knowledge and information. This type of learning strategy encourages full involvement in a community of learners that includes other students, parents, teachers and outside experts. The use of technology e.g. computer, laboratory practicals and other instructional materials are very useful for this strategy to succeed in teaching science. this is a constructivist's teaching and learning model.

Hands-on means that students are actually allowed to perform science as they construct meaning and acquire understanding.

Minds-on means that activities focus on core concepts, allowing students to develop thinking processes and encouraging them to ask questions and seek answers that enhance their knowledge and thereby acquire an understanding of the physical universe in which they live.

Authentic learning experiences means that students are presented with problem-solving activities that incorporate authentic real life questions and issues in a format that encourages collaborative effort, dialogue with informed expert sources, and generalization to broader ideas and application.

This strategy of teaching is built on the following beliefs and characteristics:

- that thinking skills, especially-higher-order skills, must be learned through practice;
- that a curriculum based on constructivist theory is well-suited to the teaching and learning of science;
- that learning assessment must be built into the process of instruction;
- that all students should have access to meaningful, engaged learning in science.

The above characteristics are the basis for a redefinition of traditional science programs. With the above elements in place, instruction will become hands-on, minds-on and authentic.

3.2 Advantages of the Strategy

The advantages of the strategy are as follows:

- It enable students to be actively engaged in constructing their own understanding of science, technology and the world in which they live in;
- It encourage students to systematically learn the process skills needed to participate in meaningful scientific investigation of natural phenomena;
- It enable the learners to gain an understanding of the knowledge and concepts that enable students to pursue the continued study of science;
- It encourage the teachers to use a variety of alternative assessment tools to allow students to demonstrate their understanding of science by solving authentic, real-life problems;

- This strategy will create an informed citizenry that will grow in its understanding of the principles of ecological balance in their environment.

3.3 The Challenges of the Strategy

Achieving a long-term, systemic science education reforms, especially with the use of hands-on, minds-on and authentic learning experience poses some challenges for the students, parents and community members, teachers, school administrators and policy makers.

3.3.1 Challenges to Students

- Take advantage of every opportunity presented to engage in the process of "doing" science;

- Develop the skills needed to seek information and solve problems;

- Keep an open and questioning mind and constantly seek new knowledge and understanding;

- Learn to work with others to share responsibility for acquiring new knowledge and understanding with peers and to value new experience as an opportunity to inquire and learn.

3.3.2 Challenges to Parents and Community Members

- Support teachers by establishing high expectations consistent with those required for successful learning. Demand high standards for learning and achievement for schools and students;

- Encourage and nurture the natural curiosity that children have about nature;

- Provide opportunities for learning in the home, allowing students to participate in activities that stimulate inquiry and investigation;

- Ensure that all expected "homework" or assignment is completed providing support and assistance as needed and appropriate;

- Create partnerships between schools and community facilitates that provide students with access to knowledge and experiences that extend and complement learning experiences in schools. These facilities may include museums, zoos, planetariums and botanical gardens to mention but few.

3.3.3 Challenges to Science teachers

- Commit to a professional development program that will enable you to change instructional strategies, adapting them to new methods for teaching. a thorough understanding of constructivist approaches to learning should be part of that program;

- Create more opportunities for students to engage in science learning that is authentic and patterned after the methods that scientists use;

- Understand the standards established for curriculum instruction, and assessment, and use them to provide effective learning opportunities for each student;

- Model attitudes that foster inquiry, acquisition of new knowledge and lifelong learning;

- Establish high achievement standards for all students and be certain that every effort is made to provide effective learning opportunities for each student;

- Seek ways to relate the learning of science to other disciplines and use technology to enhance and extend classroom experiences.

3.3.4 Challenges to Policy makers

- Create policies and laws that enable significant reform of the structure and organisation of schools. This may include length of school day and year, greater flexibility in accreditation, encouragement and support for innovation among other things;

- Exercise patience in pressing for reform;

- Provide funding for resources and training to implement reform;

- Do not impose mandates that amount to "tinkering" rather than reform.

3.4 Implications to Science Teaching

The constructivist learning strategy has the following implications for science teaching and learning:

- Science teachers must imbibe the innovation in science teaching by altering significantly the types of instruction that they have used in the past. Teachers must appreciate the fact that studying the content of science is not the same as learning science while knowledge of facts is important, facts must be learned within the context of authentic experience. Science teachers must rethink their traditional role as knowledge deliverer and accept a new responsibility as facilitator, coach and coordinator of experiences. For these to be visible, science teachers will need more planning and more instructional time than is usually allocated to make these changes a one feature of the constructivist.

- One feature of the constructivist learning strategy is that it gives the learner the opportunity to learn the principles and processes of science without being limited by traditional subject matter boundaries. There is the need for the policy makers regarding the accreditation of learning for promotion and admission to higher levels to advise their thinking away from the traditional subject practices. New criteria that will be in line with the new strategies of teaching should be set up. Such a change will help to establish the new model or else the traditional patterns of teaching science will prevail.

- Science teachers should expose the learners to several text materials to support science instruction. Again, varieties of instructional materials which should include modem technology should be used in the teaching and learning process.

- Publishers must encourage the preparation of materials that will foster inquiry, describe authentic problems and incorporate technology.

- Finally, administrators, parents, and community members must accept the new reform in science teaching as a better way of learning science. this is because the transformation of science education will require major commitments from all sectors of the greater school community.

4.0 CONCLUSION

It can be concluded that a new vision of science learning calls for instructional strategies that is far different from most traditional conceptualisations. This new paradigm for science learning emphasises engagement and meaning in ways that are not anticipated outcome of this new approach to teaching is a higher level of students' achievement in the sciences. This is the constructivist teaching and learning model.

5.0 SUMMARY

From the above discussion, you have studied the constructivist teaching and learning model which is hands-on, minds-on and authentic learning experience. You have also studied the advantages, the challenges and the implications of the new strategy on the teaching and learning of science.

In the next unit, you will study another constructivist learning strategy which is cooperative learning strategy.

6.0 TUTOR MARKED ASSIGNMENT

1. Differentiate between hands-on, minds-on and authentic learning strategy.

2. Enumerate the advantages that the constructivist learning model has over the traditional teaching methods.

3. State the implications of the constructivist learning strategy to science teaching and learning.

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UNIT 3 CONSTRUCTIVIST APPROACH TO SCIENCE TEACHING THROUGH COOPERATIVE LEARNING STRATEGY

CONTENTS

1.0 INTRODUCTION

In the last unit, you studied one at the modern strategies of teaching science which is hands-on, minds-on and authentic learning experience.

In this unit, you will study another constructivist approach to science teaching. This is cooperative learning strategy.

2.0 OBJECTIVES

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

(i) explain in simple terms what is cooperative learning strategy;
(ii) state the advantages and limitations of the strategy;
(iii) describe how you will use cooperative learning strategy to teach a chosen topic in your area of specialisation.

3.0 MAIN CONTENT

3.1 Definition of Cooperative Learning Strategy

It is a successful teaching strategy in which small groups each comprise of students with different levels of ability use a variety of learning activities to improve their understanding of a subject. Each member of a team is responsible, not only for learning what is taught, but also for helping teammates learn, thus creating an atmosphere of achievement. Students' work through the assignment until all the group members successfully understands and completes it.

Simply put, cooperative learning can be said to be an approach organising classroom activities into academic and social learning experiences whereby students' work in groups to complete a set of task collectively.

3.1.1 Types of Cooperative Learning

There are basically three major types of cooperative learning. These are formal, informal and group-based cooperative learning.

1. Formal Cooperative Learning

In this type of cooperative learning, the learning task is structured, facilitated and monitored by the teacher over a period of time. The learners are shared into groups of say 5 to 6 members. Each group is assigned a learning task with discussions lasting from a few months to a period. Examples of this type of learning may include Jigsaw, assignments that involve group problem solving and decision making, laboratory or experiment assignments and peer review work.

2. Informal Cooperative Learning

This type of learning may involve groups of two learners (e.g. turn to your partner discussions). The groups are often temporary and can change from lesson to lesson. Discussions in this type of learning have four components that include: formulating a response to questions asked by the teacher; sharing responses to the questions asked with a partner; listening to a partner's responses to the same question and creating a new well-developed answer. This category of cooperative learning enables the students to process, consolidate and retain more information learned.

3. Group-based Cooperative Learning

This category of cooperative learning involves peer groups that gather together over a long period (e.g. for a term, a year or several years) to develop and contribute to one another's knowledge mastery on a topic by regularly discussing the material, encouraging one another, and supporting the academic and personal success of group members. Group-based learning is effective for learning complex subject matter. It also establishes caring, supportive peer relationships which in turn motivates, and strengthens the student's commitments to the group's education while increasing self-esteem and self-worth. Group-based approaches make the students accountable to educating their peer group in the event that a member was absent for a lesson.

3.2 Advantages of Cooperative Learning

Research has shown that cooperative learning strategies has the following advantages:

- Promote meaningful learning among learners and enhances academic achievement;
- Increases students' retention;

- Enhances students' satisfaction with their learning experience;
- Help students develop skills in oral communication;
- Enhances social interaction and develop students' social skills;
- Promote students' self-esteem;
- Help to promote positive race relations;
- Enhances positive interdependence of groups since each group member's effort are required and are indispensable for group success.

3.3 Essential Elements of Cooperative Learning

Brown and Parker (2009) discuss the five basic elements of cooperative learning strategy.

1. There must be positive interdependence among the groups. This means that students must participate fully within their group. Again, each group members has a task or responsibility to play in the group hence must believe that they are responsible for their learning and that of their group.

2. There must be face-to-face promotive interaction among the groups. This means that members of the group must promote each other's success and assist one another with understanding and completion of assignments.

3. There must be individual accountability. Each student must demonstrate master of the content being studied and each student is accountable for their learning and work thereby eliminating social loafing.

4. Some social skills must be taught before embarking on cooperative learning strategy. For a successful cooperative learning to occur, social skills such as effective communication, interpersonal and group skills leadership, decision making, trust builders and conflict-management skills must be taught to the learners.

5. Groups must be encouraged to assess their effectiveness and decide how their performance can be improved.

3.4 Limitations of Cooperative Learning Strategy

- First and foremost, cooperative learning needs an effective and dedicated teacher who will act as a facilitator and guidance.

- According to Sharan (2010), the constant changing of cooperative learning strategy can make teachers who use it to become confused and lack complete understanding of the method.

- Teachers implementing cooperative learning may also be challenged with resistance and hostility from students who believe that they are being held back by their slower teammates or by students who are less-confident and feel that they are being ignored or demeaned by their team (Sharan, 2010).

3.5 Class activities that would promote Cooperative Learning Strategy

Kogan (1994) identified nine class activities that could promote the use of cooperative learning strategy. These are presented below:

1. **Jigsaw –** groups with five students are set up. Each group member is assigned some unique material to learn and then to teach to his group members. To help in the learning students across the class working on the same sub-section get together to decide what is important and how to teach it. After practice in these "expert" groups the original groups reform and students teach each other. Tests or assessment follows.

2. **Think-Pair-Share –** involves a three-step cooperative structure. During the first step, individuals think silently about a question posed by the instructor. Individuals pair up during the second step and exchange thoughts. In the third step, the pairs share their responses with other pairs, other teams, or the entire group.

3. **Three-Step Interview** – each member of a team chooses another member to be a partner. During the first step, individuals interview their partners by asking clarifying questions. During the second step partners reverse the roles. For the final step, members share their partner's response with the team.

4. **Round-robin Brainstorming –** class is divided into small groups (4 to 6) with one person appointed as the recorder. A question is posed with many answers and students are given time to think about answers. After the "think time", members of the team share responses with one another round robin style. The recorder writes down the answers of the group members. The person next to the recorder starts and each person in the group in that order gives an answer until time is called.

5. **Three-minute Review –** teachers stop any time during a lecture or discussion and give teams three minutes to review what has been said, ask clarifying questions or answer questions.

6. **Numbered Heads Together –** a team of four is established. Each member is given numbers of 1, 2, 3, 4. Questions are asked of the group. Groups work together to answer the question so that all can verbally answer the question. Teacher calls out a number (two) and each two is asked to give the answer.

7. **Team Pair Solo –** students do problems first as a team, then with a partner, and finally on their own. It is designed to motivate students to tackle and succeed at problems which initially are beyond their ability. It is based on a simple motion of mediated learning. Students can do more things with help (mediation) than they can do alone. By allowing them to work on problems they could not do alone, first as a team and then with a partner, they progress to a point they can do alone that which at first they could do only with help.

8. **Circle the Sage –** first the teacher polls the class to see which students have a special knowledge to share. For example, the teacher may ask who in the class was able to solve

a difficult mathematical homework question, who had visited Mexico, who knows the chemical reactions involved in how salting the streets help dissipate snow. Those students (the sages) stand and spread out in the room. The teacher then has the rest of the classmates each surround a sage, with no two members of the same team going to the same sage. The sage explains what they know while the classmates listen, ask questions, and take notes. All students then return to their teams. Each in turn, explains what they learned. Because each one has gone to a different sage, they compare notes. If there is disagreement, they stand up as a team. Finally, the disagreements are aired and resolved.

9. **Partners –** the class is divided into teams of four. Partners move to one side of the room. Half of each team is given an assignment to master to be able to teach the other half. Partners work to learn and can consult with other partners working on the same material. Teams go back together with each set of partners teaching the other set. Partners quiz and tutor teammates. Team reviews how well they learned and taught and how they might improve the process.

Self Assessment Exercise

Choose anyone of the above activity and describe how you will use it to teach a chosen topic from your area of specialisation.

4.0 CONCLUSION

In order for students' achievement to improve considerably using cooperative learning strategy, individual responsibility and accountability must be first be identified. Individuals must know exactly what these responsibilities are and that they are accountable to the group in order to reach their goal. Finally, all group members must be involved in order for the group to complete the task. For this to occur, each member must have a task that they are responsible for which they cannot be completed by any other group member.

5.0 SUMMARY

In this unit, you have studied the meaning of cooperative learning strategy. You have also studied the types of cooperative learning strategy, its essential elements, activities that could promote the strategy and the advantages as well as limitations of the strategy.

6.0 TUTOR MARKED ASSIGNMENT

1. What do you understand by the term 'cooperative learning strategy'?

2. Explain the major types of cooperative learning strategy and state their characteristics.

3. What are the advantages and limitations of cooperative learning strategy?

4. Describe any five activities that can promote cooperative learning strategy.

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UNIT 4 CONCEPT MAPPING

CONTENTS

1.0 INTRODUCTION

A primary goal of science education is to engage students in an active process of identifying and constructing meaningful learning of science concepts. Concept mapping has been identified as a useful teaching and learning strategy that can lead to meaningful learning of concepts and enhance performance in science. In this unit, you will study about concept learning as an effective teaching strategy in science education.

2.0 OBJECTIVES

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

- Define the term concept mapping;
- List the steps to be followed when constructing concept map;
- Attempt to construct a concept map using a topic from your area of specialisation.

3.0 MAIN CONTENT

3.1 Definition of Concept Mapping

Simply put, concept mapping is a graphical arrangement of the key concepts in a body of subject matter with connecting lines, labelled to show valid and meaningful relationship between the chosen concepts. According to Donovan (1991), concept mapping is a technique based on David

Ausubel's theory of meaningful learning which involves the organisations of concepts into a hierarchical arrangement.

In another development, Brodie (1991) describes concept maps as diagrams which include concepts and linking words. According to hi, the concepts that are included in the area that is being mapped are organised in such a way that the perceived relationships between them are made explicit. Also, the concepts are linked together into propositions and are arranged such that the most general concepts are at the top of the map and the least general at the bottom.

Concept map is said to be a taxonomy because it contains concepts that are arranged in a hierarchical form from the top of the map to the bottom. Concept map is similar to a flow chart in that there are connections between the different parts of the map.

Self Assessment Exercise

Give your own definition of concept mapping.

3.2 Concept Mapping and Meaningful Learning

The genesis of concept mapping is based on David Ausubel's theory of meaningful learning (Moyone and Dekkers, 1984). According to this theory, meaningful learning occurs when there is interaction between students' appropriate elements in the knowledge that already exists and the new materials to be learned. Those parts of the learners' cognitive structure (i.e. the organisation of knowledge) which can provide for the interaction necessary for meaningful learning are called "subsumers" and when such an interaction does not take place, rote learning occur. Ausubel defines subsumers as a principle or a generalised knowledge already acquired by learners that can provide for association or anchorage for the various components of the new knowledge.

The key idea of Ausubel's theory of cognitive learning upon which concept mapping is based is the nature of meaningful learning as contrasted with rote learning. Ausubel's definition of meaningful learning embraces non-verbatim and non-arbitrary substance, incorporation of new knowledge into a person's cognitive structure. On the other hand, rote learning is the arbitrary, non-substantive incorporation of new knowledge into a person's cognitive structure.

Thus, working from the Ausubel's theory, Novak et. al. (1983) have developed a strategy called "concept mapping" that can be used to illustrate progressive differentiation of new proposition. Novak et. al. (1983) posit that to achieve meaningful learning, the following conditions must be met:

(a) the new material must be inherently meaningful;
(b) the learner must be able to link new knowledge with the existing relevant knowledge;
(c) the learner must possess relevant concepts that can be related to the new concept.

Self Assessment Exercise

Why is concept mapping regarded as a flowchart and as a taxonomy?

3.3 Types of Concept Maps

Adamazyk et. al. (1994) have identified five basic structural types of concept maps which have been effectively used in the classroom. These are listed as follows:

(i) Free range map;
(ii) Object only map
(iii) Link only map
(iv) Propositional map
(v) Picture map.

A brief description of each of the maps is hereby made below:

3.3.1 The 'Free Range' Map

Here, the teacher provides a list of key words known as "prime descriptors". The students are then asked to form the links using arrows. One advantage of this type of map is that it enables the more intelligent learners to form complete links and develop sophisticated concepts by themselves. However, the disadvantage is that a detailed analysis can take a relatively long time and may not yield all the information needed for summative purpose.

3.3.2 The 'Object Only' Map

In this type of map, a predetermined structure is given to learners with the prime descriptors (key words) and linking lines already in place, although the direction of the link is omitted. The learners are then expected to write in the propositions along with the appropriate directional arrows. The concepts are already predetermined by the teacher.

The advantage of this type of map is that it is easily and quickly analysed, yielding summative information about learners' level of knowledge and understanding. The main disadvantage is that it can limit the attainment level for the more able student and it does not cater for the needs of the less able students.

3.3.3 The 'Link Only' Map

In this type of map, the students are given a pre-structured map as in the object only map, but with prime descriptors in their predetermined position. The main purpose is to demonstrate the organisation of their knowledge base.

The main advantage of this type of map is that it will enable the students to demonstrate the understanding of the concept by linking the prime descriptors to the next one.

3.3.4 The Propositional Map

In this type of concept map, both the prime descriptors and the propositions are provided for the learners on a separate sheet. The learners are then asked to choose the concepts. Another way of using this type of map is to provide the description and propositions on small pieces of card, cut into different shapes. These shapes are also being drawn on to a sheet of paper in the requirement positions for the completed map, but without the directional arrows. Learners are then expected to match the shapes and draw in the linking arrows thereby contributing to the organisation of their knowledge base.

3.3.5 The Picture Map

Here, the learners are expected to work in groups. They are expected to link pictures representing the prime descriptors either verbally or by various written and pictorial methods. This type of map is very useful with elementary pupils. However, it should be used sparingly, and with great deal of fore thought. This is because the development of language is a fundamental and intrinsic aspect of the development of concepts.

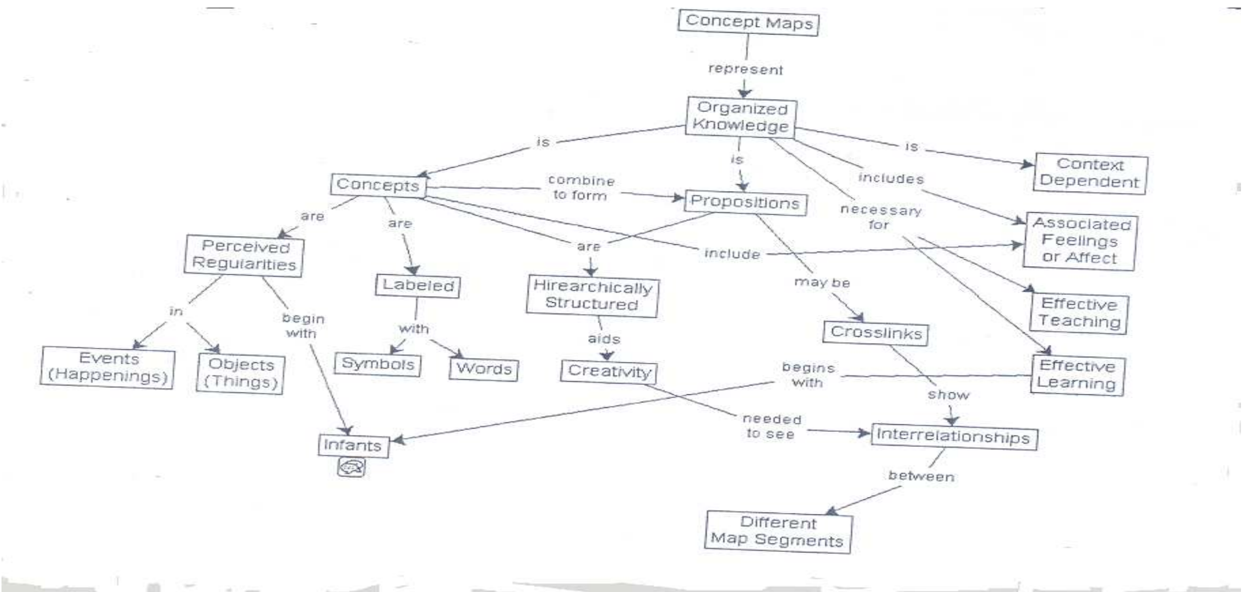
Self Assessment Exercise

Choose one type of concept map and demonstrate how you will use it to teach a concept in your area of specialisation.

3.4 Guidelines for Constructing Concept Maps

Novak (1990) suggested the steps involved in constructing a concept map as follows:

- Identify important concepts in a given area of this study;
- Rank concepts from the most general to the most specific (i.e. making propositions);
- Arrange concepts on pieces of paper and define the connections between related concepts or plotting concepts and their interrelationships in a meaningful organisational network.



Example of Concept Map

3.4.1 Guidelines for Implementing Concept Map

Adamczyk et. al. (1994) have elucidated the following points to be strongly followed when teachers are using concept mapping as a strategy of teaching:

- students should be allowed to practice construction of concept maps before it can be used for meaningful assessment purpose;
- teacher should begin with a simple topic using a small number of prime descriptors;
- teacher should work through examples with the whole class or in small groups;
- the importance of thinking about all possible links, and writing down the nature of the link should be emphasised;
- students should be made to realise that there is no single correct answer and that there is often more than one appropriate link;
- the use of arrows and their direction is virtually important in describing the proposition and so building the concept;
- concept maps are the result of both the conceptual understanding the learner, and their previous experience, both inside and outside the learning environment.

Therefore, analysis of maps should take this into account to a greater degree depending on the use of information which the map is designed to elicit.

Self Assessment Exercise

State the guidelines for implementing concept maps.

3.5 Usefulness of Concept Mapping Strategy

Below are some of the advantages of concept mapping strategy:

- According to Brodie (1991), concept mapping is an activity that can be used to make lessons more relevant to pupils by making explicit the connections that the author of a scheme perceives to exist between the concepts covered in a series of lessons;

- Concept mapping can be used by learners as a study skill to improve the layout of notes and to make revision more active (Okebukola, 1992);

- Concept mapping has also been seen as a process that allows the map's author to organise concepts in a hierarchical way from the most inclusive at the top of the map to the most specific at the bottom, and further, to make explicit their understanding of the connections that exist between these concepts;
- When learners are revising on their own, they can use concept mapping technique to make the task less boring by summarising the whole topic on one page thus enabling them to identify the bits that they do not understand;

- Concept map can be used to link together different subject areas, thereby encouraging some rationalisation of subject content;

- Concept maps have also been found to be an efficient way for the teacher to highlight the progression and differentiation of the contents that exist in a scheme (Novak, 1990);

- Lastly, concept mapping discourages learners from including irrelevance in their books as it is easy to use and simple to administer.

Self Assessment Exercise

State the usefulness of using concept mapping strategy in teaching science.

4.0 CONCLUSION

In the light of the above, it can be seen that concept mapping strategy enhances meaningful learning in students and it can be used as a tool for the collaborative constitution of knowledge.

5.0 SUMMARY

In this unit, you have studied almost everything about concept mapping strategy beginning from the definition of concept mapping, meaningful learning and concept mapping, types of concept maps, guidelines for constructing concept maps and usefulness of concept mapping strategy. In the next unit, you will learn about vee-diagram which is another strategy of teaching science.

6.0 TUTOR MARKED ASSIGNMENT

1. Elucidate the relationship between concept mapping strategy and meaningful learning.
2. With the aid of specific examples, state the usefulness of concept mapping strategy.
3. What are the guidelines to be observed when constructing concept maps?

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UNIT 5 VEE DIAGRAM

CONTENTS

1.0 INTRODUCTION

In the last unit, you have studied how concept mapping strategy can enhance meaningful learning in science classrooms. In this unit, you will study another type of strategy that can be used by science teachers to enhance meaningful learning. This strategy is vee diagram. Vee diagram and concept mapping are the two meta-cognitive strategies that allow the learner to organise his or her cognitive structures into more integrated pattern.

2.0 OBJECTIVES

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

- Define what is vee diagram;
- Describe the nature of vee diagram;
- Attempt to plot a vee diagram;
- State the implications of using vee diagram to science teaching.

3.0 MAIN CONTENT

3.1 What is Vee Diagram?

Vee diagram which is also known as vee-map is so named because the learning tool is in the form of "V". The vee diagram begins by focusing students' attention on what they know before the inquiry in the laboratory. Students then generate research questions, design and conduct experiment and interpret the data. Through interpretation, they arrive at new knowledge that must be integrated with their prior knowledge.

It should be noted that vee diagram and concept mapping are similar in terms of ideas, but they are not the same in terms of structure. According to Novak and Gowin (1984), misconceptions are really seen in concept maps with linkages between two concepts that is false or by a linkage that fails to address the main idea relating to the two or more concepts. However, in vee diagram, students' misconceptions are represented as invalid or incomplete concepts or methodological relationships or as conceptual relationships that are incongruent without the methodological relationships described in slot vee.

Since vee diagram is a concise representation of the concepts and relationships in a learners' knowledge set, it allows instructors to quickly recognise invalid, incomplete or incongruent knowledge claims which would suggest a need or remediation and thus became an efficient and effective form of communication between the learner and the instructor ((Wandersee, Mintzes and Novak, 1994).

3.2 Nature of Vee Diagram

The vee diagram strategy usually has two sides. The first side consists of the conceptual or knowing one while the second consists of a methodological or doing side. Both sides are in continuous interplay and that is what gives the V shape. What we know at any moment determines the question we ask, the way we find answers to our questions and the way we interpret our data. On the other hand, what we do determines what we will know and thus changes what we know before the experiment. A vee diagram is like a roadmap showing a route from prior knowledge to new and future knowledge.

For example, consider a child who has never seen an aeroplane and another child who has not only seen several aeroplanes, but has even boarded some. It is unlikely that the child who has never seen an aeroplane would ask predates questions concerning an aeroplane. Conversely, the other child that is familiar with aeroplane would be able to design complex inquiries based on her experience when activities about aeroplane is given to her. In this scenario, activities about aeroplane will change the understanding of both children whether drastically or subtly. The vee diagram guides students in their quest for new knowledge and helps them to interpret what they discover.

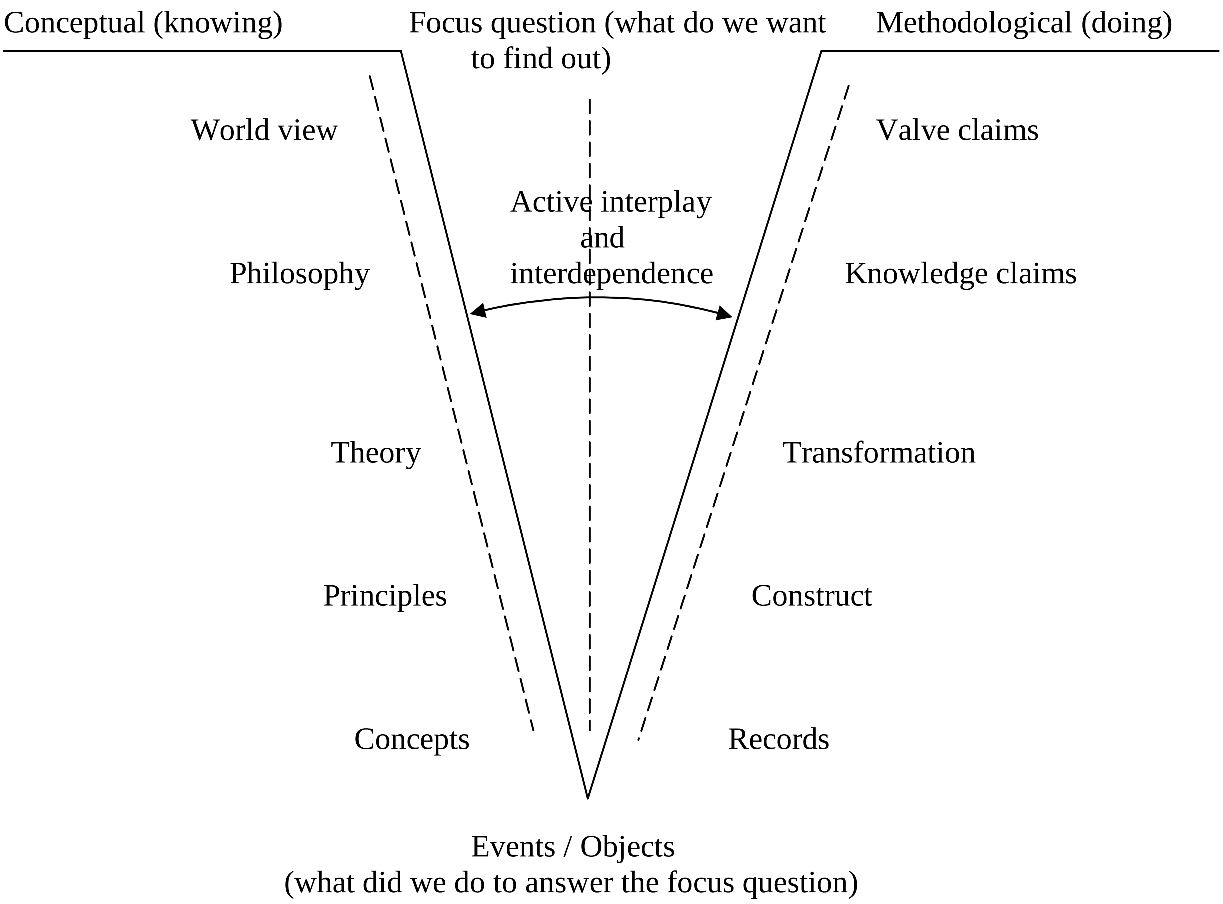
Self Assessment Exercise

Vee diagram is the same with concept map in terms of ideas but different in terms of structures. Discuss this statement.

3.3 How to Plot Vee Diagram

As earlier mentioned vee diagram is made up of two sides, the conceptual or knowing side and the methodological or doing side. Below is a hypothetical structure of vee diagram.

Figure 1: **Vee Diagram depicting the working relationship between conceptual and methodological bases**



From the above figure, it can be seen that the knowing and the doing sides of the map are separated by the focus question and by events which form the links between old and new knowledge. Focus question may be generated by individuals or group of students during a class discussion or in the course of the lesson. Students then frame a focus question and decide how they want to observe or measure the phenomena or interest based on the question. By choosing the question on their own, the students take ownership of the position and feel a responsibility for its outcome. Students may then ask themselves questions such as:

- What do we want to find out about the topic?
- What do we currently know about the topic?
- What do we do to find answers to our position?
- What did we observe and measure?
- What do our observations mean?
- How are our ideas about a topic related?

At this point, student should consider prior knowledge of the subject. The vee diagram provides a space for them to list associated words and phrases that they know before beginning the inquiry. At the bottom of the map are the objects and events. After describing the objects and events of their inquiry and listing the associated words, students can proceed to collect data. These data fit on the vee diagram as transformations. Transformations are sets of information presented in an orderly fashion, such as a table or a graph. Once students have completed their data collection, then they can be asked to reflect on the meaning of their observations and data. They could then ask questions such as: “What can we make of this experiment?” On the vee diagram, students can describe their thought under the heading “claims” which could be knowledge claim or valve claim.

In the final step of vee diagram strategy, students could create a concept map that integrates both prior and new knowledge. They could ask themselves questions such as “Do we have a central idea”?; “How do all the words and ideas relate?” and “What else can we do?” In this way, students must reflect on what they have learned through inquiry.

3.4 Implications of using Vee Diagram

- Vee diagram as a meta-knowledge strategy helps the students to understand that concepts are constructed from perceived regularities in objects or events that we can use language or symbolic labels to designate.

- When successful meta-knowledge strategies lead to understanding how humans construct knowledge and after practice in the process of constructing knowledge claims and valve claims about some observed regularities in objects and events. Thus, a science student comes to understand how a laboratory experiment illustrates the ways in which scientists have constructed knowledge claims about the observed events or objects.

- Vee diagram as a tool for meta-cognitive structure will help the teacher to think about what they will want their students to do with various classroom activities and how they want them to express the solutions.

- The vee diagram strategy helps students’ better understanding of the nature and purpose of laboratory activities. Thus, it helps students to understand how new knowledge is attained in an experimental situation.

- At a glance of vee diagram, a student can identify why she did what she did, how she did it, what she concluded, and how her prior knowledge has enhanced the understanding of the new knowledge.

- According to Novak and Gowin (1984), vee diagram is a meta-cognitive strategy for learning and assessment, which have been developed in accordance with the constructivist philosophy to enable active student to learn.

- Learners who use meta-cognitive strategies seem to learn in a meaningful fashion because they examine the conceptual and hierarchical nature of the knowledge with which they are working. Vee diagram is one of such meta-cognitive tool.

4.0 CONCLUSION

From the above discussion, it can be concluded that the physical construction of vee diagram has been shown to facilitate learning by enabling students from elementary levels through college to actively seek and develop conceptual relationship. By so doing, it helps the students to move from rote learner to meaningful learner mentally. It is hereby recommended that vee diagram strategy should be used by science teachers.

5.0 SUMMARY

In this unit, you have studied the meaning and nature of vee diagram as a meta-cognitive strategy of teaching. You have also learnt how to plot vee diagram and the importance of using vee diagram in science teaching.

6.0 TUTOR MARKED ASSIGNMENT

1. State the similarities between concepts mapping and vee diagram.

2. Describe how you will employ vee diagram in teaching a concept in your area of specialisation.

3. What are the implications of using vee diagram to a science teacher?

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UNIT 6 ESSENTIAL TEACHING SKILLS IN SCIENCE CLASSROOM

CONTENTS

1.0 INTRODUCTION

When the teacher has concluded his lesson plan, made a choice of the method to be used in his/her teaching and provided all the instructional materials, he/she still needs certain skills which will make his/her lesson interesting and effective.

In this unit, you will learn about some of the essential skills that will make a science teacher more effective in the classroom.

2.0 OBJECTIVES

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

- State and explain some of the ways by which science teachers can achieve effective science teaching;
- Enumerate, with the aid of specific examples, some teaching skills that science teachers must acquire to be successful in science classroom;
- Explain some of the challenges for effective science teaching.

3.0 MAIN CONTENT

3.1 Ways of Achieving Effective Science Teaching

The following ways are suggested to science teachers in order to achieve effective science teaching:

- creating the right classroom climate;
- planning the classroom;
- developing routines and procedures;
- assigning and managing work and assignments;
- preparing for instruction;
- managing behaviour.

3.1.1 Creating the Right Classroom Climate

Science teachers should attempt to create the right classroom climate that will ensure that the students feel safe, secure and lively during science activities. Teachers should be democratic and friendly. According to Jacobson et. al. (1993), learning decreases when teachers are autocratic and harsh with their students.

3.1.2 Planning the Classroom

The classroom plan will help to foster students' involvement and cooperation in science activities. It will also create a productive working environment for the students. Science teachers should make science rooms and laboratories stimulating and inviting.

Students should also be made part of the decision making process on how to make classroom learner-friendly. Again, teachers should arrange the classroom in such a way that students can move freely, and carryout science activities without obstruction.

3.1.3 Developing Routines and Procedures

Science teachers should create rules and regulations that are clear, specific and stated in positive manner.

Again, science students should be involved in the process of developing and maintaining the routines, procedures and rules.

3.1.4 Assigning and Managing Work and Assignments

Teachers should assign activities to students in form of group work, class activities or homework. These assignments must be relevant to the topic being taught or the topic to be taught. This will enable students to carryout some additional reading or research outside the classroom.

3.1.5 Preparing for Instruction

Science teachers should make adequate preparation before they go to the classroom to teach. They should always carryout experiments and get the result before they enter the classroom. This will make students to have confidence in the teacher.

3.1.6 Managing Behaviour

In a science classroom, students will put up diverse behaviours. Some will be positive while others will be negative. Science teachers should be able to manage behaviours of students. They should acknowledge the individual differences in the students. They should study their students and take notice of the differences in their behaviours. This will enable them to know why a child behaves the way he does in the classroom.

3.2 Essential Teaching Skills in Science Classroom

Essential teaching skills involve the following:

- adequate planning by the teacher;
- teacher behaviour and students achievement;
- other basic skills.

3.2.1 Adequate Planning by the Teacher

Planning is very important for beginning and practicing teachers. This is because it helps to simplify the complex task of teaching. Planning takes into account the classroom environment, social forces and students' cultural and intellectual backgrounds, their expectations and beliefs, as well as content, goals and learning activities. Planning fulfills three primary functions. These are emotional security, organisation and reflection.

Pre-requisite for effective planning requires, among others, three kinds of teacher knowledge:

- knowledge of content;
- pedagogical content knowledge;
- knowledge of learners and learning.

Knowledge of Content

A good knowledge of what a teacher wants to teach is a requirement for good teaching. this implies that science teacher must teach what he is knowledgeable about. A teacher that attempts to teach disciplines that he is not knowledgeable about will become an object of ridicule before his students. Science teachers must therefore study very well what they want to teach so that they can plan their lessons very well.

Pedagogical Content Knowledge

In addition to having content knowledge, teachers must also have knowledge of ways to represent topics for learners. The role of a good pedagogy of teaching in the understanding of concepts in science cannot be overemphasised. A good science teacher should be able to adopt an appropriate method of teaching perceived difficult concepts in science such that the pupils will find it very easy. For instance, a teacher who wants to teach heat and expansion knows very well that if his teaching method is not good enough, i.e. limited to only explaining and lecturing, the students will end up in rote learning. But if he uses methods that will actively involve students in the process of learning, meaningful learning will be enhanced.

Knowledge of Learners and Learning

An effective science teacher must understand learning and the factors that affects it. He must also know the learners in terms of their developmental stages, their psychology and how they can be motivated. He must also understand the social nature of the learners. Thus, planning must be student-centred. It must however be noted that student-centred planning sometimes affect the objectives of the school curriculum.

Self Assessment Exercise

Explain why a science teacher must have adequate knowledge of what he wants to teach.

3.3 Teacher Behaviour and Students Achievement

Dunkie and Biddie (1976) have established a relationship between the personality of science students and academic achievement of students. It has been discovered that the personality traits of teachers such as sense of humour, sensitivity to students' problems and other personality traits of teachers affects students' academic achievement.

3.4 Other Basic Skills

There are other basic skills that science teachers must develop in order for him to be effective. Some of these skills include: attitudes, use of time, organisation, communication, focus, feedback, monitoring and questioning to mention but a few.

Attitude:

Attitude is not a skill but a way of thinking or behaviour. It is an essential ingredient of an effective science teacher. A teacher with positive attitudes towards his students is likely to have effective teaching. Teachers that are highly effective enhance students' academic performance. In other words, teachers that use praise rather than criticism, persevere with low achievers, use their time effectively, are often regarded as high efficacy teachers. Conversely, teachers that often criticize answers given by students, spend less time on learning activities, "give up" on low achievers and nags on students and are often regarded as low efficacy teachers.

High efficacy teachers tend to be more flexible, adopting new curriculum, materials and changing strategies more readily than low efficacy teachers.

Use of Time

Classroom time is divided into four levels as follows:

Levels	Description
• Allocated time	This is the amount of time a teacher or school designates for a content area or topic.
• Instructional time	This is the amount of time left for teaching after routine management and administrative tasks are completed.
• Engaged time	This is the amount of time students are actively involved in teaching activities whether they understand it or not.
• Academic time	This is the amount of time students are actively involved in learning activities during which they are successful.

An effective science teacher organises time to be as close to the allocated time as possible. This will enable him use time effectively by giving the highest time to instruction.

Communication

Communication is the art of sharing or exchanging information. An effective teacher should be able to communicate very well with his students. His voice must be clear and audible such that everybody in the class will hear him/her. There is a strong link between effective communication and students' achievement.

There are four aspects of effective communication according to Smith and Cotton (1980). These are:

- Precise terminology;
- Connected discourse
- Transitional signals;
- Emphasis.

Precise Terminology: This means that teachers' words should be clear, precise, unambiguous and specific. For instance, vague words (e.g. perhaps, may be, might etc.) must be avoided during presentation of lessons. When vague terms are used, students are left with a sense of uncertainty and this can distract learning (Smith and Cotton, 1980).

Connected Discourse: Effective teachers keep their lessons on tract and spend less time on matters unrelated to the topic.

Transition Signals: These are forms of verbal communications that reminds students that one idea is ending and another is beginning. There should be a linkage or transition between the current topic and the next topic. For example, "we have been talking about digestion, now we are going to look at how digestive enzymes work. The above statement is signalling a transition.

Emphasis: This means signalling or emphasizing an important idea. This aspect of communication alerts students to important information in a lesson and its communicated through verbal and vocal cues ad reputation. Science teachers should endeavour to emphasise important information in a lesson.

Focus

Lesson focus is that which holds students' attention throughout the learning activity. It is what makes other components to work. Introductory focus attracts students' attention and provides framework for the lesson. It attracts attention, enhances maturation by arousing curiosity and making content attractive.

For instance, a mathematics teacher wanting to teach fraction introduces the lesson by showing students "cakes" and saying 'I've got a problem' and "How much cake have I eaten?" The cakes and the problem of the teacher attracted student's attention and provided a context for the rest of the lesson.

The cake also acted as a form of sensory focus, which is the use of stimuli, concrete objects, pictures, models, materials displayed on the overhead and even information written on the chalkboard to maintain attention. The cake provided a mental model, to help them conceptualise an abstract idea. Sensory focus serves as a continual reminder of the lesson's topic and direction.

Self Assessment Exercise

(i) Focus relates most closely to which level of classroom time discussed earlier.
(ii) Identify one important difference between introductory and sensory focus.

Feedback:

Feedback is information about the accuracy or appropriateness of a response. Effective feedback is immediate and specific, it provides corrective information for the learner, and it has a positive emotion tone, it also increases motivation to learn. Corrective feedback gives learners information they can use to check the accuracy of their background knowledge of a science concept. It helps students determine whether their constructions or interpretations of science content make sense.

Self Assessment Exercise

Read from the library, the social cognitive theory, and explain the importance of feedback in accordance with this theory?

Teachers must learn to give proper feedback on students' work (Tests, assignments etc.) as this will help them to improve in their work. To solve the problem of feedback, teachers can write an ideal answer and share it with the students.

Monitoring:

Monitoring involves checking students' verbal and non-verbal behaviour for evidence of learning progress. When teachers monitor their students, they get information about the progress of the lesson, and especially when students work independently, as there is more chance of confusion and errors. Monitoring can be done by the teacher working up and down the aisle correcting the students.

Monitoring also includes being aware of inattention, and different students' reactions during learning activities. Alert teachers notice inattentive students and walk over to them or call on them back into the lesson.

Monitoring and responding to students can simultaneously contribute to a climate of support and demonstrate high expectation for students' achievement.

The positive effects of other factors that have been discussed are strengthened when the teacher is constantly aware of and sensitive to student behaviour.

Questioning:

Teachers' questioning is one of the most powerful tools available for guiding and stimulating students' construction and elaborations of knowledge. Skillful questions can stimulate thought, help students form relationships, promote success, involve shy or reticent students, recapture students' attention, and enhance self-esteem.

Becoming skilled in questioning takes practice and hardwork. To avoid overloading their own working memories, teachers need to practice questioning skills to the point that they are nearly automatic, thus working-memory space is left available to monitor student behaviour and to assess lesson progress. Although difficult, research has shown that teachers can be expert at questioning (Kerman, 1979, Rowa, 1986).

There are four characteristics of effective questioning, as shown in the table below. An effective teacher will develop his/her lesson with questions, asking many questions during the lesson.

Characteristic of Effective Questioning

Characteristic	Description
Frequency	The number of questions teachers ask
Equitable distribution	A pattern in which all students in the class are called on as equally as possible.
Prompting	A teacher question or cue that elicits a response after a student has failed or has giving an incorrect or incomplete answer.
Wait-time	The period of silence before or after a student response.

For equitable distribution, the teacher calls any student, addressing each student by name and still focus on the goal of his/her lesson. When the student fails to answer, do not give up, but prompt them i.e. help students respond by providing cues/asking leading questions. Lastly, students' learning is enhanced when they are given wait-time, which is a period of silence before or after a student is asked a question. It increases learning by giving students time to think. In most sciences classrooms, regardless of grade or ability levels, wait-time are short, often less than one second (Rowe, 1986). Increasing wait-time to 3 – 5 seconds increases science learning in three ways:

1. The length and quality of students' response improve;
2. Failures to respond are reduced, and voluntary participation increases;
3. Equitable distribution and participation from minority students improve (Rowe, 1986; Toben, 1987).

Cognitive Levels – questions can be asked at low (recall) or high (cognitive) levels (those that require considerable student thought). Research work on the cognitive levels of teacher questions have shown both low-level, such as knowledge on the Bloom taxonomy and high-level questions such as application and synthesis, correlate positively with achievement, depending on the teaching situation.

This seemingly contradictory result refers us to goals. If the goal is learning some basic skills, then recall (low-level) questions will be most effective/appropriate, and if the goal is for student to analyse factors leading to how offspring's resemble their parents, then high level cognitive questions will be most effective. So, in asking questions, the teachers' first concern should be what they are trying to accomplish their goals and not the level of questions they choose to ask. When goals are clear, correct questions will follow.

Review and Closure:

Review summarises previous work and links students to what is coming. It occurs at the beginning of a lesson, but it can take place at any point in time during a lesson, though common at the beginning and end of a lesson. Effective reviews emphasise important points and encourage elaboration. Effective reviews involve more than simple rehearsal, they shift the learner's attention away from verbatim details to the deeper conceptual structure of the material being outlined (Dempster, 1991).

Closure – This is a form of review that occurs at the end of a lesson. Here, topics are summarised, structured and integrated. Closure pulls together and signals the end of a lesson.

An effective way of closure when science concepts, principles or generalizations are taught is to ask the students to state the definition of the concept or state the principle or generalization in their own words. This action leaves them with the essence of the topic from which they can elaborate in the next lesson.

3.5 Challenges for Effective Science Teaching

Achieving long-term effective science teaching entails some challenges. These challenges are on the part of students, parents and community members, teachers, school administrators and policy makers.

Challenges for Students

Challenges for students entail that they should:

- Take advantage of every opportunity presented to engaged in the process of "doing" science;

- Develop the skills needed to seek information and solve problems;

- Keep an open and questions mind, and constantly seek new knowledge and understanding;

- Learn to work with others, to share responsibility for acquiring new knowledge and understanding with peers, and to value new experience as an opportunity to inquire and learn

Parents and Community Members

- Support teachers by establishing high expectations consistent with those required for successful learning. Demand high standards for learning and achievement for schools and students;

- Encourage and nurture the natural curiosity that children have about nature;

- Provide opportunities for learning in the home, allowing students to participate in activities that stimulate inquiry and investigation;

- Ensure that all expected "homework" is completed, providing support and assistance as needed and appropriate;

- Create partnerships between schools and community facilities and resources that provide students with access to knowledge and experiences that extend and complement learning experiences in schools (e.g. museums, zoos, natural life preserves, science centres, aquariums, planetariums, botanical gardens.

Teachers:

- Commit to a professional development programme that will enable you to change instructional strategies, adapting them to new methods for teaching. a thorough understanding of constructivist approaches to learning should be part of that programme;

- Create more opportunities for students to engage in science learning that is authentic and patterned after methods that scientists use.

- Understand the standards established for curriculum, instruction and assessment and use them as guidelines for making instructional decisions;

- Establish high achievement standards for all students and be certain that every effort is made to provide effective learning opportunities for each student;

- Model attitudes that foster inquiry, acquisition of new knowledge, and lifelong learning;

- Seek ways to relate the learning of science to other disciplines and use technology to enhance and extend classroom experiences.

School Administrators:

- Become informed about the change process that will be needed to create a science classroom that provides active, hands-on, minds-on, authentic learning for students;

- Help restructure time and facilities, the acquisition of resources, and the professional development of teachers;

- Establish supervision systems that expect and support teacher performance that is consistent with the principles of active, engaged learning for all students in every science classroom.

Policy Makers:

- Create policies and laws that enable significant reform of the structure and organisation of schools (e.g., length of school day and year, greater flexibility in accreditation, encouragement and support for innovation);

- Exercise patience in pressing for reform;

- Provide funding for resources and training to implement reform;

- Do not improve mandates that amount to "tinkering" rather than reform.

4.0 CONCLUSION

From the above discussion, it can be concluded that modern science teaching involves student-teacher interaction. For a teacher to be successful in science teaching, he/she must develop certain teaching skills. These skills will serve as "spices" to his teaching and it will bring about meaningful learning among students.

5.0 SUMMARY

In this unit, you have studied some ways of achieving effective science teaching in science classroom. You have also seen some suggested teaching skills that science teacher needs to imbibe in order for him to be successful in his teaching. you have equally learnt some of the challenges and implications of essential teaching skills as it affects the students, parents, science teachers, school administrators and policy makers. It is hoped that you will become a better science teacher after having gone through this course.

6.0 TUTOR-MARKED ASSIGNMENT

1. What are the ways by which science teachers can become more effective in the science classroom?

2. As an experienced science teacher, explain some teaching skills that will make your lesson more interesting to your students.

3. State the challenges of effective science teaching to parents, school administrators and policy makers.

7.0 REFERENCES/FURTHER READINGS

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