NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF EDUCATION

COURSE CODE: EDU 240

COURSE TITLE: SUBJECT METHODS (INTEGRATED SCIENCE)

MAIN COURSE

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COURSE GUIDE

EDU 240
SUBJECT METHODS (INTEGRATED SCIENCE)

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INTRODUCTION

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

WHAT YOU WILL LEARN IN THIS COURSE

This course is to bring to consciousness of those to be involved in Integrated Science teaching at junior secondary level. So the overall aim of EDU 240 (Subject Methods II) Integrated Science is to introduce you to some of the rudiments of integrated science teaching. You will as well learn about the meaning of integrated science, philosophy and objectives of integrated science, justification for teaching integrated science and the nature of science; science education curriculum reforms at both primary and secondary school levels and psychological theories of learning and its implications for science teaching.

COURSE AIMS

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

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

COURSE OBJECTIVES

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

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

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

- explain the meaning of integrated science
- discuss the concept of integration
- compare the characteristics of integrated science and non-integrated science
- trace the historical development of integrated science in Nigeria
- give reasons why integrated science should be taught in schools
- explain the nature of science
- advance reasons for science education curriculum reforms in Nigeria
- discuss the contributions of some cognitive psychologists such as Ausubel, Brunner, Gagne and Piaget to science teaching and their implication for science teaching
- outline the methods of teaching integrated science
- describe the various resources for teaching integrated science
- prepare a scheme of work, lesson plan and lesson note for teaching integrated science in junior secondary classes
- describe the design and organisation of science laboratory
- outline the safety and management procedure in science laboratory
- develop test items for multiple choice and essay in integrated science.

WORKING THROUGH THE COURSE

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

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

THE COURSE MATERIALS

Major components of the course are:

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

STUDY UNITS

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

Module 1 The Meaning Of Science, Historical Development Of Integrated Science

Unit 1 The meaning of Integrated science
Unit 2 Historical development of Integrated
Unit 3 Philosophy and objectives of Integrated Science
Unit 4 Justification for teaching Integrated science
Unit 5 Nature of science

Module 2 Science Education Curriculum Reforms And How Students Learn Science

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

Module 3 Methods and Techniques of Teaching Integrated Science

Unit 1 Methods of teaching integrated science
Unit 2 Resources for teaching integrated science
Unit 3 Preparation for teaching integrated science
Unit 4 Science laboratory design, safety and management
Unit 5 Evaluation of science teaching and learning with reference to Integrated science

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

PRESENTATION SCHEDULE

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

ASSIGNMENT FILE

There are fourteen assignments in this course. That is one assignment per unit. These are designed to ensure that you really understood each of the units. In this file, you will find all the details of the works you must submit to your tutor, for marking. Remember your assignments are as important as the examinations as they carry weightings of 30% for undergraduate.

ASSESSMENT

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

TUTOR-MARKED ASSIGNMENT (TMAS)

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

Assignment questions for the units in this course are contained in the assignment file. You will be able to complete your assignment from the information and materials contained in your reading your study units

and, references. However, it is desirable to demonstrate that you have read and researched more into other references, which will give you a wider view point and may provide a deeper understanding of the subject.

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

FINAL EXAMINATION AND GRADING

The final examination for EDU 240 will be for two hours duration and will carry 70% of the total marks for undergraduate students. The examination will consist of questions, which reflect the type of self testing, practice activities and tutor-marked assignments/problems you have encountered previously. All areas of the course will be assessed.

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

COURSE MARKING SCHEME

Assessment	Category of Student	Scoring	Mark
Assignment 1 – 14	3 for undergraduate	Each counts for 10 marks	30 marks
Final Examination	Undergraduate		70 marks
TOTAL			**100% of course marks**

HOW TO GET THE MOST FROM THIS COURSE

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

2) Each of the study units follows a common format. The first item is an introduction to the subject matter of the unit, and how a particular unit is integrated with the other units and the course as a whole. Next to this is a set of learning objectives. These objectives allow you to know what you should be able to do, by the time you have completed the unit. These learning objectives are meant to guide your study. The moment a unit is finished, you must go back and check whether you have achieved the objectives. If this is made a habit, then you will significantly improve your chances of passing the course.

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

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

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

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

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

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

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

4) 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 text books on your desk at the same time.

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

6) Well before the relevant due dates (about 4 weeks before due dates), visit your study centre for your next required assignment. Keep in mind that you will learn a lot by doing the assignment carefully. They have been designed to help you meet the objectives of the course and, therefore, will help you pass the examination. Submit all assignments not later than the due date.

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

8) When you have submitted an assignment to your tutor for marking, do not wait for its return before starting on the next unit. Keep to your schedule. When the Assignment is returned, pay particular attention to your tutor's comments, both on the tutor-marked assignment form and also the written comments on the assignments, consult your tutor as soon as possible if you have any questions or problems.

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

TUTOR AND TUTORIALS

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

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

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

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

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

SUMMARY

EDU 240 intends to introduce you to Subject Methods II (Integrated Science). Upon completing the course, you will be equipped with basic knowledge and skills that will place you in the status of practicing integrated science teachers.

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

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

MODULE 1 THE MEANING AND HISTORICAL DEVELOPMENT OF INTEGRATED SCIENCE

INTRODUCTION

In this module, you will be exposed to the concept of Integrated Science. In the late sixties and early seventies, several attempts were made to improve the teaching of General Science in schools. One of such attempts resulted to the introduction of Integrated Science at lower level of secondary education presently referred to as Junior Secondary level.

The concern of this module therefore is to examine the meaning and historical background of the development of Integrated Science teaching, trace the changes in the objectives of Science Education that have occurred throughout the period and examine the trends of continuity which may be revealed in Integrated Science programmes in Nigeria. In view of this, the module one of the material is divided into five (5) units as follows:

Unit 1 Meaning and history of Integrated Science
Unit 2 Historical development of Integrated Science across the Globe
Unit 3 Philosophy and Objectives of Integrated Science
Unit 4 Justification for Teaching Integrated Science in School
Unit 5 Nature of Science

UNIT 1 MEANING OF INTEGRATED SCIENCE

CONTENTS

1.0 INTRODUCTION

In the unit, you will be introduced to various definitions of Integrated Science, the meaning of integration as related to science and comparison of characteristics of Integrated and Non–Integrated Science as well as the factors that make Integrated Science education worthwhile not only in the developed countries but also in the developing third world countries.

2.0 OBJECTIVES

After studying this unit, you should be able to:

- Define Integrated Science
- Explain the concept of Integration
- Compare in a tabular form the characteristics of Integrated Science and non–Integrated Science
- Mention the popularity factors of Integrated Science

3.0 MAIN CONTENT

3.1 Meaning of Integrated Science

In a simple and in general terms, Bajah (1983) sees integrated science as only a way of teaching science. When science is taught in such a way as to present scientific ideas as a unified whole, then we say that the ideas have been integrated.

SELF-ASSESSMENT EXERCISE 1

What will you consider as a classical definition of Integrated Science?

There are many classical definitions of Integrated Science which you may find in many advanced books. One of the definitions is given here for your consideration. Bajah (1983) defines Integrated Science as an approach to the teaching of science in which concepts and principles are presented so as to express the fundamental unity of scientific thought and avoid premature or undue stress on the distinctions between the various scientific fields.

SELF-ASSESSMENT EXERCISE 2

Name **six** fields in the study of Science.

There are many fields in the study of science. They are astronomy, biology, chemistry, geology, physics, zoology etc. The approach to the

investigation of scientific problems may demand knowledge in one or more fields of science. Using an approach therefore which does not emphasize the boundaries between the various fields of science is desirable in the study and teaching of Integrated Science. Hence, integrated science therefore stresses the fundamental unity of science.

SELF-ASSESSMENT EXERCISE 3

Mention some advantages that made Integrated Science to survive in our Junior Secondary School Curriculum in Nigeria.

The advantages of integrated have made it possible for Integrated Science to survive in the curriculum of many countries at different levels. These advantages include:

- the savings in time, personnel and resources when duplications are eliminated;
- the availability of scientific education for non-specialists
- the satisfaction of the needs of young learners whose logic differ from the logic of single subject disciplines
- a more accurate picture of the processes which constitute science
- increased potential for problem solving.

SELF-ASSESSMENT EXERCISE 4

What are the difficulties which the inclusion of Integrated Science in our Junior Secondary School Curriculum faced in the past?

Although Integrated Science has survived in the curriculum at Junior Secondary level, it has faced some serious problems in the past. One of the most outstanding problems in Nigeria is the inadequate production of qualified teaching staff for the subject. Teachers had traditionally been trained in one or two of the science subjects. On the other hand, integrated science curricula for schools embrace biology, chemistry, earth science, physics and agriculture. Teachers therefore feel insecure to teach aspects of the curricula which are unfamiliar to them. One innovation in the adequate provision of teachers for integrated science at the Junior Secondary level is the provision of an integrated science education degree for both serving and non-serving Nigeria Certificate of Education (NCE) Science teachers at various universities in Nigeria either on full-time or sandwich basis.

3.2 The Concept Of Integration

d'Arbon (1972) in his study of the concept of science subjects in secondary schools wrote that "Integration", when applied to science courses, means that the course is devised and presented in such a way that students gain the concept of the fundamental unity of science; the commonality of approach to problems of a scientific nature; and are helped to gain an understanding of the role and function of science in everyday life, and the world in which they live.

SELF-ASSESSMENT EXERCISE 5

Mention the purpose of integration in science.

Integrating principles are intended to produce a course which:

- is relevant to students needs and experiences
- stresses the fundamental unity of science
- lays adequate foundations for subsequent specialist study and adds a cultural dimension to science education.

SELF-ASSESSMENT EXERCISE 6

Name some integrated disciplines that you know as well as the subjects that are involved.

In not too long ago, there has been an increasing interest in integrating the separate sciences. The move towards integration is not of course confined to science. Several areas of the school curriculum are also moving towards integration, for instance, the integration of Geography, history etc. to form social studies, biology and chemistry to form biochemistry; geology and physics to form geo-physics etc. All over the world, educators and scientists have joined forces to produce programs such as the Biological Sciences Curriculum Study (BSCS), the Chemical Bond Approach (CBA) and CHEM Study program in chemistry, Physical Science Study Committee (PSSC) and Harvard Project Physics (HPP) and the Earth Science Curriculum Project (ESCP). These programs demonstrate how science disciplines may be represented in different ways, each project lending itself to some form of interdisciplinary or integrated approach.

3.3 Characteristics of Integrated Science and Non-Integrated Science

A critical examination at integrated science requires a concise description of its unique aspects in order to clarify how integrated science differs from non-integrated science. To further support the above statements, we have attempted to compare and contrast certain characteristics of integrated science against those of non-integrated science. The table below summaries those characteristics.

Table 1.0: Comparison of Characteristics

S/N	CHARACTERISTICS OF INTEGRATED SCIENCE	CHARACTERISTICS OF NON-INTEGRATED SCIENCE
1.	Traditional subject matter boundaries are completely removed	Individual identity of biology, chemistry, geography and physics are visible
2.	The course is organized around a selected unifying topic	The course is not organized around a topic which unifies the individual subject
3.	The course usually serves a general education function	The course usually serves a specialist's education function
4.	The sequence tries as much as possible to avoid duplication of content	Duplication of topics are unavoidable in some cases e.g. electrolysis
5.	The course usually lasts for three years and is sequential	The course usually lasts for more than three years and is sequential

SELF-ASSESSMENT EXERCISE 7

What makes integrated science a unique subject?

It is evident from the table of comparison of characteristics that integrated science emphasizes organization of learning experiences around a topic/theme. It is likely that this unification of concepts around a theme makes integrated science unique. Firstly, the learning experiences and concepts of integrated science are organized around the themes "Energy, Life and Matter" while in some other integrated science programmes, the concepts are organized around the themes "Matter, Life, Mind and Society".

SELF-ASSESSMENT EXERCISE 8

What is the merit of organizing concepts around themes?

Organising concepts around common themes is a good way of deliberately removing the subject mater boundaries. The main criticism against the current integrated science programmes in Nigeria is the fact that the various subject disciplines namely biology, chemistry and physics are evident in the various units. In fact it has been suggested that what is now regarded as integrated science is no more than putting together topics in biology, chemistry and physics.

3.4 Popularity Factors of Integrated Science

The concept of integrated science has been fully established in most countries of the world. This can be attributed to the following factors identified by Haggis and Adey (1979).

- There is a worldwide movement to introduce science into primary school education.
- There is a rapid and widespread development of integrated science education at the lower secondary level.
- Integrated Science education is a rapidly developing and expanding field.
- Much greater attention is now being paid to the training and retraining of teachers for integrated science.
- The scope of integrated science course is now being extended.
- There is a trend towards greater social relevance in integrated science courses.
- An emphasis is now being placed on environmental issues in integrated science.
- Attempts are being made to inter-relate integrated science courses with other curriculum areas.
- Integrated science courses in science and technology education are now being developed.

4.0 CONCLUSION

This unit exposed you to the meaning of integrated science as well as the various positions so far taken in integration in science in an attempt to explain the fundamental unit of science.

5.0 SUMMARY

In this unit, we have learnt that there are many classical definitions of integrated science. One of them is given by Bajah (1983) which defined integrated science as an approach to the teaching of science in which concepts and principles are presented so as to express the fundamental unity of scientific thought and avoid premature and undue stress on the

distinctions between the various scientific fields. d'Arbon (1972) explained the concept of integration in science to mean that the course should be devised and presented to reflect the concept of fundamental unity of science.

The unit also discussed the characteristics of acceptability of science and non-integrated science and favours that make integrated science education worthwhile.

6.0 TUTOR –MARKED ASSIGNMENT

Advance reasons for the universal acceptability of Integrated Science in spite of the skeptical views being expressed by subject specialists.

7.0 REFERENCES/FURTHER READING

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

Bajah, S.T. and Okebukola, P. (1984). Teaching Integrated Science Creatively. Ibadan, Ibadan University Press, d' Arbon J. (1977, "A study of the concept of Integration in Science subjects in secondary schools' cited in Cohen in New Trends in Integrated Science Teaching. III, Paris UNESCO.

Haggis, Sheila and Philip Adey (1979). 'A review of Integrated Science Education Worldwide', Paper presented at the NNOUN/ICASE International Conference. Integrated Science Worldwide. The Netherlands. New Trend in Integrated Science Teaching. V, Paris, UNESCO.

UNIT 2 HISTORICAL DEVELOPMENT OF INTEGRATED SCIENCE ACROSS THE GLOBE

CONTENTS

1.0 INTRODUCTION

The concern of the unit is to examine the historical background of the development of integrated science teaching, trace the changes in the objectives of science education that have occurred throughout the period and examine the threads of continuity which may be revealed in Integrated Science programmes in Nigeria.

The historical development of integrated science across the globe will focus on the following:

- The Development of Specific Science Curricula (1870 – 1900)
- The Nature Study Movement (1890 – 1920)
- Recent Trends (1910 to Present).

2.0 OBJECTIVES

After studying this unit, you should be able to:

- Discuss the historical development of integrated science
- List all the integrated science projects embarked upon in Nigeria from the past to the present day
- Discuss the genesis of transforming from General Science to Integrated Science.

3.0 MAIN CONTENT

3.1 The Development of Specific Science Curricula (1870 - 1900)

The thirty years (three decades) following 1870 witnessed increasing demand for elementary school science. This increasing demand grew out of various factors of economic and social development which occurred during the 18th and 19th centuries included:

- The rapid development of science and technology in Europe and America and their application to industry and everyday life.
- The fruitfulness of the laboratory method in technology.
- The increasing need for skilled labour to man the several developed industries.
- The influence of a new philosophy of education which emphasized pupils' activity as a natural expression of biological development.

SELF-ASSESSMENT EXERCISE 1

Generate more to the list of the social and economic benefits of the 18th and 19th centuries.

It was during the periods that special interest groups began to turn their attention to the schools. Attempts were made to utilize, in some cases distort the sciences to serve their purposes. This distortion was especially noticeable in connection with narcotics and stimulants and humanness. The primary objectives of all science programmes were first hand observation and experience. Experimentation and problem-solving types of activities were beginning to be considered as significant science teaching techniques. The programmes of elementary science proposed during the last half of the 19th century could not affect practice, because of the lack of teachers to handle the programme.

3.2 The Nature Study Movement (1890 – 1920)

During this period many science educators in Europe, America and parts of Africa showed great enthusiasm for the introduction of the study of nature into the school. The main purpose of this movement was to improve agriculture and to overcome the desire of farmers' children to leave the farm for the city.

SELF-ASSESSMENT EXERCISE 2

Think back to days when Nature Study was offered in the School. Could you remember some objectives of this subject. Mention them.

The objectives of nature study focused on the learning of facts for their own sake. It also emphasized the aesthetic and moral learning which might be derived from scientific observation. Although, the nature study movement advocated a well-rounded program which embraced the natural and physical sciences, in practice, but the subject matter was very much limited to materials from the biological sciences. This was probably due to the fact that those who were most interested in introducing nature study into the schools were largely specialists in the biological sciences. In parts of Africa, Europe and America, nature study still form part of their curriculum but with a different name (e.g. general science, rural science, hygiene etc.) depending on the country.

3.3 Recent Trends (1910 to Present)

In the past four and half decades, there have been changes in the nature of science taught in schools. For instance, science had become more integrated and emphases have been on the products (i.e. concepts, laws and theories) and the processes of science, which students were both to understand and frequently to perform. The decade of the 1960's was marked by the initiation and development of a large number of school science curriculum projects that were designed to improve science programs.

SELF-ASSESSMENT EXERCISE 3

List the primary and secondary schools science curriculum projects embarked upon in Nigeria in the last three and half decades.

Several primary and secondary science projects such as the African Primary Science Programme (APSP), Bendel Primary Science Project (BPSP), Primary Education Improvement Project (PEIP), Project for Six Northern States, Ife Six-Year Primary Science Project and National Primary Science Project (NPSSP) started in early 1970's. At secondary school level, we have the Basic Science for Nigerian Secondary School (BSNSS) popularly known as Aiyetoro Science Project, Nigerian Integrated Science Project (NISP), Nigerian Secondary Schools Science Project (NSSSP) and National Science Curriculum for Senior Secondary Schools. All these projects shall be examined in details under Units 1 and 2 in Module 2.

The NISP for example was initiated by the Science Teachers Association of Nigeria (STAN) in 1970 at Ibadan, and had as its director, Professor Akin Osiyale (now retired) of the University of Lagos. The NISP evolved from the work of curriculum review committees on separate disciplines of biology, chemistry, physics and integrated science and follow-up writing workshops. One of the objectives of NISP was to produce instructional materials on integrated science for use in first and second years of secondary school course. The project clearly represents the efforts of experienced science teachers throughout the country of Nigeria.

SELF-ASSESSMENT EXERCISE 4

What are the major criticisms of the General Science as a subject that resulted to the change to Integrated Science?

So many years ago, in many countries of the world, science courses were devised that attempted to cover the whole range of science in a balanced way. Such courses were in effect coordinated surveys of biology, chemistry and physics. Little was the real unity in the presentation of the course and in the examination of it. Teachers could not achieve any real integration in their teaching and teacher-training courses rarely prepared teachers for a unified approach to their teaching.

General Science courses were also regarded as too superficial, as an inadequate base from which to develop higher level science courses and they were allocated too little time by schools authorities.

SELF-ASSESSMENT EXERCISE 5

How is the concept of integration receiving attention in other school subjects?

In not too long ago, there has been an increasing interest in integrating the separate sciences. The move towards integration is not of course confined to science. Several areas of the school curriculum are also moving towards integration, for instance, the integration of geography, history, government etc. to form social studies, the integration of economics, accounting, commerce etc. to form business studies.

It is very important to note that the new science curriculum projects developed during the 1960's have themselves illustrated integration within the discipline. For example, modern physics courses are no longer a mixture of light, heat and sound, dynamics, electricity and magnetism, physics itself is unified through major concepts. Biology is

no longer divided into botany and zoology. Thus, integrated science teaching is one of the logical steps in our educational development.

4.0 CONCLUSION

This unit exposed you to the various historical development of integrated science with particular reference to the threads of continuity from development of specific science curricula to nature study as the beginning of science later to General Science and finally Integrated Science.

5.0 SUMMARY

In this unit, you learnt about the historical background of the development of integrated science from the development of specific science curricula in 1870 – 1900 to the nature study movement 1890 – 1920 and finally what is regarded as recent trends from 1910 to present time. The recent trends include when science is being taught as General Science but later changed to Integrated Science in 1971.

6.0 TUTOR-MARKED ASSIGNMENT

What are the problems and prospects of integration approach to the teaching of Integrated Science?

7.0 REFERENCES/FURTHER READING

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

Bajah, S.T. (1983). Teaching Integrated Science Creatively. Ibadan, Ibadan University Press.

Urevbu, A. (1990). Studies in Science Education, Methodology of Science Teaching. Juland Educational Publishers, Benin-City. Pp. 141 – 161.

UNIT 3 PHILOSOPHY AND OBJECTIVES OF INTEGRATED SCIENCE

CONTENTS

1.0 INTRODUCTION

The previous two units (1 & 2) tries to examine the various positions so far taken in "integration" in science in an attempt to explain the meaning and partly philosophy of Integrated Science. This unit will therefore be a continuation of the philosophy of Integrated Science as well as the objectives and development of Integrated Science. The focus of the entire unit shall be on integration as a new strategy, objectives of integrated science in Nigeria and development of science teaching in Nigerian secondary schools.

2.0 OBJECTIVES

After studying this unit, you should be able to:

- Identify the latest strategy at ensuring full integration in science.
- Define a module
- Use diagrams to show all the scientific concepts used in illustrating the Modules on Life, Energy, Matter and Society (LEMS).
- Outline the objectives of Integrated Science.
- Briefly discuss the development of science teaching in Nigeria from the days of General Science to the formation of Integrated Science.

3.0 MAIN CONTENT

3.1 Integration as a New Strategy

When specialist teachers are confronted with the teaching of Integrated Science, there is always the evidence of bias towards their own special discipline. Take for example; a chemistry teacher thus treats the chemistry section of the Integrated Science well, than the other sections on biology and physics. This same mode of treatment of topics is equally true about the biology or physics specialist teachers.

In view of the unfortunate state of affairs in integrated science classes as stated above, there is the need for an entirely new philosophy and approach to integrated science.

SELF-ASSESSMENT EXERCISE 1

Has the concept of integration passed as illusion?

Although the meaning of integration has been clearly understood, there is need to devise a means by which the spirit of integration can be practicalised in the classroom. Integration should not be restricted to mere theorizing alone, all hands must be on deck to make the theory a reality and all teachers of integrated science should bear this in mind. In line with this assertion, Bajah (1981) proposed four modules to achieve better integration of science. In proposing these modules, he had his focus on integration of science by organizing learning experiences around 'theme' rather than putting together of subject matter from definite disciplines. Based on the unifying theme of integrated science i.e. LIFE, ENERGY, MATTER, SOCIETY = 'LEMS', he was able to build up four modules from the general theme.

SELF-ASSESSMENT EXERCISE 2

What is a Module?

A module according to Bajah (1981) is defined as a learning package. In a module, there could be an interplay of ideas from biology, chemistry and physics relating to the central theme. The only significant thing in this approach is the fact that each module as you will see in not too long will deal with a theme which can then have other sub-concepts. Any teacher who takes up a module will find it hard to isolate certain areas as belonging to some subject discipline because the central theme will always remain. The four modules developed by Bajah (1981) are shown in Fig. 3.1 – 3.4.

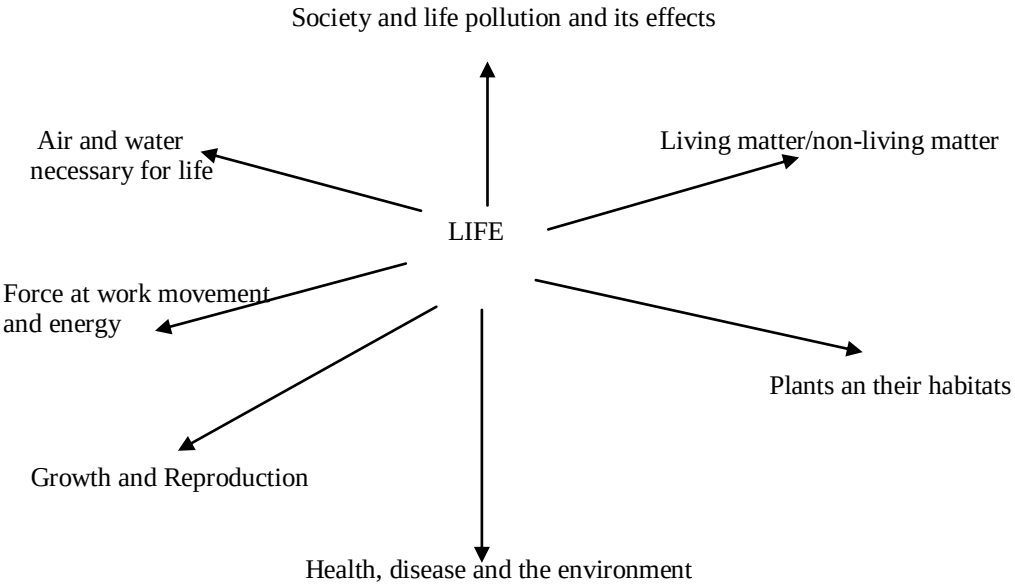
Society and life pollution and its effects
Air and water necessary for life
Living matter/non-living matter
LIFE
Force at work movement and energy
Plants an their habitats
Growth and Reproduction
Health, disease and the environment

Fig. 3.1

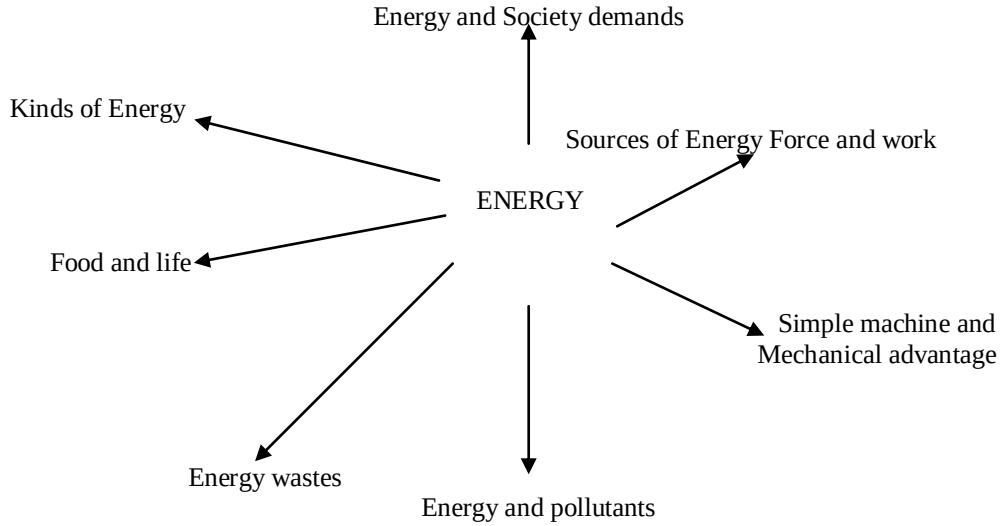
Energy and Society demands
Kinds of Energy
Sources of Energy Force and work
ENERGY
Food and life
Simple machine and Mechanical advantage
Energy wastes
Energy and pollutants

Fig. 3.2

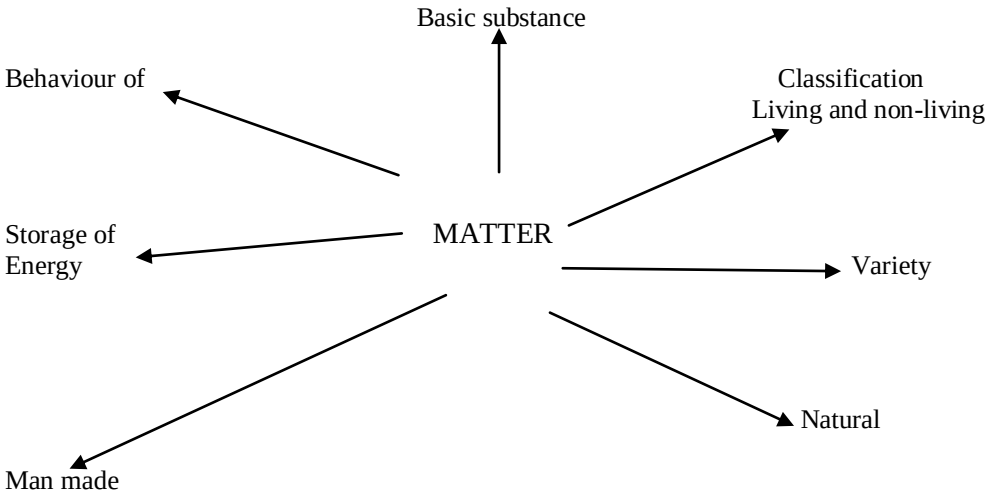

Fig. 3.3

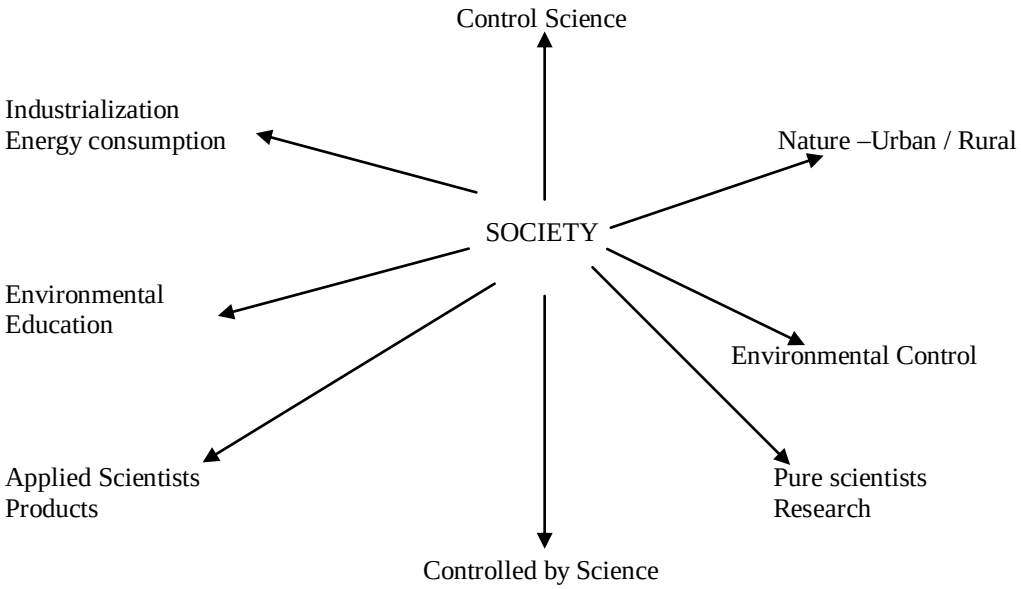

Fig. 3.4

He also went further by proposing a "flow chart" which should begin with Living matter, the Environment and Non-living matter and the interdependence of related concepts on one another. A combination of these culminated into the three basic themes of LIFE, ENERGY and MATTER. The relationship between science and society can also be incorporated. An approach like this will keep an integrated science teacher abreast of the full meaning and tenets of integration in sciences.

3.2 Objectives of Integrated Science in Nigeria

Objectives of Integrated Science in Nigeria are based on relevant portions of the National Policy on Education as they relate to science education in general and, to integrated science in particular. It is clear from the National Policy that secondary education is expected to be:

(i) preparation for useful living within the society; and
(ii) preparation for higher education.

Government plans that secondary education should be of 6-year duration and be given in two stages, a junior secondary stage and a senior secondary school stage; each being of three years duration. The junior secondary school will be both pre-vocational and academic, it will be free as soon as possible and will teach all the basic subjects which will enable pupils to acquire further knowledge and develop skills. Students who leave school at the junior high school stage may then go on to an apprenticeship system or some other scheme for out-of-school vocational training.

SELF-ASSESSMENT EXERCISE 3

What do you consider as the essence of an Integrated Science to your students?

Whatever science programme is developed for the Junior Secondary Schools, it must take into consideration the above specific national education objectives which emphasize flexibility of the science programme such that it can be applicable to all parts of the country and for a considerable length of time.

Based on the above guiding principles, it was agreed that the essence of an integrated science course is to begin to teach the students what science is and how a scientist works.

Thus, the objectives of integrated science are aimed at enabling the student who is exposed to it acquire the following skills:

- observing carefully and thoroughly
- reporting completely and accurately what is observed
- organizing information acquired
- generalizing on the basis of acquired information
- predicting as a result of the generalizations

- designing experiments (including controls where necessary) to check predictions
- using models to explain phenomena where appropriate.
- continuing the process of inquiry when new data do not conform to prediction.

3.3 Development of Science Teaching in Nigerian Secondary Schools

The teaching of science in Nigerian secondary schools dates back to 1878, Taiwo (1975). It started as general science; it later disintegrated into the three basic core science subjects, biology, chemistry and physics.

SELF-ASSESSMENT EXERCISE 4

What are the causes of the lack of uniformity in teaching of science in the past?

Because of the scarcity of trained science teachers and resources for science teaching, there was lack of uniformity in science teaching in our schools. Some schools were offering General Science which consisted of biology, chemistry and physics. The other schools had adopted a single approach to science teaching. The schools that were offering it as three separate subjects taught General Science as a basic course leading to the School Certificate level while the other category taught General Science at the lower forms and in the senior classes.

The concept of General Science as a subject to be offered up to the School Certificate level has its historical source from Britain whose educational system we inherited, Abdullahi (1981).

SELF-ASSESSMENT EXERCISE 5

Outline the objectives of General Science course as published by British Association Policy paper on General Science in Schools.

The British Association Policy paper on General Science in schools argued that as much as the knowledge of General Science forms an essential part of a liberal education it should be taught in all secondary schools. The course was designed to achieve the following objectives:

- For developing in the child certain attitudes and skills such as accurate observation, logical reasoning and a desire to experiment.
- General Science would deal with everyday application of science.
- General Science should show the unity of science rather than the compartmentalization of science into separate disciplines such as biology, chemistry and physics.

By 1950 most secondary schools in Nigeria were offering General Science in one form or another but the general trend was to offer it as a

single subject up to the School Certificate Examination partly because of the dearth of science teachers in single subject areas and mostly because of the lack of resources needed to teach basic sciences up to School Certificate level.

SELF-ASSESSMENT EXERCISE 6

What are the causes of the failure of General Science in Nigeria by the mid-1950s?

By the mid-1950s, the teaching of General Science in Nigerian schools began to experience a failure for the following reasons:

- Students who had successfully completed School Certificate courses could not be easily accepted into the Higher School Certificate courses introduced in 1951 to study biology, chemistry and physics except the few ones that had distinction in the General Science.
- General Science at the School Certificate level was seen to be less demanding than any two single subjects–i.e. biology and chemistry or chemistry and physics not only in the coverage but also less demanding intellectually.
- The teachers often taught the topics in which they possess the knowledge and skills. Hence, in some schools it was not uncommon to find three teachers assigned to the same General Science course.

During the same time, i.e. mid-1950s, most secondary schools had returned to the science education pattern with a two-tier approach. General Science was taught during the first two years to every student in a five year secondary education programme. Students are then allowed to specialize during the last three years so that those who desire careers in science could choose two or the three basic sciences depending on their abilities.

In order to popularize science in the schools, science teachers all over the country met on 30th November, 1957 to inaugurate the Science Teachers Association of Nigeria (STAN). This association championed the successful introduction of Integrated Science into the Nigerian educational system in 1971, as a form of science to be taught to students at the junior secondary school level. The successful introduction of integrated science into the junior forms resulted in a shift in the objectives and methods of science teaching in our secondary schools.

The STAN integrated science project was concerned with the teaching of science through inquiry and discovery approach in which students

come to understand and to develop science concepts by investigating and experimenting on their own.

4.0 CONCLUSION

This unit exposed you to know more about the concept of integration and how it can be evidenced in the classroom. It also examined the objectives of integrated science in Nigeria as well as development of science teaching in our schools.

5.0 SUMMARY

In this unit, you learnt about the following:

- Four modules proposed by Bajah (1981) to achieve better integration of science are: Life, Energy, Matter and Society.

- Module is defined by Bajah (1981) as a learning package.

- The objectives of integrated science must take into consideration the national education objectives.

- That the Science Teachers Association of Nigeria (STAN) championed the introduction of integrated science into the Nigerian Educational System in 1971.

6.0 TUTOR-MARKED ASSIGNMENT

Differentiate between the objectives of General Science and Integrated Science in Nigeria.

7.0 REFERENCES/FURTHER READING

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UNIT 4 JUSTIFICATION FOR TEACHING INTEGRATED SCIENCE

CONTENTS

1.0 INTRODUCTION

In the previous three units, you were treated to the meaning, historical development and philosophy of integrated science. In this unit, you will be exposed to the rationale for teaching integrated science in Nigerian schools. In an attempt to justify the inclusion of integrated science in the school curriculum, attempt would be made at providing some information on why teaching integrated science, objectives for teaching integrated science in Nigerian schools, the roles of teachers in teaching the subject and the objectives of training integrated science teachers.

2.0 OBJECTIVES

After studying this unit, you will be able to:

- Outline the reasons for teaching integrated science;
- State the roles of integrated science teachers in achieving the objectives for teaching integrated science;
- Outline the rationale for extending the teaching of integrated science beyond the first three years in secondary school in Nigeria.

3.0 MAIN CONTENT

3.1 Why teaching Integrated Science

Several reasons can be given for teaching integrated science in Nigerian schools. Such reasons are as follows:

(i) The search for unity in Science

From pedagogical standpoint, integration of the basic science minimizes fragmentation of learning and links together basic scientific information. Integrated science teaching also ensures academic teaching experience in science in which the subject matter boundaries between various scientific disciplines (e.g. biology, chemistry and physics) are dissolved in favour of broad ideas that transcend all the basic sciences. It also expresses the fundamental unity of scientific thought and avoids premature specialization in the sciences.

SELF-ASSESSMENT EXERCISE 1

Discuss other advantages accruing from integrated science.

Integrated science is geared to cater for all levels of ability in children who are all potentially useful citizens of tomorrow. With integrated science, those students who are weak in science and cannot continue in school will have had an exposure to science which can hopefully assist them to contribute intelligently in the technical, agricultural and other sectors of the nation.

(ii) National Development

Development, according to Abubakar (1969), is a complex process and science is clearly a part of it. Science becomes relevant to development only when people realize its importance to their lives, and develop positive attitudes towards science as a developmental tool.

SELF-ASSESSMENT EXERCISE 2

What purposes should integrated science serve in national development?

Integrated science teaching should treat interactions between scientific research and the agricultural, technological and social problems which arise in the developing village, the growing city and the emerging nation. Integrated science is a good beginning that takes inherently a wider view of what science can do.

(iii) Psychological Reasons

Psychological reasons have also been advanced for the continuing emphasis on integrated science. The integrated approach seems to be more consistent with the child's way of looking at and reacting to the world. For example, "a child may be looking at a lemon as biological specimen. It can next proceed to use it to produce a lemon battery, float

the lemon on water and then taste the juice. Thus, according to Balogun (1978), the child might within a lesson span separate science without knowing that he is doing so.

Also, it is highly probable that an integrated approach to science would enhance transfer of learning by giving the child more instance to use the concepts and principles learned in one discipline in another related discipline.

3.2 Role of Teachers in the Teaching of Integrated Science

To adopt an integrated approach in the teaching of integrated science is a big task. We have already established that integrated science involves presentation of scientific ideas as a unified whole. This calls for a wide range of knowledge in the field of science. This does not infer that you have to be a specialist in all fields of science. Scientific knowledge can be obtained through consultation with specialists and wide range of scientific texts. Integrated science encourages the teacher to find out about things.

Knowledge is not static, hence the teacher continues to search for scientific knowledge by reading other science textbooks, journals and magazines, as well as consulting with specialists and other teachers.

Science in whatever form involves a continuous search for explanations of phenomenon in nature. The teacher needs to approach science as a human activity.

Other roles of the integrated science teacher include:

- Using simple and locally available materials familiar to teachers and pupils alike in teaching the subject.
- As much as possible, minimize the use of costly and sophisticated scientific apparatus which could be beyond the reach of most of the schools and teachers.
- Integrated science teacher needs to cultivate the habit of seeing the subject as an approach of investigation of nature within his or her environment.
- Ecological approach should be employed in the teaching of integrated science.
- He must possess the ability to learn along with the students being taught.

On a general note, any would-be integrated science teacher must be prepared to put in his best in terms of time and effort.

SELF-ASSESSMENT EXERCISE 3

What are the roles of the teacher in promoting the tenets of integrated science?

3.3 Objectives for Teaching Integrated Science

There are a number of reasons that abound for teaching integrated science to students. Basically, the primary reason could be to prepare the students to pass a prescribed examination. In addition to passing the prescribed examination, other long term objectives for teaching integrated science include:

(i) to develop students' ability to observe;
(ii) to train the students how to tackle or proffer explanations of some observations and occurrences in their environment;
(iii) to direct the attention of the learners towards matters which are significant to them and the society to which they belong;
(iv) to continue the process of science concept building for acquiring a science vocabulary;
(v) to prepare student to face future challenges of scientific nature in his school career;
(vi) to make students well informed and scientifically literate;
(vii) to enable students acquire and demonstrate the intellectual competence and professional skills necessary for the teaching of integrated science in primary and junior secondary schools as in inquiry based subject;
(viii) develop in students the ability to impart and encourage in their pupils the spirit of inquiry into living and non-living things in the environment;
(ix) to develop the ability and motivation in students in working and thinking in an independent manner;
(x) to enable students carryout scientific investigations, emphasizing cooperation, development of appropriate science processes and skills;
(xi) to improve students' written and oral communication skills;
(xii) to develop in students ability to solve problems of scientific nature;
(xiii) to create in the mind of students a clear understanding of the nature of science, of its role in contemporary society, of its potential and its limitations as a guide to action;
(xiv) to teach students to be responsible citizens to themselves, to their fellow men and to the whole biosphere;
(xv) to produce people who have learnt how to learn and are still willing to learn;

(xvi) to identify and foster those who have the potential to carry special responsibilities in science and science-related fields of human endeavour – i.e. the scientists, engineers and technicians.

3.4 Objectives for Training Integrated Science Teachers

In preparing teachers of integrated science, the following are the principal objectives:

(i) to instill in students a commonality of approach to problems of scientific nature i.e. the scientific method;
(ii) to enable students gain the concept of the fundamental unity of science;
(iii) increasing students' understanding of the role and function of science in everyday life and in the world in which they live in

4.0 CONCLUSION

In this unit, you have been exposed to the reasons for the teaching of integrated science including the roles of the teachers for promoting the tenets of integrated science.

5.0 SUMMARY

In this unit, you have learnt about the following:

- that the reasons for teaching integrated science in Nigerian schools are:
    - the search for unity in science
    - national development
    - psychological reasons.
- the basic objective for the teaching of integrated science is to express the fundamental unity of science;
- that in order to disseminate scientific knowledge, through the integrated approach, the teacher has a central role to play;
- that, an integrated science teacher must be prepared to work hard in order to be able to cope with the big task of teaching the subject.

6.0 TUTOR-MARKED ASSIGNMENT

1. Outline the main objectives of teaching integrated science.
2. What are the rationales for training integrated science teachers?

7.0 REFERENCES/FURTHER READING

Abubakar, I. (1969). The Role of Science and Technology in National Development. In Adeniji Adrarlegbe (Ed). A Philosophy for Nigeria Education. Report on the National Curriculum Conference, Ibadan, September 8 –12, Heinemann Publishers.

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UNIT 5 THE NATURE OF SCIENCE

CONTENTS

1.0 INTRODUCTION

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

SELF-ASSESSMENT EXERCISE 1

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

2.0 OBJECTIVES

After studying this unit, you should be able to:

- List the processes or methods of science;
- List and explain the attitudes of scientists or scientific attitudes;
- List and explain the products of science;
- Explain the nature of science.

3.0 MAIN CONTENT

3.1 The Nature of Science

A major goal of science is to understand the world around us. How do scientists go about understanding the mysteries of our world? Like good detectives, they use special methods or processes peculiar to science

alone to determine the "truths and facts" about nature, which constitute the major products of science.

The methods or processes of science are self-correcting, self-evaluating and independent of the people or event on whom they operate. They include:

- identifying problem
- observation
- hypothesizing / prediction
- analyzing
- inferring
- extrapolating
- synthesizing
- evaluating
- classifying
- measuring
- describing
- experimenting
- asking insightful questions
- formulating problems
- designing experiments
- constructing laws, principles and generalizations, etc.

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

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

- suspending judgement until enough data is collected;
- objectivity while collecting, analyzing, evaluating and interpreting data;
- intense curiosity by being fascinated with the world around him/her;
- humility and skepticism (being free from pride and arrogance as well as taking everything with a pinch of salt);
- tenacity by thinking positively about failure and not giving up very easily;
- open-mindedness – free from prejudice and personal biases;
- strong determination;

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

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

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

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

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

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

SELF-ASSESSMENT EXERCISE 2

How are concepts, laws, theories and principles related?

3.2 Scientific Concept

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

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

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

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

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

SELF-ASSESSMENT EXERCISE 3

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

3.3 Scientific Theory

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

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

SELF-ASSESSMENT EXERCISE 4

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

3.4 Scientific Law

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

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

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

4.0 CONCLUSION

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

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

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

5.0 SUMMARY

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

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

6.0 TUTOR-MARKED ASSIGNMENT

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

7.0 REFERENCES/FURTHER READING

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MODULE 2 SCIENCE EDUCATION CURRICULUM REFORMS AND HOW STUDENTS LEARN SCIENCE

INTRODUCTION

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

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

Unit 1	Science Education Curriculum Reforms in Nigeria I
Unit 2	Science Education Curriculum Reforms in Nigeria II
Unit 3	Psychological theories of learning and their implications for Science Teaching I
Unit 4	Psychological theories of learning and their implications for Science Teaching II

UNIT 1 SCIENCE EDUCATION CURRICULUM REFORMS IN NIGERIA I

CONTENTS

1.0 INTRODUCTION

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

2.0 OBJECTIVES

After studying this unit, you should be able to:

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

3.0 MAIN CONTENT

3.1 Science Curriculum Development

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

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

SELF-ASSESSMENT EXERCISE 1

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

Notable among the developed primary science projects are as follows:

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

3.1.1 University of Nigeria Primary Science Pilot Scheme.

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

The focus of the scheme was on local materials and improvised equipment such as the use of jam-jars, bamboo microscopes, bamboo cages etc. in the teaching of primary science.

SELF-ASSESSMENT EXERCISE 2

Who was the initiator of this scheme?

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

3.1.2 The African Primary Science Project (APSP)

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

SELF-ASSESSMENT EXERCISE 3

What is the main focus of SEPA?

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

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

3.1.3 Bendel State Primary Science Project (BPSP)

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

SELF-ASSESSMENT EXERCISE 4

What is the focus of BPSP?

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

The developer of the project in 1972 produced a series of pupils textbooks called "Science is Discovery" together with the Teachers' Guide.

3.1.4 Ife Six Year Yoruba Language Primary Science Project

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

Some of the overall objectives of this project were:

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

The revised aims and objectives of the projects are:

- The project was to organize writing workshops for the development and evaluation of curriculum materials
- The project was to develop materials with appropriate methodology for teaching and learning the prepared curriculum effectively.
- Curriculum materials were to be developed in both Yoruba and English.

SELF-ASSESSMENT EXERCISE 5

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

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

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

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

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

SELF-ASSESSMENT EXERCISE 6

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

Some of the problems encountered with the project were:

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

3.1.5 The Primary Education Improvement Project (PEIP)

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

SELF-ASSESSMENT EXERCISE 7

What is the aim of this project?

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

SELF-ASSESSMENT EXERCISE 8

Does this project have materials produced for its execution?

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

3.1.6 Ondo State Primary Science Project

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

SELF-ASSESSMENT EXERCISE 9

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

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

SELF-ASSESSMENT EXERCISE 10

What is the general purpose of this project?

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

SELF-ASSESSMENT EXERCISE 11

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

A combination of approaches were recommended for the teaching of the project which are processes, conceptual, thematic or project approach and the guided discovery approach that involves the activity of the child. This was made to run through the entire project.
The materials produced for the execution of the project include the followings:

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

4.0 CONCLUSION

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

5.0 SUMMARY

In this unit, you leant that:

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

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

6.0 TUTOR-MARKED ASSIGNMENT

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

7.0 REFERENCES/FURTHER READING

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

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

UNIT 2 SCIENCE EDUATION CURRICULUM REFORMS IN NIGERIA II

CONTENTS

1.0 INTRODUCTION

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

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

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

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

2.0 OBJECTIVES

After studying this unit, you should be able to:

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

3.0 MAIN CONTENT

3.1 Basic Science for Nigerian Secondary School (BSNSS)

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

SELF-ASSESSMENT EXERCISE 1

What approach did the syllabus of this project based upon?

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

SELF-ASSESSMENT EXERCISE 2

What is the philosophy of the project?

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

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

SELF-ASSESSMENT EXERCISE 3

What are the topics listed in each of the units in the two blocks?
Block I, with five units:

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

Block II, with four units:

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

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

SELF-ASSESSMENT EXERCISE 4

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

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

3.2 The Nigerian Integrated Science Project (NISP)

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

SELF-ASSESSMENT EXERCISE 5

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

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

SELF-ASSESSMENT EXERCISE 6

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

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

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

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

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

3.3 The Nigerian Secondary Schools Science Project (NSSSP)

The NSSSP was developed in 1970 by the Comparative Education Study (CES) and CESAC (Comparative Education Study and Adaptation Centre) in biology, chemistry and physics as alternative syllabus for Forms III – V of secondary schools all over the federation.

SELF-ASSESSMENT EXERCISE 7

What method of teaching does the project adopted?

The project adopted the guided discovery method of teaching and the conceptual theme approach to content selection. The philosophy of the project was active students' participation. The students are required to go through a series of activities designed to foster inquiry and manipulative skills.

Textbooks for students and Teachers Guides were developed for the three science subjects namely: biology, chemistry and physics as Books 1, 2 and 3. The book 1 is for Year III, Book 2 for Year IV and Book 3 for Year V.

3.4 The National Science Curriculum for Senior Secondary Schools

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

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

SELF-ASSESSMENT EXERCISE 8

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

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

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

SELF-ASSESSMENT EXERCISE 9

Could you suggest how the teaching syllabii were arranged?

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

- Topic
- Performance objectives
- Content
- Activity
- Notes.

The curriculum also recommended the use of improvised local materials.

4.0 CONCLUSION

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

5.0 SUMMARY

In this unit, you learnt that:

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

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

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

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

6.0 TUTOR-MARKED ASSIGNMENT

Outline the topics in STAN NISP Book 1 and the concepts stated under the topics.

7.0 REFERENCES/FURTHER READING

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

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

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

CONTENTS

1.0 INTRODUCTION

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

2.0 OBJECTIVES

After studying this unit, you should be able to:

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

3.0 MAIN CONTENT

3.1 David Ausubel's Theory of Learning

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

SELF-ASSESSMENT EXERCISE 1

What is the meaning of subsumer?

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

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

SELF-ASSESSMENT EXERCISE 2

What is advance organiser?

Ausubel advocates for introduction of what he called advance organiser. Advance organizers are alternative set of link or "anchorage" Ausubel is an advocate of verbal learning.

He proposes that meaningful learning can take place by two processes namely:

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

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

Teaching and Curriculum Development

- Teaching of science subjects must not begin until the teacher is sure of previous knowledge and if not, it should be provided.

- Teaching of science subjects must begin with new learning or knowledge in a sequential manner.

- Science teacher must not present new materials during teaching unless the learner is ready.

- Ausubel supported the use of expository method in teaching of science subjects as the method can lead to high level of understanding and generality as against the use of discovery approaches which are extremely time consuming.

- Contents in the science curriculum must be arranged in sequential order.

SELF-ASSESSMENT EXERCISE 3

What is discovery?

3.2 Jerome Brunner's Theory of Learning

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

SELF-ASSESSMENT EXERCISE 4

How many forms of discovery processes does Brunner say exist?

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

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

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

SELF-ASSESSMENT EXERCISE 5

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

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

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

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

SELF-ASSESSMENT EXERCISE 6

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

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

The interpretation of these three stages together is that when a child at junior secondary school level for example shows deficiencies in his learning capacity especially in symbolic representation, it could be that such a child was deficient at the two earlier stages, which he/she

skipped. It is therefore compulsory to fill in the skipped gap by providing concrete support that will make up for the deficiency.

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

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

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

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

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

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

4.0 CONCLUSION

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

5.0 SUMMARY

In this unit, you have learnt that:

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

- Jerome Brunner's theory of learning centers on:
  - learning through discovery
  - discovery aids problem-solving and creativity development
  - two forms of discovery namely: assimilation and accommodation.
  - Three types of human activity for learning namely:
    - Enactive representation
    - Ionic representation
    - Symbolic activities.

6.0 TUTOR-MARKED ASSIGNMENT

Discuss how you as an integrated science teacher will apply Jerome Brunner's ideas in the teaching of integrated sciences in your laboratory.

7.0 REFERENCES/FURTHER READING

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UNIT 4 PSYCHOLOGICAL THEORIES OF LEARING AND ITS IMPLICATIONS FOR TEACHING II

CONTENTS

1.0 INTRODUCTION

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

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

2.0 OBJECTIVES

After studying this unit, you should be able to:

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

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

3.0 MAIN CONTENT

3.1 Robert Gagne's Theory of Learning

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

SELF-ASSESSMENT EXERCISE 1

Name the highest level of Gagne's learning hierarchy.

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

SELF-ASSESSMENT EXERCISE 2

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

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

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

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

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

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

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

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

3.2 Jean Piaget's Theory of Learning

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

SELF-ASSESSMENT EXERCISE 3

What are the developmental stages identified by Jean Piaget?

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

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

3.2.1 Sensory – motor stage (0 – 2 years)

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

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

3.2.2 Pre – operational stage (2 – 7 years)

SELF-ASSESSMENT EXERCISE 4

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

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

SELF-ASSESSMENT EXERCISE 5

List the child attributes at pre-operational stage.

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

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

At this stage also, the child represents objects by images. For this reason, he constantly reorganizes his picture of the world (i.e. his/her environment) through imaginative play. The child also uses language (i.e. words) by talking, questioning, listening and experimenting. Talking to self or object is part of the characteristics of this stage.

3.2.3 Concrete – operational stage (7 – 11 years)

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

SELF-ASSESSMENT EXERCISE 6

What is the implication of concrete – operational stage?

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

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

3.2.4 Formal operational stage (11 – 15 years)

SELF-ASSESSMENT EXERCISE 7

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

Progression through the previous stages results in accumulation of experiences and development of mental structures, which are necessary

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

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

- Science teachers should promote exploration and interaction with environment using locally available materials.
- Science teachers should ensure that learners deal with concrete materials before going to the complex ones and later they will learn abstract concepts and generalizations.
- Science teachers should commence teaching of science concepts starting from simple to complex ones.
- Science teacher should present new ideas and knowledge at the level consistent with the child's present state of development, thinking and language.
- Science teacher should focus on problem solving rather than rote memorization during teaching/learning process.
- Science curriculum should be designed in such a way that the student will have opportunities to perform desirable mental operations.

4.0 CONCLUSION

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

5.0 SUMMARY

In this unit, you have learnt that:

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

- Gagne believes that the materials meant for learning must be sequentially structured.
- In the implications of Gagne's theory for science teaching and curriculum development:

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

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

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

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

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

6.0 TUTOR-MARKED ASSIGNMENT

List and discuss the Jean Piaget's general principles of how you, as an integrated science teacher, should teach integrated science in your classroom.

7.0 REFERENCES/FURTHER READING

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MODULE 3 METHODS AND TECHNIQUES OF TEACHING INTEGRATED SCIENCE

INTRODUCTION

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

Unit 1 Methods of Teaching Integrated Science
Unit 2 Resources for Teaching Integrated Science
Unit 3 Preparation for Teaching Integrated Science
Unit 4 Science Laboratory Design, Safety and Organisation
Unit 5 Evaluation of Science Teaching and Learning with reference to Integrated Science

UNIT 1 METHODS OF TEACHING INTEGRATED SCIENCE

CONTENTS

1.0 INTRODUCTION

The word teaching embraces curriculum planning, instruction, measurement and evaluation. The methods of teaching are the approaches or means, which a teacher could adopt in order to carryout the function of instruction of lessons. Some of the methods used by science teachers in presenting scientific information, principle or skill to the pupils include: lecture or chalk-talk, demonstration, discussion, project, discovery, laboratory or investigative, field trips, etc. Each

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

SELF-ASSESSMENT EXERCISE 1

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

2.0 OBJECTIVES

After studying this unit, you should be able to:

- list some methods that are adequate for teach integrated science;
- describe the activities involved in each method;
- state the advantages and disadvantages of each method;
- explain the factors to be considered in choosing any method(s) to be used for teaching a particular lesson.

3.0 MAIN CONTENT

3.1 Selection of Teaching Method

Before selecting a method, approach or technique for teaching in integrated science, the teacher should consider the following:

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

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

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

Similarly, the inquiry or discovery method and project method will teach problem solving skills better than discussion or lecture methods.

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

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

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

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

SELF-ASSESSMENT EXERCISE 2

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

3.2 Methods of Teaching Integrated Science

The methods of teaching integrated science could be grouped into two:

(i) The general methods

(ii) Specialized methods or strategies.

The general method of teaching integrated science includes:

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

The specialized methods are used for specific purposes in integrated science teaching. They include:

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

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

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

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

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

Its disadvantages include:

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

SELF-ASSESSMENT EXERCISE 3

Discuss any four methods of teaching integrated science. State their advantages and disadvantages.

The discovery method/inquiry method: The discovery method involves a structured or unstructured exploration in the laboratory in which the student, through his mental processes such as observing, measuring, classifying, hypothesizing, etc. can draw conclusion from data, which has been gathered and analyzed.

There are two types of discovery method namely: (1) Guided inquiry (2) Unguided inquiry methods. Both involve "finding out" and lead to what is generally regarded as the scientific method, which includes the following processes:

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

Advantages

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

Disadvantages

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

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

Advantages of discussion method

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

Disadvantages

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

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

SELF-ASSESSMENT EXERCISE 4

What are the merits and demerits of project method?

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

Advantages of laboratory method

1. Adequate for illustrating scientific principles, laws and inculcate in students how to write laboratory reports.
2. Provides opportunity for students to develop practical and manipulative skills while using science equipment and apparatus.
3. It enables students to imbibe the culture of replication of experiments done by others in the past.
4. Inculcate the habit of critical thinking and improves understanding of concepts, laws, principles and facts.
5. It leads to better retention and recall of scientific information, hence engenders positive attitude towards science by the learner
6. It makes students to become familiar with the scientific processes of observing, inferring, classifying, measuring, interpreting data, hypothesizing, etc.

Disadvantages

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

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

Advantages

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

Disadvantages

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

4.0 CONCLUSION

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

5.0 SUMMARY

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

6.0 TUTOR - MARKED ASSIGNMENT

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

7.0 REFERENCES/FURTHER READING

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UNIT 2 RESOURCES FOR TEACHING INTEGRATED SCIENCE

CONTENTS

1.0 INTRODUCTION

One basic assumption made in developing Integrated Science is that formal laboratories and traditional science equipment would not be necessary for teaching the subject. It is against this background that, material resources for teaching Integrated Science shall be dealt with in this unit. As stated earlier on in this course, the teacher plays a central role in the effective teaching of Integrated Science.

The teacher is the manager of all affairs that goes on within the science classroom or science laboratory. He also manages a number of things outside his science classroom and laboratory. In line with this, resources for the teaching of Integrated Science can be categorized into two major parts. These are:

(i) Material/non-human resources
(ii) Human resources.

These two resources shall be extensively dealt with in this unit.

2.0 OBJECTIVES

After studying this unit, you should be able to:

- realize and discuss the central role of the teacher in the effective utilization of resources for teaching integrated science
- list the two major resources for teaching integrated science
- give detailed explanation on each of the resources available for the teaching of integrated science.

3.0 MAIN CONTENT

3.1 Non Human/Material Resources

Both the human and non-human resources at the Integrated Science teacher's disposal are inseparable. The reason(s) for this is not far-fetched. Science is an experimental subject, which involves the use of materials, equipment and apparatus. Let us now examine these material resources in much more details.

(i) Integrated Science Classroom

Integrated Science like other science subjects could be handled in the laboratory or the conventional classroom depending on the situation. This means that integrated science will just be one of the subjects taught in the classroom. Then there is the need for proper attention to be given to the structure of the classroom. Wherever available, classroom for teaching integrated science should be large enough and spacious enough to allow free movement of learners in the classroom. There would be frequent needs for students to leave their seats to collect pieces of equipment/apparatus from the teacher's demonstration table. There would also be a frequent need for the integrated science teacher to move round the classroom to supervise students' work either as individuals or in groups.

(ii) Classroom Furniture

Desks, benches and tables usually constitute the furniture in the classrooms. Learners' desk tops should be of reasonable area, flat tops and horizontal but not slacking. The desks should be movable and detached from the benches.
This is necessary so that it would be possible to put such desks together into groups of two or four students or more as occasion may demand. Thus, it is important to provide good working situation because group work would dominate most of integrated science teaching strategies.

(iii) Service point

There are two important service points in an integrated science classroom. These are:

(a) water tap service point
(b) burners (Bunsen burners)

There should be at least four water taps in a classroom to accommodate forty students. Where there are no pipe borne water, there should be at least four plastic buckets of water in the classroom; and placed on tall stools or stands.

There should also be four Bunsen burners with movable gas cylinders in a class of forty students. These gas cylinders should always be operated by the integrated science teacher or the laboratory assistant or his assistant. More preferably, the gas cylinder should be located on the sides of the classroom and very close to the windows. Students' attention should however be drawn to the danger inherent in the use of gas in the classroom.

(iv) Teacher's Demonstration Table

Teacher's demonstration table is very important in the teaching of integrated science. The teacher demonstration table should therefore be located / constructed on a high platform in the classroom. This has the following advantages:

(i) it enables the students participate fully in the lesson or what the teacher is demonstrating;
(ii) it will prevent unusual overcrowding of anxious students round the demonstration table;
(iii) it enhances effective classroom management and control;
(iv) it enforces safety precautions during a demonstration.

3.1.1 Equipment and Apparatus

(i) Fire Fighting Equipment

If all safety precautions are taken, it is unlikely to have fire outbreak in an integrated science classroom. However, it is usually advisable to keep in the classroom a fire extinguisher. Where a fire-extinguisher could not be procured due to its high cost, it is advisable to have a bucket of dry sand placed in an accessible position in the classroom in place of conventional fire extinguisher. There should also be at least two exits from the classroom especially when there is need to rapidly evacuate students from the classroom in the occasion of fire outbreak.

(ii) Glassware (or Plastic wares)

Glassware – test tubes, beakers, wash glasses are essential tools in the teaching of integrated science. Glasswares no doubt can be expensive, most especially where breakages is high. Nowadays

there has been move to replace glasswares with plastic wares especially if no direct heating in an open fire is required. Below is a list of some basic pieces of glasswares or plastic apparatus necessary for the teaching of integrated science.

(a)	test tubes	(b)	boiling tubes
(c)	measuring cylinders	(d)	petri dish
(e)	watch glasses	(f)	funnel
(g)	flat bottomed flask	(h)	round bottomed flask
(i)	stirring rods	(j)	delivery tubes
(k)	beakers	(l)	volumetric flasks
(m)	thermos flasks	(n)	reagent bottles
(o)	dropper bottles	(p)	specimen bottles
(q)	photometer	(r)	conical flasks
(s)	trough	(t)	basins

The number and sizes of the apparatus are to be determined by the integrated science teachers. This is necessary so that it would be possible to put such desks together into groups of two or four students or more as occasion may demand. Thus, it is important to provide good working situation, because group work would dominate most of integrated science teaching strategies.

3.1.2 Locally Available Materials / Apparatus

A number of useful pieces of materials are now readily obtainable in our environment (especially in open markets). Of particular interest is the range of plastic materials which are manufactured locally. For instance, plastic basins, buckets, cups and receptacles can now replace troughs, beakers, Petri dishes etc. Here the teacher needs to apply his 'native wigg' or 'personal discretion' as to which of these locally available materials can be brought into the teaching of integrated science.

Occasionally, too, teachers can bring useful pieces of discarded equipment and utensils from home. Some of these useful discarded pieces of apparatus can be requested for from non-integrated science teachers. Hence, cooperation between the home and school could be a useful way to enhance an effective teaching of integrated science.

SELF-ASSESSMENT EXERCISE 1

i. Write down a list of glasswares available for the teaching of Integrated Science.
ii. Give an account of what an Integrated Science classroom should look like.

3.2 Human Resources

In consideration of the human resources available for teaching Integrated Science, two major resources stand out. These are:

(i) Qualified Integrated Science teacher
(ii) Laboratory staff and other support staff.

(i) Qualified Integrated Science Teachers

It is no news that there is problem of teacher supply and demands. It appears as if integrated science is facing a special type of problem. There is currently insufficient number of integrated science specialists. No teachers, even the NCE and University graduates want to be known as integrated science specialists. Rather, they prefer being single subject specialists or at best two subject specialists (especially at NCE level). This situation has created the present scarcity of integrated science teachers at all levels of Education in Nigeria. Suffice it to say however, that the situation is currently being addressed. More Colleges of Education and Universities are now running programmes leading to the award of Nigerian Certificate in Education, NCE (either as single or double major) and at first degree level. A number of Universities also offer higher degrees in Science Education even up to Doctoral level. With this move in the positive direction, non-availability of integrated science teachers will soon be a thing of the past. With the three / four year education programme in Colleges of Education and Universities, it is now possible to train and prepare specialist integrated science teachers. However, it is worthy of note to state that, integrated science at the junior secondary school level should and in fact must be handled by science education graduates who are knowledgeable enough in both the **'content'** and **'processes'** of the subject.

For the single science subject graduates who might be interested in teaching integrated science, opportunities are now available for them to undergo in-services training courses. Graduate science teachers should take the advantage of such vacation courses to update themselves with the philosophy and approaches to the teaching of integrated science. There is also the need for various Ministries of Education and school principals to support such teachers to attend such courses.

(ii) Laboratory Technicians

In a standard laboratory, provision should be made for laboratory staff such as laboratory technicians/laboratory technologist. They constitute a vital component of the teaching force. But the most unfortunate thing with our education system is that, school administrators are yet to see

the need for these all-important support staff for effective teaching of not only integrated science alone but all the sciences. This lukewarm attitude of school administrators towards their employment has often put a lot of burden on the teacher. This category of support staff usually renders useful assistance for the integrated science teachers in effective handling of his or her lesson. The absence of qualified laboratory technicians in most of our schools can make the job of the teacher of integrated science very difficult, but as the situations are now, the integrated science teacher has to cope with the problem.

Most school systems do **employ laboratory assistants** or **attendants** to help the science teachers. The problem with such assistants or attendants is that most of them are not specially trained to work in a laboratory. It then behoves on the teacher to take up the responsibility of training such support staff anytime they are employed to assist him or her. The integrated science teacher should also make laboratory 'assistant' or **attendant** to be interested in science. It is also the responsibility of the integrated science teacher to recommend his untrained laboratory assistants for the many in-service courses run by the various Ministries of Education etc.

4.0 CONCLUSION

It has been established in this unit that, an array of resources is available for effective teaching and learning of integrated science at any level of education. The resources were broadly classified into two groups viz: the human and non-human resources. Teachers of integrated science should harness these abundant human and non-human resources to achieve the national goal for teaching integrated science.

5.0 SUMMARY

In this unit, you have learnt about the following:

- that there are two main kinds of resources available for teaching of integrated science'
- that the resources could either be materials/physical or human resources;
- that physical/non-human resources include the science classroom, science laboratory, service point, equipment/apparatus, glasswares/plastic wares, time and time table, integrated science curriculum/syllabus, scheme of work etc.
- that human resources include the integrated science teachers themselves, laboratory technologist, technicians, laboratory assistants and laboratory attendants.

- that the resources are at the disposal of the integrated science teacher who would need to harness all for the attainment of goal of science education;
- that in all, the teacher plays a central role.

6.0 TUTOR-MARKED ASSIGNMENT

Write a detailed but concise essay on the teacher as a manager of learning environment or learning experience.

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UNIT 3 PREPARATION FOR INTEGRATED SCIENCE TEACHING

CONTENTS

1.0 INTRODUCTION

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

2.0 OBJECTIVES

After studying this unit, you should be able to:

- describe a integrated science curriculum, syllabus and scheme of work
- prepare a integrated science scheme of work
- prepare a lesson plan on a chosen integrated science topic
- prepare a note of lesson on a chosen integrated science topic.

SELF-ASSESSMENT EXERCISE 1

How does an integrated science teacher begin the teaching of integrated science with junior secondary students?

As an integrated science teacher you should begin by looking at the subject curriculum for the topics to teach that will draw upon the student's stock of knowledge of integrated science. This stock of knowledge is sorted out and the topics classified in the curriculum.

3.0 MAIN CONTENT

3.1 What is a Curriculum?

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

The term integrated science curriculum can therefore be defined as:

- a systematic arrangement of a number of integrated science topics into a unit for a particular level of integrated science students.

- All integrated science experiences the integrated science students have under the schools direction

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

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

SELF-ASSESSMENT EXERCISE 2

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

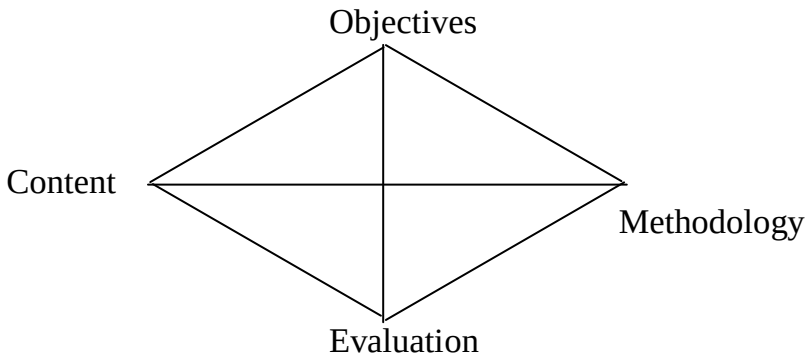

Fig. 1: Interrelated Components of Curriculum

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

3.2 Integrated Science Syllabus

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

There are two types of integrated science syllabus:

i) Integrated science examination syllabus
ii) Integrated science teaching syllabus

SELF-ASSESSMENT EXERCISE 3

Mention two each of integrated science examination and teaching syllabi.

The integrated science examination syllabus indicates integrated science topics to be covered for a particular examination in integrated science. For instance, Junior Secondary Certificate Examination syllabus on integrated science is integrated science examination syllabi.

The integrated science teaching syllabus is an outline of the work planned to be done in a course of one term or one year with each class at junior secondary school level in integrated science. The integrated science topics are arranged in a logical sequence according to the

relationship between the various integrated science topics in the syllabus.

SELF-ASSESSMENT EXERCISE 4

Who are the people responsible for the development of the integrated science syllabus in Nigeria?

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

As an integrated science teacher, you should employ the following principles in drawing up an integrated science -teaching syllabus from integrated science examination syllabus and the Integrated Science Curriculum for level of students being considered.

These are:

- arrange the integrated science topics in such a way that your teaching proceeds from the known to the unknown. Taking into consideration the background of the students

- proceed from easy integrated science concepts to the abstract concepts.

In integrated science teaching at junior secondary one (JSS1) for instance, causes of motion of material bodies should be preceded first by the concepts of distance, time and speed. You as an integrated science teacher should ensure that the integrated science teaching syllabus is arranged so that the topics suit the intellectual or academic level of the students. A most effective integrated science teaching syllabus lends itself to the formulation of the scheme of work from it since it spells out the following necessary information:
What integrated science topics are to be covered in a specific period;

- The depth of coverage of the integrated science topics
- The sequence of treatment indicating the integrated science topics that will require more time than others
- Guidelines for methods of teaching
- References and materials needed for each integrated science topics.

SELF-ASSESSMENT EXERCISE 5

Which of the two integrated science syllabus has a direct relation with integrated science scheme of work?

3.3 Integrated Science Scheme of Work

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

SELF-ASSESSMENT EXERCISE 6

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

The integrated science scheme of work should be revised from time to time depending on the rate at which the integrated science students progress in the learning of the integrated science concepts. The integrated science scheme of work which can also be referred to as a written plan showing what integrated science topics are to be covered weekly or fortnightly is drawn up from an integrated science teaching syllabus taking into consideration the following factors as stated by Abdullahi (1982).

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

SELF-ASSESSMENT EXERCISE 7

List the components of a good integrated science scheme of work.
The scheme of work on integrated science will also assist you as a integrated science teacher to fulfill the following functions in the school:

- it will direct attention to major integrated science topics

- it will facilitate careful and meaningful planning on the part of the integrated science teacher
- it will allow for greater flexibility in the implementation of integrated science teaching syllabus.

3.4 Integrated Science Lesson Plan

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

SELF-ASSESSMENT EXERCISE 8

Should the preparation of an integrated science lesson plan be a weekly or monthly affair?

An integrate science lesson plan is a daily outline of learning activity for integrated science students at junior secondary school level. The plan is usually drawn up after the preceding integrated science lesson.

SELF-ASSESSMENT EXERCISE 9

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

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

Format of a suggested Daily Integrated Science Lesson Plan

Subject:	Integrated Science
Class:	JS1
Date:	Day/Month/Year
Unit:	Living things in the environment
Topic:	Plants and Animals
Average age:	10 years
Time of the lesson:	9.05 – 9.45am

Duration: 40 minutes

Instructional Objectives: These are the objectives that are stated in terms of what an integrated science teacher is going to do during this particular lesson or period. It focuses attention on the teaching process rather than on the learning outcomes to be attained by instructional objectives are:

- To differentiate between plants and animals
- To demonstrate how to examine some cells under a microscope
- To draw and label plants and animals cells on the chalk-board
- To classify animals into those with backbones and those without
- To classify plants to whether they have flowers or not

Behavioural objectives: These are the objectives that are stated in terms of the outcomes the teacher expects from his/her teaching. Here the attention is shifted from the teacher to the learner. As regards this lesson, the behavioural objectives are stated as follows:

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

- Describe the differences between plants and animals;
- Draw and label correctly plant and animal cells;
- Classify animals into those that have backbones and those that do not;
- Classify plants according to whether they have flowers or not

TIME	PART OF THE LESSON	ACTIVITY
9.05–9.07(2mins)	Introduction	Instruct a student to bring his desk to the front and ask the students to push the desk forward to cover some distance. Ask the students to mention the differences between the two.
9.079.37(30mins)	Presentation	i. Put a microscope on the table in front of the class and ask the students to come up to the front to have a look at it. ii. Operate the microscope for the students to see. iii. Ask a student to scrap the inside of his/her cheek with a clean spoon. iv. Put the scrapings on a microscope slide and add one drop of iodine solution or methylene blue. Mix well and cover with a covership. v. Instruct the students to come one after the other to look at the slide under the microscope. vi. Ask them what they see. vii. Instruct them to draw what they see. viii. Instruct the students to watch carefully take a thin strip of onion skin that they can see through (i.e. transparent). ix. The teacher places this thin skin on a microscope slide and adds a drop of iodine solution for students to see. x. Instruct the students to come one after the other to look at the slide under the microscope. xi. Ask the students what they see. xii. Instruct them to draw what they see. xiii. Classify animals on the basis of their foods (i.e. grass eaters (herbivores), flesh eaters (carnivores) and both grass and flesh eaters (omnivores). xiv. Classify animals into those with backbones (vertebrates) and those without backbones (invertebrates). xv. Classify plants into those have flowers (flowering plants) and those without flowers (non-flowering plants).
9.37 – 9.40 (3 mins)	Summary	Highlight some of the important points and the correct label diagrams on the chalkboard
9.40 – 9.45 (5 mins)	Evaluation / Assignment	Ask questions on what you taught either orally or written.
	Home work	For assignment ask the students to further read the topic treated from their textbook and answer the questions provided in the exercise.

SELF-ASSESSMENT EXERCISE 10

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

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

* General Information:

  - School
  - Subject
  - Class
  - Age
  - Time and Duration
  - Topic
  - Unit

* Objective — What product, process or affective objectives does the integrated science teacher have for this integrated science lesson?

* Resources — What equipment, teaching aids, text material etc. will be needed?

* Introduction — This relates to how the integrated science teacher will prepare integrated science students for this lesson.

* Learning Activities — Presentation / Development of lecture, demonstration, discussion etc. should fit the objectives

* Time Allotment — Approximately how long do you expect each activity to last

* Evaluation /Assignment — How will the integrated science teacher determine if integrated science students have learned what he/she have taught. The integrated science teacher may decide to give integrated science students some work to do at home or during the lesson or at students' free time in the school. All these should feature in the integrated science lesson plan.

SELF-ASSESSMENT EXERCISE 11

What is the difference between an integrated science lesson plan and lesson note?

3.5 Integrated Science Lesson Notes

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

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

A specimen of an Integrated Science Lesson Note prepared by a B. Sc. (ed.) student:

School:	Name of the School
Date:	Day / Month / Year
Subject:	Integrated Science
Class:	Junior Secondary One (JS 1)
Time:	9.05 – 10.25 am (40 minutes)
Unit:	Living things in the Environment
Topic:	Plant and animals
Objectives:	At the end of the lesson the students should be able to:

- Describe the differences between plants and animals
- Draw and label plants and animal cells
- Classify animals on the basis of the foods they eat (i.e. herbivores, carnivores and omnivores)
- Classify animals into those with backbones (vertebrates) and those without backbones(invertebrates)
- Classify plants into flowering and non-flowering plants.

Previous Knowledge:	Students must have learnt living things and their characteristics.

Teaching Aids: Microscope, slide, iodine, solution or methylene blue, clean spoon, onion.

References: STAN (1999) Nigerian Integrated Science Project. Pupils' Textbook One. New Edition. Heinemann Educational Books (Nig.) Ltd. Pp. 44 – 51.

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

1. What is living things?
2. Give examples of living things in the school environment.
3. Mention the characteristics of living things.

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

Presentation or Development:

Step I: The teacher demonstrates how to use a microscope placed on the table in front of the class.

Step II: The teacher instructs the students on what to do to get the microscope perform.

Step III: The teacher assists the students in mounting the slide containing the specimen on the microscope to watch and draw what they see.

Step IV: The teacher assists the students in modifying and labeling the respective diagrams of both the animal and plant cells drawn.

Step V: The teacher asks the students to name different animals and the foods they ate.

Step VI: The teacher assists the students in classifying the animals name above into grass eaters (herbivores), flesh eaters (carnivores) and both grass and flesh eaters (omnivores).

Step VII: The teacher asks the students to name animals with backbones (vertebrates) and those without backbones (invertebrates).

Step VIII: The teacher asks the students to name plants that have flowers and those without flowers.

Summary:

- Both plants and animals show all the characteristics of living things (they move, feed, breathe, excrete, grow, reproduce and respond to changes in the environment).
- Plants and animal cells have a cell membrance, cytoplasm, vacuole or vacuoles and a nucleus.
- Plant cells have a cell wall and usually contain chloroplasts (these contain a green material which gives plants their green colour). These are absent in animal cells.
- Plants are usually rooted in one place, whereas most animals can move from place to place.
- Animals can be grouped into those that eat grass (herbivores), those that eat flesh (carnivores) and those that eat both grass and flesh (omnivores).
- Examples of herbivorous animals are goat and cow; carnivorous are cat and dog while omnivorous is man.
- Animals can be grouped into those which have backbones (vertebrates) and those which do not (invertebrates).
- Examples of vertebrates are fish, goats, dogs, man etc. while invertebrates are centipedes, crabs, spiders etc.
- Plants can be grouped into those that have flowers (flowering plants) and those that do not (non-flowering plants).

Evaluation: The teacher asks the students the following questions orally:

1) How would you distinguish a plant from an animal?
2) Name three invertebrates and three vertebrates that you know.
3) Give examples of flowering and non-flowering plants in your area.

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

(i) Draw and label a typical animal cell and a typical plant cell.
(ii) List **10** each of herbivores, carnivores and omnivore animals.

SELF-ASSESSMENT EXERCISE 12

Write an integrated science lesson note for a choosen integrated science topic for JS1 students that will cover a 40 minutes period.

4.0 CONCLUSION

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

5.0 SUMMARY

In this unit, you learnt:

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

6.0 TUTOR-MARKED ASSIGNMENT

1 List the components of a well written integrated science lesson note.

2 Develop an integrated science lesson note that you will use to teach "States of matter" in junior secondary One (JS1) integrated science class for forty minutes.

7.0 REFERENCES/FURTHER READING

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

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UNIT 4 SCIENCE LABORATORY DESIGN, SAFETY AND MANAGEMENT

CONTENTS

1.0 INTRODUCTION

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

2.0 OBJECTIVES

After studying this unit, you should be able to:

- describe a science laboratory
- discuss some of the safety rules that should be enforced in any science laboratory
- describe the organisation of the science laboratory
- discuss how a science laboratory is managed
- discuss the major roles of the head of any science unit
- discuss the roles of the science teacher and laboratory attendant in the science laboratory

3.0 MAIN CONTENT

3.1 The Science Laboratory

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

SELF-ASSESSMENT EXERCISE 1

When and how does the laboratory work begin?

The laboratory work became a permanent feature in science teaching in high schools in the 19th century (Abdullahi, 1982). The practice then was that the community scientists arranged demonstration lectures that usually attracted young ones who were interested in learning science. Prominent pioneer scientists such as Lavoisier, Priestley, Cavendish, Dalton and Berzelius converted their homes into laboratories where regular demonstration lecturers were held.

The laboratory work is very important to students who study science because most recent and modern science curricula emphasize students' full involvement in science teaching through practical work in the laboratories. The Nigerian Integrated Science Projects (NISP) developed by STAN and the Nigerian Secondary School Science Project (NSSSP) developed by CESAC placed much emphasis on laboratory work. The emphasis on laboratory work is in keeping with the demand of science which requests certain skills to be developed in the students. Such desirable knowledge and or skills include:

- the ability to plan an experiment and analyse the practical problem into its component parts;
- the ability to perform experiment;
- the ability to interpret the results of the experiment and draw conclusion.

SELF-ASSESSMENT EXERCISE 2

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

3.2 Science laboratory design

Any modern science laboratory design has the following general features:

(a) Preparation Room This room should have the following facilities:

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

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

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

(d) Detached Store Highly inflammable substances like ether, petroleum ether, toluene, acetone and alcohol are kept in special stores which are located in a separate place outside the laboratory.

(e) Staff office for laboratory technicians

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

SELF-ASSESSMENT EXERCISE 3

How safe is your school science laboratory?

3.3 Science laboratory safety

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

SELF-ASSESSMENT EXERCISE 4

How does health hazard occur in science laboratory?

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

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

SELF-ASSESSMENT EXERCISE 5

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

These features could be:
adequate storage facilities
fire equipment
scape routes
ventilation facilities
first aid box.

3.3.1 Science laboratory techniques for safety

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

SELF-ASSESSMENT EXERCISE 6

How will you as a science teacher enforce the ten safety rules?
The rules are:

i) Do wait outside the laboratory until you are asked to come in;
ii) Do only the experiments authorized by your teacher;
iii) Do heat liquids slowly and rotate test tubes to avoid overheating one area;
iv) Do wet the end of glass tube before inserting it into rubber-tube or stopper and use a towel to insert the glass tube;

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

SELF-ASSESSMENT EXERCISE 7

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

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

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

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

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

SELF-ASSESSMENT EXERCISE 8

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

3.3.2 Organization of the science laboratory

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

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

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

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

SELF-ASSESSMENT EXERCISE 9

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

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

SELF-ASSESSMENT EXERCISE 10

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

The apparatus to be stored in the store room vary in sizes and in shapes, the small pieces of apparatus, magnets, polythene rods etc. can conveniently be stored in shallow drawers and other sets of apparatus of slightly larger sizes such as ray-boxes requires rather deeper drawers. It is suggested that one wall of the storeroom should have cupboards

containing trays of three different depths. Such trays enable the whole volume of a cupboard to be utilized, whereas the conventional cupboard with a shelf uses only a fraction of the total volume for actual storage.

3.4 Science laboratory management

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

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

SELF-ASSESSMENT EXERCISE 11

What do you think should be the major concern of head of any science subject in the management of their unit in your school?

3.4.1 The Head of Science Unit

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

These are:

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

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

- **Training of personnel in the unit**: This should be one of the major concerns of any of the science unit heads. You should make sure that the staff members both teaching and non-teaching in the unit are recommended for promotions, attend conferences,

workshops and seminars and are also given study leave when appropriate.

SELF-ASSESSMENT EXERCISE 12

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

3.4.2 Some roles of the Head of Science Unit

- **Formation of Unit timetable** – The head of any science unit joins his/her colleagues in other science units to work on the general school timetable for scheduling the different unit's timetable that involve the staff members within the unit and displays it in their different unit laboratory.

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

  Some of the headings could be:

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

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

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

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

SELF-ASSESSMENT EXERCISE 13

Apart from the teaching of the science subjects, what other roles do you perform in your school as an integrated science teacher?

3.4.3 Other Roles of any Science teacher in the laboratory

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

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

- **Stock control, requisition and receipt of supplies**–As a science teacher, you should ensure that you take proper records of all the incoming and outgoing stock from the science storeroom. You should also have a requisition book for your request and always issue a receipt or sign for supplies made to the storeroom.

- **Recording breakages/damages**–There could be breakages especially with glasswares and damages of equipment in the

laboratory. These breakages and damages should be recorded by any science teacher for replacement.

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

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

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

SELF-ASSESSMENT EXERCISE 14

Do you have science laboratory technician(s) in your school?

3.4.4 Roles of any science laboratory technicians/assistants

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

The primary duty of any science laboratory technician(s) is to maintain and repair damaged science equipment. Apart from this, a science laboratory technician(s) also performs the following tasks:
Keeping all science materials/equipment clean and tidy;
Setting up or dismantling demonstration equipment;

- Ordering of all science equipment;
- Storing of all science equipment in accordance with a regular order;
- Keeping adequate records of purchases and damages;
  Make minor repairs of any science equipment;

- Experienced technicians or attendants also serve as science resource persons to science students.

4.0 CONCLUSION

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

5.0 SUMMARY

In this unit, you learnt that:

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

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

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

- water
- gas
- electricity

- The management of any science laboratory involves:

- the head of the unit
- the science teacher
- the science laboratory technicians/attendants.

6.0 TUTOR-MARKED ASSIGNMENT

1 Itemize and discuss the use of laboratory exercise in teaching integrated science at junior secondary level.

2 What are the advantages of using laboratory method in teaching science at junior secondary level?

7.0 REFERENCES/FURTHER READING

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UNIT 5 EVALUATION OF SCIENCE TEACHING AND LEANING WITH REFERENCE TO INTEGRATED SCIENCE

CONTENTS

1.0 INTRODUCTION

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

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

2.0 OBJECTIVES

After studying this unit, you should be able to:

- define test and assessment;
- discuss the functions of the classroom tests;
- list and discuss the forms of assessment in science;
- state the merits and demerits of all the forms of 'paper and pencil' tests;
- discuss the principles of test construction in science teaching with particular reference to integrated science;
- describe a marking scheme;
- describe how to prepare marking schemes for essay type and objective type examinations.

3.0 MAIN CONTENT

3.1 Meaning of Test and Assessment

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

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

SELF-ASSESSMENT EXERCISE 1

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

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

3.2 Functions of Tests

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

- instructional
- guidance
- administrative

3.2.1 Instructional functions of a test

- Testing of students progress in the science class provides the science teacher with the information on the students rate of learning. This will enable the teacher to provide more appropriate instructional guidance.
- Test construction reminds the science teacher of the objectives of the course. The process of test construction at times helps the science teacher to redefine the course objectives in clearer terms.

3.2.2 Guidance functions of tests

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

3.2.3 Administrative functions of tests

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

3.3 Forms of Assessment used in teaching/learning processes

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

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

3.3.1 Oral form of Assessment

SELF-ASSESSMENT EXERCISE 2

What is the usefulness of this form of assessment in integrated science teaching?

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

3.3.2 Written form of assessment

SELF-ASSESSMENT EXERCISE 3

How often do you as an integrated science teacher encourage the use of this form of assessment when teaching integrated science?

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

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

3.3.3 Project form of assessment

SELF-ASSESSMENT EXERCISE 4

What form of assessment will you as an integrated science teacher use in assessing your teaching?

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

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

3.4 Essay type test

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

SELF-ASSESSMENT EXERCISE 5

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

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

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

SELF-ASSESSMENT EXERCISE 6

Construct **four** essay type questions in integrated science for JS1 students on the concept of work.

3.4.1 Merits and Demerits of Essay Type Test

The merits of essay tests are:
It promotes better study habit;
It reduces the possibility of cheating;
It requires a high degree of thinking rather than rote learning;
It demands recall rather than identification

The demerits of essay tests are:

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

3.5 Objective Type Test

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

SELF-ASSESSMENT EXERCISE 7

List the forms of objective test

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

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

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

3.5.1 Short answer items or completion test

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

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

SELF-ASSESSMENT EXERCISE 8

Construct five short answer items on a chosen topic in integrated science for JS1 class.

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

1. The outer layer of an animal cell is ……...
2. The vacuoles of animal cell may contain ……...
3. The cell wall of a plant cell is made of a substance called ……
4. Living things can be divided into …… and ……
5. Animals that eat grass only are called ……..…….
6. Living organisms without backbones are called ……
7. Plants can be classified into …….. and …….
8. Animals with backbones are called ……
9. Another name for backbone is ……
10. Most animals move about, while plants remain in …….

3.5.2 Multiple choice items

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

SELF-ASSESSMENT EXERCISE 9

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

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

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

Some of the demerits of multiple-choice tests are:

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

Examples of multiple choice test on integrated science are:

1. All living things are made up of ……..
A. cellulose
B. one or more cells

C. no cell
D. less cell
E. more or less cells

2. The activities of the cell in either plant or animal is controlled by ……
A. vacuole
B. membrance
C. cytoplasm
D. nucleus
E. cell wall

3. Which of the following group of animals are carnivores?
A. goat and cow
B. cow and cat
C. cat and dog
D. goat and cat
E. cat and man

4. Which of the following is NOT an example of a vertebrate?
A. snake
B. frog
C. lion
D. centipede
E. bird

3.5.3 Matching items

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

SELF-ASSESSMENT EXERCISE 10

When is the matching item useful in teaching / learning process?

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

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

A	B
Chloroplast	A rigid structure which supports the body and is important in movement.
Omnivores	The substance that make the plant cell more rigid than an animal cell.
Skeleton	Small green objects which give plants their characteristic green colour.
Cellulose	Animals that feeds on both plants and flesh.

3.5.4 True – False Items

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

Examples of true/false items on integrated science are:

T F - All living things are made up of one or more cells.

T F - Animals that are made up of one cell only are called unicellular

T F - Animals that feed on plants only are called carnivores

T F - Spiders, scorpions and mosquitoes are vertebrates

T F - The followings are characteristics of living things: Movement, Feeding, Reproduction, Dancing, and Sleeping etc.

3.6 Principles of test construction in science teaching

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

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

Table 1: Table of specification for an integrated science multiple choice test

Integrated Science Concepts Tested	COGNITIVE LEVELS TESTED						TOTAL
	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation	
Learning about things	3	2	1	0	0	0	6
Living things	4	2	2	0	0	0	8
Reproduction	3	2	1	0	0	0	6
Personal Health	5	3	2	0	0	0	10
Total	**15**	**9**	**6**	**0**	**0**	**0**	**30**

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

SELF-ASSESSMENT EXERCISE 11

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

In all, a total of 30 items are generated to cover all the 4 integrated science concepts listed. The 30 items are also spread according to the cognitive levels required in all the concepts. It is observed that no item was distributed in each of the integrated science concepts to the evaluation levels of cognition. This is because at the junior secondary level of integrated science learning, students may have not attained such level of cognition. In the 4 concepts to be tested no items are distributed to analysis, synthesis and evaluation because it is believed that these concepts are usually considered abstract by students. With reference to the National Curriculum on Integrated Science, the document recommended that items to be tested should cover the first two cognitive levels (i.e. knowledge and comprehension) for the first year of junior secondary level while the first three levels (i.e. knowledge, comprehension and application) are recommended for the third year of junior secondary level.

3.7 Marking schemes for grading essay type and objective type in Integrated Science

What is a marking scheme?

A marking scheme is a model solution prepared by an examiner with marks distributed proportionately across the different sections of test items in the essay type examinations. In the case of objective test, the marking scheme required correct responses. All correct responses carry

equal marks despite the varying degrees of difficulty associated with different test items.

SELF-ASSESSMENT EXERCISE 12

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

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

SELF ASSESSEMENT EXERCISE 13

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

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

4.0 CONCLUSION

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

5.0 SUMMARY

In this unit, you learnt that:

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

- the three major functions of tests are:
- Instructional
- Guidance
- Administrative

- the three forms of assessment in teaching/learning processes are:
- oral form
- written (essay and objective) form
- project form

- the forms of objective type test used in school setting are:
- short answer items
- multiple choice items
- matching items
- true -false items

- steps to consider while constructing objective tests in science:
- identification of major concepts to be tested
- identification of the different cognitive levels at which concepts are to be tested
- decision on the number of test items to be included in the test
- preparation of a table of specification to guide you on the selection of test items to be used.

6.0 TUTOR-MARKED ASSIGNMENT

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

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