COURSE GUIDE

EDU 754
SUBJECT METHODS (INTEGRATED SCIENCE)

COURSE TEAM

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INTRODUCTION

This course is EDU 754: SUBJECT METHODS (INTEGRATED SCIENCE). There are 3 modules namely Historical Development of Integrated Science and Philosophy, Philosophical and Psychological Development of Integrated Science and Techniques for Teaching Integrated Science. It is a three (3) credit unit course and consists of eleven study units. No prerequisites are required for studying this course. This is because it has been prepared using suitable illustrations that are indigenous in character. Other aspects that are technical in nature have been systematically presented in a manner that would progressively enhance your understanding.

The course guide constitutes one of the many resource materials which you can avail yourself of towards effective study and successful completion of both the course and programme of your study.

Contained in this course guide are very useful pieces of information relating to the course. These include: aim and intended learning outcomes, the content of the course, materials for your use in this course, services that are available to aid your learning, and relevant information about assignments and examination. In addition, it guides you on planning your time for a more purposeful study. Information on how much time it may take you to complete each of the study units, as well as the tutor marked assignments is provided.

In addition to the above, this course guide offers answers to a number of questions you are likely to ask. Notwithstanding, you should feel free to visit (or call) your study centre in the event that you have other issues requiring attention. In the light of all of these, I urge you to diligently go through this course guide; carefully complete the feedback form before you commence studying the course. It is mandatory for you to submit the feedback form and your first assignment to the tutorial facilitator.

I wish you success at every stage of your programme.

COURSE AIM

The aim of this course is to introduce you to some of the rudiments in the teaching Basic Science and Technology in either primary school or junior secondary school or in tertiary institutions. You will learn and understand the philosophy and objectives of Integrated Science as incorporated in Basic Science and Technology curriculum and its origin. You will also be exposed to the different psychological theories of learning, their applications and implications in the teaching of Basic

Science and Technology which are necessary for you to function effectively in your chosen field of study and career.

INTENDED LEARNING OUTCOMES

For each of the units that make up this course, there are a number of intended learning outcomes. They are designed to help you in measuring the degree of your progress in the course. It is very important therefore, that you go through them prior to studying the respective units. Conclusively, by the time you finish this course, you should be able to:

- explain the nature of science
- advance reasons for science education curriculum reforms in Nigeria
- trace the historical development of integrated science in Nigeria
- discuss the concept of integration
- compare the characteristics of integrated science and non-integrated science
- understand the philosophy and objectives of integrated science
- discuss the contributions of some cognitive psychologists such as Brunner, Gagne and Piaget to science teaching and their implication and applications in teaching integrated science
- outline the methods of teaching integrated science
- describe the various resources for teaching integrated science and improvisation
- describe the usefulness of ICT in the teaching and learning of integrated science
- prepare a syllabus, scheme of work, lesson plan and lesson note for teaching integrated science in both primary and junior secondary classes
- design, organise and manage integrated science laboratory
- develop test items for multiple choice and essay in integrated science and other methods of evaluations applicable in assessing outcomes
- Be prepared for degree programme in integrated science

COURSE SUMMARY

An overview of the course is presented here in terms of the topics within each module. Module 1 presents Historical Development of Integrated Science and Philosophy. Module 2 explains Philosophical and Psychological Development of Integrated Science and Module 3 presents Techniques for Teaching Integrated Science. This course comprises eleven (11) study-units. A study-unit comprises a unit of work to be done in one (1) week, and whose completion requires you to put in about three (3) hours. Each unit contains specific intended

learning outcomes, guidance on how you should study, material to be read, self-assessment exercises. You should be able to achieve the intended learning outcomes stated for each of the study-units and the course if you devote quality attention to the exercises and assignments.

TEXTBOOKS AND REFERENCES

The primary text for the course is your course material. This notwithstanding, it is very important that you access additional sources. You will find a list of references and other materials for further reading at the end of each unit. Make some effort to get as many as you can.

COURSE MARKING SCHEME

Your assessment in the course will be based on a particular grading or marking scheme. This is presented below:

Assessment	**Marks**
Assignment 1- 4 (four submitted but the best three of all the assignments selected)	Three assignments, marked out of 10% each, totalling 30%.
Final Examination	70% of overall course score
Total	100% of course score

COURSE OVERVIEW

The table below presents the course in terms of the time required to complete each of the study-units in addition to the assignments.

Unit	**Title of Study-Unit**	**Weeks/Activity**	**Assignment**
	Course Guide	1	
Module 1 Historical Development of Integrated Science			
1	Nature and spirit of science	2	Assignment
2	Science Education Curriculum Reform in Nigeria	3	Assignment
3	Historical Development of Integrated Science Curriculum in Nigeria	4	Assignment
4	Concept of Integrated Science	5	TMA 1 to be submitted
Module 2 Philosophical and Psychological Development of Integrated Science			
1	Philosophy and Objectives of Integrated Science Psychological	6	Assignment

	Theories and Implications for Teaching		
2	Integrated Science	7	Assignment
3	Methods of Teaching Integrated Science	8	Assignment
4	Resources for Teaching Integrated Science	9	TMA 2 to be submitted
Module 3 Techniques for Teaching Integrated Science			
1	Planning for Integrated Science Teaching	10	Assignment
2	Integrated Science Laboratory, design, safety and Management	11	Assignment
3	Evaluation Procedures of the Outcomes in Integrated Science teaching and learning process	12	TMA 3 to be submitted
	Revision	13	
	Examination	14	
	Total	**14**	

Using the overview above, plan your personal timetable to aid your study.

HOW TO GET THE MOST FROM THIS COURSE

As far as distance learning is concerned, you go through course materials that are carefully prepared in a manner that would enable you read and study in ways suitable to you. The study units in this course have been prepared in a fashion peculiar in distance learning where you do not need face-to-face engagement with a lecturer.

Following from the above, the various study units possess unique characteristics that have been prepared to enhance a systematic study of this course. In each of the study units, there is an introduction, which serves as an opening to the unit and a link between it and preceding/successive units and the entire course. Second, there are prescribed intended learning outcomes, which you should attain by the time you have gone through the respective units.

As a “compass”, you should refer back to the intended learning outcomes after you have completed each unit to assess your degree of attainment. Attempting the self-assessment exercises should guide you toward attaining the intended learning outcomes since they aid you in self-evaluation of the work done. Therefore, attempt every self-assessment exercise as you encounter it in the unit before progressing to other issues.

Each study-unit also consists of glossary and summary, which are intended to unite the areas treated in the unit and also act as "prompters" to aid you in recalling the salient aspects of what you had previously studied in the unit.

Going through each of the units – involving studying a unit and attempting the exercises and assignments – would take you about three (3) hours. Therefore, ascertain the duration of time you put into the first unit so as to enable you know the average time that may be required to complete each unit, and be able to plan your time-table correspondingly. There are wide margins on both sides of each page in the course book; you are to use the spaces to note important ideas or points for the purpose of quick revision. We have no doubt that, if you make effective use of the various features, your performance in this course would be satisfactory.

COURSE DELIVERY

You are an open and distance learner. Your learning results from studying your course material, and the guide provided to help you navigate through the course. Because you are not taught your course directly by a conventional teacher, certain service mechanisms are put in place to enhance your study of the course. These include tutorials, facilitation, and counselling.

TUTORIAL SESSIONS

The main purpose of tutorial sessions is to provide a forum where you could present your questions to an individual, who functions as your tutorial facilitator, and whose responsibility it is to provide answers or clarifications that would enrich your understanding of your course. Eight (8) hours of tutorials are allowable in this course. Therefore, you could maximise the period by ensuring that you have the phone number and/or e-mail address of your tutorial facilitator.

The study centre nearest to you is the point where information about the venue for tutorials and the time allotted for facilitation is provided. You are therefore, encouraged to study and prepare your questions prior to your attendance at a tutorial session so as to be able to benefit optimally. The flexibility of tutorials allows you to arrange with your facilitator what such sessions would entail. Although tutorials are not mandatory, participating in them has the potentials to enhance your performance in the course and your programme.

FACILITATION

As stated earlier, you will have opportunities to interact with your tutorial facilitator, who is an expert in the field. The sessions that you would have with him will be conducted in English. Basically, the medium of instruction shall be the course material. However, certain practical integrated science lab activities would be introduced where necessary to help in demonstrating some concepts that you might raise questions about. You are encouraged to go through areas of the course material that are not too clear to you, and note your questions in ways that would clearly express areas where you require clarifications. Sessions will be held in the study centre nearest to you. You are advised to note the average time it would take you to leave your home to get to the centre so that you will not be unduly late for meetings. However, facilitation shall be conducted under flexible arrangements. Therefore, let your facilitator know ahead of time if you would be late to meetings or be absent altogether. Also feel free to ask your tutorial facilitator questions regarding your assignments, and other difficulties you might have in relation to the course.

COUNSELLING

In order to help you cope effectively with your programme generally, counselling services are provided to address issues of personal and academic nature. These services are provided by the centre manager and tutorial facilitators. These individuals are on hand to handle the challenges you might have so that they become manageable. Therefore, ensure that you have the phone numbers as well as the e-mail address of your study centre, and those of your centre manager and facilitator.

ASSESSMENT

Opportunities are provided for periodic assessments. Assessment is approached from two perspectives; you assess yourself during the course of your study of the course material by attempting the self-assessment exercises in each unit. You are to judge your performance in the light of the model answers provided for each question. (These answers are to be seen after you must have done the exercise). There are some assessments that are carried out by your tutor who grades your tutor-marked assignments as well as your examination papers. The tutor-marked assignments must be submitted to your facilitator at the stipulated time for each.

However, if you have genuine reason(s) why your submission(s) would be late, let your facilitator know on time, and whether it would be possible to grant you an extension. You are required to do a total of four

(4) tutor-marked assignments. However, only three of the best would count towards your grading. Each of the three is weighted 10% (a total of 30%).

In preparing your tutor-marked assignment for submission to your tutorial facilitator, ensure you observe the following:

- Write the course code and title, and the assignment number on the cover of your assignment. It should also include your name, matriculation number, your programme and the date of submission.
- Make your answers to the questions as compact as possible. In other words, be direct to the point. Your responses should be based on the course material, other reference sources and your personal experiences.
- Use ruled foolscap sheets for your assignments, and make for yourself a copy that you can easily refer to. The answers should be hand written, and margins of about 1.5 inches should be given at the left side of your sheet(s). Give enough space between questions.
- Ensure that your assignment gets to your tutorial facilitator on or before the date given for submission.

In the event that your work will not be ready by the deadline, inform your centre manager and tutorial facilitator to find out if there could be an extension.

FINAL EXAMINATION AND GRADING

There will be a final examination in this course – EDU 754 – which will last for two hours. Grading of the examination shall be based on 70%. The examination questions will bear relationship with the ones encountered in the self-assessment exercises and tutor-marked assignments. The assessment will cover all areas of the course. You are encouraged, therefore to study all the aspects thoroughly. In addition to going through the various exercises and assignments, compare your responses in your copies of the tutor-marked assignments with your present understanding to see whether there is some improvement that you could utilise in the examination.

Your eligibility to sit for the examination will be based on your submitting all four tutor-marked assignments prior to the examination. It will also depend on whether you have registered to take the examination. To ensure that you are not late in registering for the examination, consult your centre manager who should be able to provide you with information on registration.

CONCLUSION

The purpose of this course guide is to formally introduce you into the course, and to lead you through certain measures you could take to make the best out of this course, and enhance your overall performance in your programme of study. These measures are contained in the aim and intended learning outcomes of this course, course summary, overview, self-assessment exercises, among others. You are advised to thoroughly study this course guide and ascertain if you have understood the issues discussed before proceeding to study the course.

SUMMARY

The course EDU 754: (Subject Methods) Integrated Science is designed to introduce you to some of the rudiments in the teaching Basic Science and Technology in either primary school or junior secondary school or in tertiary institutions. You will learn and understand the philosophy and objectives of Integrated Science as incorporated in Basic Science and Technology curriculum and its origin. You will also be exposed to the different psychological theories of learning, their applications and implications in the teaching of Basic Science and Technology. The development of science process skills is the bane of Integrated science, as trained Integrated Science teacher you will be equipped with the type in teaching methods that will enable you develop the science process skills in the teachers in training as well as students in basic science and technology at primary and secondary school levels. The course will also improve and increase your knowledge for high education. EDU 754 will help you to understand the process of improvisation that will enable you improvise your teaching materials as alternative or in the absent of standardised materials. The course will equip you to be able to develop, organise, manage and use Basic Science and Technology laboratory in teaching as well as ensure safety of both materials and personnel. You will be exposed to the use of ICT as an instructional material and learning instrument and to develop your computer literacy that will enable you teach with ICT equipment and develop ICT literacy in pupils and students as well as teachers-in- training. At the end of thoroughly studying the course, you should be able to apply/interpret the aspects of this course addressed.

MAIN COURSE

CONTENTS

MODULE 1 HISTORICAL DEVELOPMENT OF INTEGRATED SCIENCE

INTRODUCTION

In this module, you will be exposed to the historical development of integrated science in primary and junior secondary schools. The module will examine the nature and spirit of science, the concept of integrated science and its relationship with STEM (science, technology, engineering and mathematics). The module is divided into four (4) units namely:

Unit 1 Nature and Spirit of Science
Unit 2 Science Education Curriculum Reform in Nigeria
Unit 3 Historical Development of Integrated Science Education in Nigeria
Unit 4 Concept of Integrated Science and STEM

UNIT 1 NATURE AND SPIRIT OF SCIENCE

Unit Structure

1.1 Introduction

You did chemistry or biology or agricultural science in secondary school, how did you perceive science? Many students perceive science as abstract and difficult to learn in school. But man cannot do without science. Science is very important in human life. We need science and we are all enjoying the outcome of science. In this unit, we are going to discuss the meaning of science, product of science, branches of science, science process skills and scientific attitudes. By the time we finish our

discussions in this unit you will be able to explain the relevance of science to humanity.

1.2 Intended Learning Outcomes

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

- explain the meaning of science
- identify the products of science
- differentiate the different branches of science
- Carry out some science processes
- identify the scientific attitudes

1.3 Nature and Spirit of Science

1.3.1 Meaning of Science

As earlier mentioned, you did science in secondary school. From your understanding: What is science? Science is man's activities to explore and explain natural happenings. In the early days of our fore-fathers, twins were killed. It was a taboo. Today, triplets are considered as blessing. One can leave Nigeria in the morning and is in London by evening. So many other things. Why are these things possible? What brought about these changes? These are the work of science. Science consists of observing the world by watching, listening, observing and recording. It is curiosity in thoughtful action about the world and how it behaves (https://spaceplace.nasa.gov > science). Science is man's activities to explore and explain natural phenomena. It is a process of acquiring knowledge of our environment. It is man's gate way to nature. Baja (1992) beautifully described science as the continued search for adequate methods of understanding our environment. According to Ezeliora et al (2011), science is a body of organised knowledge acquired through a process of inquiry. Abd-El-Khalick (1998), explained the nature of science as making the unnatural natural. Science is knowledge that concerned with the physical world and its phenomena and involve unbiased observations and systematic experimentation. From the above explanation, science is both process and product.

Self-Assessment Exercise 1

In your own understanding explain the concept science.

1.3.2 Products of Science

In the previous step you learnt that science is a process of acquiring knowledge of our environment. When the knowledge is acquired, it is converted by the same process and applied to the environment either to change or improve it to meet the needs of humanity. In investigations, the process is used to generate and gather data. The data is analysed and interpreted and applied to the environment. Science is both a body of knowledge (Product) and method of inquiry (Process) (https://www.pupilstutor.com> relate). Resulting to the product of science, finding cures to cancer and clear forms of energy are just two topic examples of product of science. Science generates solutions for everyday life and help to answer the great mysteries of the universe (UNESCO, 2021). Describe one example of the product of science. Science contributes to ensuring a longer and healthier life, monitor our health, provide medicines to cure diseases, alleviate aches and pains, help to provide water for our basic needs including foods, provide energy and makes life more fun including sports, music, technology. Last but not the least, it nourishes our spirit (UNESCO, 2021).

Science has helped man discover the mineral-crude oil in the ground, discover the benefits of tree to man. From all these, man is able to develop, build and manufacture many things that have made human life better. Science has helped man to accomplish God's injunction to till and subdue the Earth (Ezeliora, 2016).

Science product is never born spontaneously in research mind. Normally it is a result of efforts of many scientists whose works and achievement have provided the background for and paved way to the inventions of new products. Products of science is continuous. Science is a product because without these historic steps, a yet more complex idea could not have appeared. Without Newton's laws of motion, Einstein would have nothing to build upon.

Product of science can be physical or virtual. Physical products include durable goods such as cars, furniture and computers and non-durable goods such as foods and beverages. Virtual products are offering services or experiences such as education and software.

Self-Assessment Activities 2

Describe one science product that is invented based on previous knowledge.

1.3.3 Branches of Science

Science by nature is integration of many ideas or knowledge. Science is divided into three main branches of science: physical science, earth science and life science. Physical science describes the world as observed by use of physical measurement of mass, length and time or their derived units like velocity, force or volume. There are branches of science that deals with inorganic materials which are materials that are not living. Some examples of physical sciences are physics, astronomy and chemistry. Earth science is a field of natural science that deals with the materials of the earth and its atmosphere. Some types of earth science include meteorology, geology, oceanography and environmental science. Life science is a branch of science that involves the study of organic things which are things that are living. There are several branches of life science including biology, ecology and agriculture (https://www.indeed.com >; https://neurotray.com>).

1.4 Spirit of Science

In our previous lesson in one of the definitions of science we discussed science as a process of acquiring knowledge of our environment. Now you are going to learn the spirit of science which are the science process skills and their influences on the behaviour and value of scientists.

1.4.1 Science Process Skills

Science by its nature is a process. Acquisition of scientific knowledge is a process and its application involves processes. What are these processes? Science processes are those methods of steps followed in acquiring scientific knowledge. They are the methods peculiar to science in determining the facts about nature. They are called scientific methods (https//www.researchgate.net). The methods involve exploring, observing and answering questions (https://static.nsta.org). Scientific methods help to focus one's scientific question and work through observation and data collection to answer the question. They are step by step activities used in the process of acquiring scientific knowledge. In the process of applying the scientific methods, one develops skills known as science process skills.

Processes	**Skills**
Observation: This is the basic step to scientific method. It involves critically looking at a substance so as to explain or describe it in detail	Observation skill
Classification: After observation you group the substance based on	Classification skill

your observation according to similarity and differences based on size, shape, colour, texture.	
Measurement: this involves determining the numerical value of size, volume, length, weight.	Accuracy
Prediction: From the information you get from above you may guess what the substance is	Judgemental skill
Analysis: This is going into details to determine the characteristics of the substance such as boiling and melting points, soluble or insoluble in water, action with heat	Investigative skill
Inference: From the characteristics above, you can for sure say that the substance is this. You give it a name	Inference skill
Synthesis: you treat the substance with other materials to find out what it will form. Compare the new substance with the original substance.	Inventive, creative, innovative skill
Experimentation: with the new substance formed you begin the investigation again starting with observation	Investigative skill

From the above table you could see that each process develops a skill in the individual. These are the scientific methods, also called science processes. These processes develop in the individual science process skills.

Self-Assessment Exercise 3

Get a tumbler, add water to half of it and add two cubes of sugar to it. Look at it after three minutes and explain what you see. Which of the process skills have you acquired?

1.4.2 Scientific Attitudes

What you learn influences your behaviour. For example, lawyers are logical, mathematicians are conscious of number, carpenters carry on pencil on the head for measurement. The process you used in learning brings change in your behaviour, attitude and values. So also the use of scientific methods by scientists develops in them some scientific

behaviours or values. Scientific attitude is the desire to know and understand, questioning to all statements, search for data and their meaning, search for verification and consideration of consequences, (Gardner,1975; Osborne, Simon & Collins, 2003). Scientific attitudes are beliefs, values qualities held in awe by scientists. Scientists have questioning attitudes. Give one example of scientific attitudes. These attitudes are:

Curiosity: this is an eagerness to know, to find out and ask more questions emanating from observations, measuring, classifying, inference, analysis and so on. When you are looking at the tumbler with water and two cubes sugar, what attitude are you exhibiting? You are trying to find out what happened to the sugar.

Objectivity: giving judgement based on facts without sentiment.

Sceptics: Suspending judgment and respect for evidence of relevant facts.

Humility: Ready to accept corrections and criticism from others

Open-mindedness: Science is activity oriented involving many people who must work as a team to support other's ideas that relate one's knowledge.

Team Spirit: ability to work together

Honesty: reporting results without manipulation (https://www.researchgate.net>).
These are the scientific attitudes, values which are characteristics of scientists.

Self-Assessment Exercise 4

As an Integrated Science teacher, which of the scientific attitudes have you developed?

1.5 Summary

In this unit you have learnt that science is a process of acquiring knowledge about our environment. The outcome of the processes give rise to the products of science used in solving problems facing humanity. Science is made up of physical and biological components. In using the science processes, the individual develops scientific skills and develop scientific attitudes.

1.6 Glossary

- **Products of science:** knowledge acquired using science process skills. That is science as process and product.
- **Scientific Attitude:** behaviours or values exhibited by scientists such as curiosity, honesty and so on.

1.7 References/Further Readings/Web Resources

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1.8 Possible Answers to Self-Assessment Exercises

SAE 1

Science is an organised knowledge acquired through the process of scientific method. Science is man's activities to explore and explain natural phenomena. It is a process of acquiring knowledge of our environment. It is man's gate way to nature.

SAE 2

Nikola Tesla and Thomas Edison are the people that invented electricity. Their invention was based on Faraday's Law of Electrolysis.

SAE 3

The sugar dissolved in water as no trace of it was seen. The process skills I have acquired is observation.

SAE 4

Honesty: I can report observations correctly and accurately

Measurement: I measured correctly during titration of the acid and base.

UNIT 2 SCIENCE EDUCATION CURRICULUM DEVELOPMENT AND REFORM IN NIGERIA

Unit Structure

2.1 Introduction

In this unit, you will learn some of the events that led to the development of science curriculum, the trends in the science curriculum reforms and the development of the new integrated science curriculum- the Basic Science and Technology curriculum for primary and junior secondary school students.

2.2 Intended Learning Outcomes

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

- explain the reasons for the development of science curriculum
- describe the trend of reforms in science curriculum
- give reasons for the new integrated Basic Science and Technology curriculum.

2.3 Science Curriculum Development and Reform

2.3.1 Science Curriculum Development

In the previous unit, you learnt the nature of science and spirit of science. In this unit, you will learn how the concept of integrated science come into existence. In Nigeria, the introduction of some form of science dates back to the time of the Christian missionaries in 1840s and 1850s but was not rich enough to help development. Serious teaching of science was delayed by the missionaries and the colonial rulers. Since the motive for colonisation was essentially exploitative trade and only tangentially education, the issue of science education for

the development of the natives was not considered important. Africans like Nigerians were assumed to be inferior human being's incapable of understanding core science by the colonial masters. What was taught as science was called Nature Study. Later, it was up graded to General Science. Its depth was too shallow and the language and examples were purely Europeans (researchgate.net). When science was introduced in the primary schools, physics, biology and chemistry were taught in secondary schools.

The science curricula developed were patterned and adapted to foreign ones both in language and presentation, even examples were foreign to our children. With the launching of Sputnik 1 by Russians in 1957, there was a worldwide review of the philosophy of science education. Federal government realising the importance and crucial role of science in nation building, noticing that the deficits in the nature of science been taught to Nigerian children cannot lead the country to anywhere. After independent, in 1969 curriculum summit was convened to review all the school curriculum and adapt them to suit Nigerian children and address Nigeria's problem. Science was among the school subjects given thorough reform and review. Science Teachers Association of Nigeria (STAN) formed in 1957 was called upon to develop the science curriculum to suit our learners to the benefit of our country. STAN created and developed science curriculum for primary and secondary schools and later developed Integrated science for junior secondary school as link between primary science and secondary school science. The curriculum for physics, biology and chemistry followed the trend as in developed countries like America and Europe. Variations in curriculum trend were mostly in the primary and junior secondary schools.

Self-Assessment Exercise 1

Describe the situation that gave rise to reform of Science Education in Nigeria.

2.3.2 Trends in Primary and Junior Secondary School Science Curriculum Reform

In the previous days, you learnt development of science in Nigeria. A lot of external influences and foreign curricula motivated many of the curriculum innovations in science in primary and junior secondary school. Some of the foreign curricula are: Elementary Study of Science (ESS) in 1960, S-A Process Approach (SAPA) of 1962, Science Education for Africa Project (SEAP) of 1970, Science Teacher Education Project (STEP) of 1970 and so on. Due to these influences and coupled with the historic National Curriculum Conference held in

1969, spurred various bodies including government agencies to develop science curricula for primary levels that will reflect Nigeria's needs and suitable for the development of the Nigerian child. As a result, each region in the federation embarked on curriculum project and developed curriculum for the children of their region including science curriculum. For instance:

- Primary Science Curriculum Project was developed in 1963 at University of Nigeria Nsukka for primary schools in the then Eastern region.
- The African Primary Science Project was developed in 1965 at Kano for the Northern region.
- Bendel State Primary Science Project was developed in 1970 for the Mid-Western region.
- Ife Six Years Yoruba Language Science Project was developed in 1970 at University of Ife the present Obafemi Awolowo University, Ile-Ife for Western region.
- Primary Education Improvement Project was developed at Ahmadu Bello University, Zaria for the Northern region in 1970.
- Ondo State Primary Science Project developed in 1974.

All these science curriculum projects have one common objective to produce child-centred science curriculum for the Nigerian child for technological development of Nigerians.

STAN as a body with the introduction of the 6-3-3-4 education system was charged with the development and reformation of science curriculum for both primary and secondary school students and to produce one common science curriculum for primary and junior secondary schools called integrated science which is continuously under constant review to address the needs of Nigerian child. Other curriculum agents are National Educational Research and Development (NERDC). The most resent curriculum under use for integrated science is Basic Science and Technology Curriculum was developed by NERDC.

Self-Assessment Exercise 2

Explain the reasons for series of reform in the lower basic science in Nigeria.

2.3.3 Development of Basic Science and Technology Education Programme

The most recent innovative curriculum for integrated science in use in Nigeria is the Basic Science and Technology curriculum. Which level of school children use this curriculum and why? The Basic Science and Technology curriculum is developed for primary school and junior

secondary school students. This two groups belong to the 6-3- system of education for 9-Years programme. The 6-3- system is taking to be for basic education for laying the foundation for all knowledge. Thus the name: Basic Science and Technology. This was in line with the introduction of the Universal Basic Education (UBE) system in September, 1988. Following this, in 2008 the Federal Government of Nigeria through the Nigerian Educational Research and Development Council (NERDC) developed and introduced the 9-Year Basic Education Curriculum (BEC) in schools by realigning all extant Primary and Junior Secondary School Curricula to meet the key targets of the UBE programme. In view of some contemporary and national concerns and needs and to make the curriculum more practical, the present curriculum was developed to meet the need to attain Millennium Development Goals (MDGs) and implement the National Economic and Empowerment Development Strategies (NEEDS).

The Basic Science and Technology is an integrated science programme meant to lay solid foundation for science and technology in primary and junior secondary schools. It is also re-structured and re-aligned to include contents like environmental education, drug abuse education, population and family life education as well as sexually transmitted infections. The overall objectives of the new science curriculum are to enable the learners:

- Develop interest in science and technology
- Acquire basic knowledge and skills in science and technology
- Apply their scientific and technological knowledge and skills to meet societal needs
- Take advantage of the numerous career opportunities offered by science and technology
- Become prepared for further studies in science and technology

It is a 9- years programme comprises of 3 years of Early Childhood Care Development and Education (ECCEDE), 6 years of Primary and 3 years of Junior secondary school. It also covers special interventions directed at nomadic and migrant children, mass literacy as well as the almajiris and other vulnerable and excluded groups. The main agencies coordinating the programmes of Basic Science and Technology (BST) are the Universal Basic Education (UBEC), National Commission for Nomadic Education (NCNE) and National Mass Education Commission (NMEC). The Education National Minimum Standard and Establishment of Institutions Act 16 of 1985, together with the 1999 Constitution empowered the Ministry of Education to ensure a uniform standard of educational provisions in school and colleges. In view of the foregoing, the document charts the strategies and road-map for the education sector for the achievement of the goals of Vision 20-2020, 7-

Point Agenda, National Economic Empowerment and Development Strategy II (NEED II) and Millennium Development Goals (MDGs).

Self-Assessment Exercise 3

Outline the objectives of Basic Science and Technology curriculum. Do they reflect the spirit of integration of science?

2.4 Summary

Introduction of curriculum in our school system dated back to the missionary era. Subsequent approaches brought series of reforms to the curriculum development including science curriculum. The unit examined the trends in curriculum development and the subsequent reforms following the subsequent changes in the education system. The main objectives of the present science curriculum for both primary and junior secondary schools are highlighted.

In this unit you learnt that introduction of science curriculum in our educational system started with missionary activities in our schools. The earlier curriculum was not meant to develop us. It was not adapted to the needs of the Nigerian child both in language and in content. Every aspect of the curriculum was foreign to the Nigerian child. After independent, Nigerians took to the reform of the curriculum, made it adaptable the Nigerian child so as to addresses the needs of the Nigerian society. The reform of the curriculum is continuous till date following the changes in our education system and societal needs.

2.5 Glossary

These are targets government sets for human development to be achieved through education

- Millennium Development Goals (MDGs)
- National Economic Empowerment and Development Strategy II (NEED II)
- Vision 20-2020
- 7-point Agenda *Sputunik 1:* This is the first air craft that Russians went to the Space with in 1957.

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2.7 Possible Answers to Self-Assessment Exercises

SAE 1

The existing science curriculum adopted by the colonial masters were:

- Alien to Nigerian child
- Not adapted to suit the Nigerian child
- Too foreign to Nigerian child
- Has no knowledge depth to develop the Nigerian child for national development
- The launching of the Sputunik 1 by Russia in 1957 opened everybody's to the relevance of science.

SAE 2

Many reasons were behind the reforms of the science curriculum namely to:

- have unified, one common textbook for basic science and technology
- effect reformation in line with Universal Basic Education programme
- achieve global view.

SAE 3

The main purpose of BSTC is to produce a curriculum adaptable to the needs of the Nigerian child so that at the end of it the child will be self-reliant and contribute to the survival of Nigerian society. Its specific objectives include to:

- develop interest in science and technology
- acquire basic knowledge and skills in science and technology
- apply their scientific and technological knowledge and skills to meet societal needs
- take advantage of the numerous career opportunities offered by science and technology
- become prepared for further studies in science and technology.

UNIT 3 HISTORICAL DEVELOPMENT OF INTEGRATED SCIENCE IN NIGERIA

Unit Structure

3.1 Introduction

In the previous units you learnt the nature and spirit of science and historical development of science curriculum and all the reforms till date. In this unit you will learn the background that led to the introduction of integrated science in school curriculum as well as regional science projects embarked for the development of integrated science curriculum to the present Basic Science and Technology Curriculum.

3.2 Intended Learning Outcome

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

- narrate the trend of events to the development of integrated science curriculum
- describe the different regional science projects and their objectives
- compare the regional projects with Basic Science and Technology
- explain the reason for Basic Science and Technology Curriculum.

3.3 Historical Development of Integrated Science Curriculum in Nigeria

3.3.1 Outside Influences in the Development of Basic Science Education

Many years before the 19th century witnessed increasing demand for basic school science as Physics, Chemistry and Biology are taught in higher schools. Thus, there exists a gap before one gets to higher school to learn about science. Varied factors of social and economic development during the time contributed to this increasing demand for basic science:

- The rapid development of science and technology in Europe and America and their application to industry and everyday life
- Influence of laboratory method in technology
- Increasing demand for skilled labour to man developed industries
- Emergence of a new philosophy of education that emphasized pupils' activity as a natural expression of biological development

During these periods special interest groups developed attention to basic science in schools. The primary objectives of basic science programmes were first-hand observation and experience. Experimentation and problem-solving types of teaching were considered as significant as scientific techniques. Due to lack of teachers, the proposed elementary science could not be practice. This period also witnessed great enthusiasm towards nature from science educators across Europe, America and Africa that geared towards introducing nature study programme in schools. The main purpose of the movement was to improve agriculture and to overcome the desire of farmers' children from leaving the farm for the city. The objectives of nature study focused on the learning of facts for their own sake. It also emphasized the aesthetic and moral learning that might be derived from scientific observation. Nature study embraced the natural and physical sciences but their subject matters were limited to biological sciences. This was because those who were interested in introducing nature study in schools were specialists in the biological sciences. In parts of Africa, America and Europe nature study still form part of school curriculum but with different names such as general science, rural science, hygiene depending on the country. With physics, chemistry and biology been learnt in the senior or higher classes, attempts were made to launch an integrated aspect of science in the primary schools that will enable the pupils have integrated knowledge of their environment, enable them have a holistic view of their environment. Thus, science at that level was given general names such as nature study, general science or rural science. In 1969, integrated science was initiated by UNESCO to assist

member countries in promoting scientific literacy in a unified way both at primary and secondary school levels (https://www.ajol.info > view and https://www.coursehero.com).

Self-Assessment Exercise 1

What outside factors led the introduction of integrated science in our school system?

In the past four decades, there have been changes in the nature of science taught in our schools. For instance, science had become more integrated and emphases have been on the products (that is concepts, laws and theories) and the processes of science which students were both to understand and frequently perform. The decades of 1960's was marked by the initiation and development of a number of school science curriculum projects that were designed to improve science in the primary level. After the 1969 curriculum summit, several primary school science projects were embarked upon by the different regional governments to improve science education in their region (https://core.ac.uk > PDF). Notable among the developed primary science projects are:

- University of Nigeria Primary Science Pilot Scheme
- African Primary Science Project
- Bendel State of Nigeria Primary Science Project
- Ife Six Year Yoruba Primary Science Project
- The Primary Education Improvement Project
- Ondo State Primary Science Project
- National Primary School Science Project
- Basic Science and Technology Programme

University of Nigeria Primary Science Pilot Study

This is the first Primary Science Curriculum project in Nigeria developed at 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, Nsukka and the Ford Foundation. The focus of the scheme was on local materials and improvised equipment such as the use of jam-jars, bamboo microscope, bamboo cages and so on in teaching of primary science. The essence of using local material was to provide materials for teaching primary science as well as to integrate science to the local materials within the environment of the learner, to remove the abstract nature of science from the early learner. The project placed emphasis on pupils' practical activities.

The African Primary Science Project (APSP)

APSP is one of the earliest curricula 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 of Africa (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. APSP with headquarters in Accra in 1965 to 1970 provided copies of printed materials consisting of pupils' textbook to Nigeria and teachers' guide and films which were distributed to schools mostly in Lagos. Also printed and provided was the Child Observation Checklist used in the evaluation of child learning.

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 Science Project. The project was directed by the State Ministry of Education. It was jointly financed by United Nations Educational Scientific and Cultural Organization (UNESCO), United Nations Children's Fund (UNICEF), United Nations Development Programme (UNDP) and the Government of the former Mid-Western State of Nigeria. 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. In 1970, series of pupils' textbooks called Science Discovery together with the Teacher's Guide were produced.

Ife Six Years Yoruba Language Science Project

The 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. Babatunde Fafunwa. The overall objectives of this project were:

- To develop a primary education curriculum with a strong value, since primary education is the 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 instructions

when given in the child's mother tongue is more effective and meaningful than using second or foreign language

Other objectives of the project were:

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

The project was supported financially by the Ford Foundation of America and former Western State Ministry of Education. The main objective of the project by the initiator was to develop a primary education for the child and make him/her an intelligent citizen of this country. The group set up a lexical Committee to select the right choice of words and concepts that would correctly express in Yoruba the concepts not easily identifiable with local language. The generally project was to exploit the use of mother tongue (Yoruba) in the teaching and learning of primary school subjects. The materials produced are ***Sayensi*** for primary classes books from 1 to 6 both teachers' guide and pupils' text. The teachers' manual was also produced.

The Primary Education Improvement Project (PEIP)

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 British Council. The project was formerly called UNICEF/UNESCO assisted project but later called PEIP. The project is aimed at making children think and study science like the scientists, hence it adopted the philosophy of American Association for the Advancement of Science (AAAS) process and skills with emphasis on the process of science such as observing, measuring, classifying, using numbers, manipulating, communicating and so on. The curriculum materials produced for the project were series of pupils' textbooks 1 to 6, workbooks and teachers' guide which provide detailed information for the teacher to carryout science activities specified in the pupils' text.

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 the state in 1976. The project drew its inspiration from the outcome of the APSP workshop. 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 teachers' guide. The teachers' guide was not completed for all classes before the creation of the state in 1976.

Self-Assessment Exercise 2

What are the common objectives in the regional science projects?

3.3.3 Introduction of Integrated Science Curriculum in Schools

However, studying of physics, chemistry and biology in higher classes were expected to cover the whole range of science in a balanced way bringing out the unity among the subjects but the little real unity was observed in the presentation of these courses. The teachers could not achieve any real integration in their teaching of these science courses because teacher training courses rarely prepared the teachers for the unified approach to their teaching of those science subjects in the higher classes. Furthermore, General Science courses were too superficial and inadequate to develop higher level science courses within the little times allocated to them by school authorities. Science at the primary school is considered to help the pupils master the basic understanding of scientific concepts and cultivate the habit of exploring science with an open mind. In view of these problems STAN embarked on curriculum development early 1970's and was mandated to develop science curriculum for both primary and secondary schools. STAN during the planning and development of science curriculum after the 1969 Conference Summit introduced integrated science to enable junior secondary school students acquire the basic skills of science before proceeding to senior secondary science. Primary science was introduced for the primary school. Instead of several text books for basic science, one integrated science text book was produced for each level. The science topics taught at these levels are arranged into six strands of scientific investigation, life and living things, the material world, energy and change, earth and beyond, science, technology and society. With the introduction of the 6-3-3-4 education system which brought about the 9-year basic education, one common curriculum was developed in science for the basic levels known as Basic Science and Technology Curriculum for both primary and junior secondary children.

Self-Assessment Exercise 3

What factors led to the introduction of integrated science in Nigerian school programme?

3.4 Summary

In this unit, the background needs that led to the introduction of integrated science in the school curriculum globally and in Nigeria and the subsequent developments that led to its continuous reforms at

different stages especially in Nigeria were discussed. The regional governments played important role in the reform by producing their primary science projects programmes and materials. The regional projects though similar in objectives but do not ensure unified curriculum and knowledge for the pupils. Because of these discrepancies Science Teachers Association of Nigeria (STAN) was asked to develop one science text book for the implementation of basic science in our schools. As a result of the new education system of 9-year basic education arising from the Universal Basic Education (UBE) National Education Research Centre (NERC) realigned primary science and junior secondary science curricula and produced the present Basic Science and Technology Curriculum for primary and junior secondary schools. Basic Science and Technology curriculum is integrated science text book by nature and arrangement.

3.5 Glossary

- These are United Nations funding centres. They help and sponsor projects for development and give grants.
  - United States Agency for International Development (USAID)
  - Education Development CENTRE (EDC)
  - United Nation Children's Fund (UNICEF)
  - United Nations Educational Scientific and Cultural Organisation (UNESCO)
  - United Nations Development Programme (UNDP)
- Science Teachers Association of Nigeria (STAN) is association of science teachers in Nigeria that work towards the development and reforms of science curriculum in primary, secondary and tertiary institutions.
- National Education Research Centre (NERC) is government research and publication centre. They responsible for the development and improvement of curriculum.

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3.7 Possible Answers to Self-Assessment Exercises

SAE 1

Outside factors that influenced the introduction of integrated science in the schools are:

- To fill the gap existing between primary science and higher school science
- Rapid development of science and technology
- Increase demand for skilled labour
- Emergency of new philosophy of education that emphasize pupils' activity.

SAE 2

The main objectives of regional science projects include:

- To produce child-centred curriculum in science
- To develop a scientist
- To develop science education for the child
- To create spirit of inquiry in the child
- To teach the science using local materials

SAE 3

Factors that led to the introduction of integrated science in our schools are:

- Inability for Physics or Chemistry teachers to unify the three branches of science.
- General science was too superficial and inadequate to develop high level science course.
- To enable pupil to master the basic understanding of scientific concepts.

UNIT 4 CONCEPT OF INTEGRATED SCIENCE AND STEM

Unit Structure

4.1 Introduction

In the previous units, you learnt about the historical development of science curriculum in Nigeria and the evolving reforms science curriculum has gone through till date and is still subject to change towards development of humanity. It is through these reforms that integrated science was introduced into the science curriculum. In this unit, you are going to learn the meaning of integrated science and its characteristics. You will also examine STEM as an example of integration of scientific ideas.

4.2 Intended Learning Outcomes

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

- explain the concept integrated science
- outline the characteristics of Integrated Science
- identify the relationship between STEM and Integrated Science.

4.3 Meaning of Integrated Science

4.3.1 Concept of Integrated Science

All we have been talking about is integrated science, from your own understanding, what is integrated science? The term integrated science is often used as a synonym for interdisciplinary and unified science, which may be applied generally to any curriculum effort in which two or more previously separated science subjects are combined, (Showalter, 1975); (*https//link.springer.com*>). In a simple and general term, Bajah (1983)

sees integrated science as 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 (*Isi.princeton.edu*.). Nagaraj (2013), defined integrated science as a holistic and constructive learning process in which the learner is wholely involved. There are many classical definitions of integrated science which you can find in recent books. One of the definitions is given here for your consideration. Bajah (1983), 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 or under stress on the distinction between the various scientific fields (http://www.georgewright.org >). In other word, integrated science is child-centred. This expression brings in the earlier objective of the regional projects for teaching science in the primary school. Meaning that integrated science is the best means of making science meaningfully and realistic to children who are coming in contact with scientific knowledge for the first time in their life.

d'Arbon (1972), described integration when applied to science courses as 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. Nagaraj (2013) perceived integration as a holistic and constructive learning. In other words, integrating principles are intended to produce a course which:

- Is relevant to students' needs and experiences
- Stresses the fundamental unity of science
- Lays adequate foundation for subsequent specialist study and adds a cultural dimension to science education.

The regional science project curriculum reflected this nature of integration in its set up.

The Basic Science and Technology curriculum that was revised in 2012 is the result of the restructuring and integration of four primary and junior secondary science curriculum. The following science subjects were integrated into one:

- Basic Science
- Basic Technology
- Physical and Health Education
- Information Technology

This becomes necessary in order to reduce the number of subjects offered in primary and junior secondary schools, to prevent repetition and duplication of concepts that resulted in curriculum overload. It encourages innovative teaching and learning approaches and techniques that promote creativity and critical thinking in students, it promotes holistic view of science at all level for better understanding of a contemporary and changing world and to infuse emergent issues that are of national and global concern such as gender sensitivity, globalization and entrepreneurship into the curriculum.

Self-Assessment Exercise 1

Explain in your own words what is meant by integrated science.

4.3.2 Characteristics of Integrated Science

A critical examination of the basic science and technology curriculum (BSTC) clarifies how integrated science differs from other curricula arrangements. In Integrated curriculum the traditional subject matter boundaries are completely removed. In BSTC the curriculum is developed around these topics:

- Basic Science
- Basic Technology
- Physical and Health Education
- Information Technology.

The integration of the curriculum is as shown below. The infusion of drug abuse education, disaster/ risks reduction and management, climate change, consumer education, relevant elements of NEEDS shows the integrated nature of the programme. The subject flow systematically and spirally from primary one to JSS3. The BSCT is organized around a selected unifying topic. It serves a general education function.

The structure of the Basic Science and Technology Curriculum

Theme	**Primary**	**JSS**
Basic Science	• Exploring our environment • Living and non-living	• Learning about our environment • You and energy • Science and development
Basic Technology	• Understanding Basic Technology • You and Energy	• Understanding basic Technology • Materials and Processing

		• Drawing Practice • Tools, Machines, Process, Safety
Physical and Health	• Fundamental movement • Athletics • Games and Sports • Health Education • Pathogens, Diseases and Prevention, Drug Eradication • Responsible Parenthood	• Basic Human Movement • Sports and Games • Health Education • Moving our Body Parts • Athletics • Contact and Non-Contact Games
Information Technology	• Basic Computer Operation and Concepts, Basic Concepts of Information Technology	• Basic Computer Operation • Computer Ethics • Computer Applications • Basic Knowledge of Information Technology

The sequence arrangement of topics tries as much as possible to avoid duplication of content. The course usually lasts for three years and is sequential. Integrated science emphasizes organization of learning experiences around a topic or theme. This unification of concepts around a theme makes integrated science unique. For example, in BSTC the learning experiences and concepts are organized around the themes Energy, Life and Mind while in some other integrated science programme the concepts are organized around the themes Matter, Life, Mind and Society.

SELF-ASSESSMENT EXERCISE 2

What are the major themes in the arrangement of BSTC?

4.3.3 Science, Technology, Engineering and Mathematics (STEM)

Science, Technology, Engineering and Mathematics (STEM) are interrelated and interwoven bundle of knowledge that forms the ingredients for technological breakthrough. It is a typical example of integration of scientific process and science product Ezeliora (2016). For instance, science studies the flow of electronics in electrical conductors by using already existing tools and knowledge by applying the process skills (stem education journal.springeropen…). This new found

knowledge in science is used by engineers to create new tools and machines such as semiconductors, computers and other forms of advanced technology. In this sense both scientists and engineers are considered technologist. According to Rugumayo in Ezeliora (1997) STEM education builds in individual in varying proportions. While the scientist explores what is, the engineer creates what has not existed before and the technologist translates ideas and plans into working realities aware of his/her responsibility and duties towards the society. Mathematics we know is a language of number and space which both the scientist, technologist and engineer used in their processes The same person is a scientist, technologist, engineer and mathematician. The traditional subjects matter boundaries are removed. STEM education brings about the integration of ideals that gives rise to new products. According to Ezeliora (2016), STEM is a typical process of integration of scientific ideas to yield the expected result for human development. The integrated science teacher should always work toward integration of science knowledge while teaching basic science and technology. This is the reason behind developing Basic Science and Technology Curriculum to start early in life to develop the unified knowledge of science and technology so as produce self-reliant individuals who will be functional in the society for the betterment of the society. A holistic person is formed who will be able to apply both physics, chemistry, biological knowledge in addressing human problem.

SELF-ASSESSMENT EXERCISE 3

Pick three objectives of STEM that reflect integration of ideas.

4.4 Summary

In this unit, you are taught the meaning of integrated science, its characteristics and the resemblance of BSTC as an integrated curriculum. You are also shown how integration of knowledge in STEM reflects the reality in integration, develops self-reliant and holistic person which is the hallmark education. Basic Science and Technology curriculum is organised to inculcate innovative, inventive and creative skills early in the learner for holistic development and become self-reliant individual which is the major objective of education.

4.5 Glossary

- Science (S) acquired knowledge through process skills.
- Technology (T) application of the acquired knowledge for a purpose.
- Engineering (E) using the acquired knowledge to develop tool.
- Mathematics (M) language of number and space that control all of them without which none is possible.

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4.7 Possible Answers to Self-Assessment Exercises

SAE 1

Integrated science is the unification of scientific ideas ignoring their boundaries. In other word, getting knowledge from different branches of science to form one. For instance, in the process of exploring the environment, physics knowledge is involved, chemistry and biology form part of what to be done to in the process of exploring the environment.

SAE 2

The topics upon which BSTC is organised are: basic science, basic technology, physical and health education and information technology

SAE 3

Three objectives of STEM are:

- Ideas are interrelated
- Unified knowledge
- Produce self-reliant individuals.

MODULE 2 PHILOSOPHY AND PSYCHOLOGICAL THEORIES OF BASIC SCIENCE AND TECHNOLOGY CURRICULUM

UNIT 1 PHILOSOPHY AND OBJECTIVES OF BASIC SCIENCE AND TECHNOLOGY CURRICULUM

Unit Structure

1.1 Introduction

In the previous units, you learnt that the Integrated Science in use in our schools is replaced with the present Basic Science and Technology Curriculum (BSTC). The BSTC as you learnt is a replicate of integrated science and technology for the 9-years basic science and technology programme. You will learn in this unit the philosophical background and objectives of Basic Science and Technology curriculum.

1.2 Intended Learning Outcomes

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

- explain the philosophy of basic science and technology curriculum
- state the objectives of basic science and technology curriculum.

1.3 Philosophy and Objectives of Basic Science and Technology Curriculum (BSTC)

1.3.1 Philosophy of Basic Science and Technology Curriculum

Basic science and technology curriculum is the product of the re-structuring and integration of primary and junior secondary school science curriculum into:

- Basic Science
- Basic Technology
- Physical and Health Education
- Information and Communication Technology

It was developed in line with the requirement of the 9-year basic education programme for 6-years primary and 3-years junior secondary based on the 6-3-3-4-Universal Basic Education system adopted in the nation's education programme (*https://link.springer.com.*). It is meant to catch the young learners early to love science, learn science, become self-reliant and function to create changes in their environment. It is organised to develop a holistic view of science at these levels of education. 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 (*https://files.eric.gov>).* Integrating principles embedded in BSTC is to produce course which:

- Is relevant to students need and experiences
- Stresses the fundamental unity of science
- Lays adequate foundation for subsequent specialist studies and adds a cultural dimension to science and technology education.

The sequence of arrangement of topics avoids duplication of content and learning experience organised around a theme. This helps to reduce overload of learning materials which makes learning over burden to the learners. The contents are arranged in modules. This unification of concepts around a theme makes BSTC unique and gives its integration outfit.

Self-Assessment Exercise 1

Outline the integrated characteristics of BSTC

1.3.2 Objectives of Basic Science and Technology Curriculum

In last class, the discussion was on the philosophy of BSTC which showed that BSTC is an integrated programme for basic science and technology education for beginners. Basic Science and Technology Curriculum was conceived out of the present need and desire of the society to develop holistic view of science and technology at primary and junior secondary school level. BSTC is developed to accommodate the 9-year Basic Education Programme in science and technology. Other factors that influenced the curriculum are the need to attain the Millennium Development Goals (MDGs) and implementation of the National Economic and Empowerment Development Strategies (NEEDS). BSTC is structured around basic science, basic technology, physical and health education and information technology to reduce the number of subjects offered in primary and junior secondary schools, prevent repetition and duplication of concepts that resulted in curriculum overload, encourage innovative teaching and learning approaches/techniques that promote creativity and critical thinking in students, promote holistic view of science at all levels for better understanding of a contemporary and changing world and to infuse emergent issues that are of national and global concern such as gender sensitivity, globalisation and entrepreneurship into the curriculum. BSTC includes contents like environmental education, drug abuse education, population and family life education and sexually transmitted infections. Each of these are further developed into modules:

1. Basic Science:

Theme 1 Leaning about our environment
Theme 2 You and energy
Theme 3 Science development

2. Basic Technology

Theme 9 Materials and processing
Theme 10 Drawing practice

3. Physical Health Education

Basic body movement
Sports and games
Health education
Moving our body
Athletics

4. Information Technology

Theme 11 Basic computer
Theme 12 Basic knowledge of information technology
Theme 13 Computer application packages**.**

Thus, the overall objectives of BSTC are to enable the learner to:

- Develop interest in science and technology
- Acquire basic knowledge and skills in science and technology
- Apply their scientific and technological knowledge and skills to meet societal needs
- Take advantage of the numerous career opportunities offered by science and technology
- Become prepared for further studies in science and technology

The contents are organised around a theme arranged in modules. Specific methods to be used by teachers and students to achieve the objectives were specified such as project method, inquire method, field trip and other innovative methods.

Self-Assessment Exercise 2

What Are the Specific Objectives of BSTC?

1.4 Summary

In this unit, the philosophical background and objectives of basic science and technology were discussed and stated. The philosophy and objectives were organised around the principles and practice of integration. The contents were developed around themes arranged in modules. They are built around themes with other national and international interest such as NEEDS and MDGs. The five main objectives were outlined based on the philosophy on which the curriculum is based so as produce self-reliant and functional member of the society.

1.5 Glossary

- **MDGs** - Millennium Development Goals
- **NEEDS -** National Economic and Empowerment Development Strategies

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1.7 Possible Answers to Self-Assessment Exercises

SAE 1

The integrated characteristics in BSTC include:

- The contents are developed around a theme.
- The contents are organised in module.
- It helps the learner to have a holistic view, fundamental unity of science and technology and the commonality approach to scientific problems.

SAE 2

The objectives of BSTC are to enable the learner:

- To develop interest in science and technology.
- Acquire basic knowledge and skills in science and technology.
- Apply their scientific and technological knowledge and skills to meet societal needs.
- Take advantage of the numerous career opportunities offered by science and technology.
- Become prepared for further studies in science and technology.

UNIT 2 PSYCHOLOGICAL THEORIES OF LEARNING AND THEIR IMPLICATIONS IN THE TEACHING OF BASIC SCIENCE AND TECHNOLOGY CURRICULUM

Unit Structure

2.1 Introduction

In the previous module, you learnt the nature of science, what science is and its relevance to humanity. You also learn about integrated science as a unified science programme, its characteristics and objectives in relation to the present day Basic Science and Technology curriculum. In this module, you are going to learn the theories of learning as developed by psychologists and their implications and applications in the teaching of Basic Science and Technology curriculum. Can you explain how you learnt those things you know? Human beings generally have patterns of thinking. How these expand to include new ones and how concepts are formed in the human beings are questions to address. Various psychologists such as David Ausubel, Jerome Brunner, Robert Gagne, Jean Piaget and many others have provided answers to these questions on how human beings learn. Answers to these questions carry very large consequences in the organization of science lessons. These psychological theories are very essential in the execution and implementation of BSTC in the classroom.

2.2 Intended Learning Outcomes

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

- articulate the key concepts in David Ausubel's Theory of Learning

- identify the import principles in Jerome Brunner's Theory of Learning.
- explain Robert Gagne's Theory of Learning
- describe Jean Piaget's Cognitive Theory of Learning.

2.3 Psychological Theories of Learning

2.3.1 David Ausubel's Theory of Learning

David Paul Ausubel was an America psychologist. His most significant contribution to the fields of educational psychology, cognitive science and science education learning was on the development and research on advance organizers. Ausubel's theory of learning is concerned with how individuals learn large amounts of meaningful materials from verbal/textual presentations in a school setting in contrast to theories developed in the context of laboratory. In 1963,Ausubel developed Subsumption Learning Theory. The theory focuses on how individuals acquire and learn large chunks of meaningful information through visual means or text materials (*https://www.learningbp.com.*).According to Ausubel, meaningful learning, learned information is completely understood and can now be used to make connections with other previously known knowledge, aiding in further understanding. His learning theory is one of the most important for teaching/learning. Developing thinking skills in students requires specific instruction and practice rather than application. The four major tips to apply Ausubel's theory of learning are that it:

- leads off with the key takeaway
- encourages learner to apply previously acquired knowledge
- Includes both receptive and discovery based activities
- makes it meaningful.

Concept mapping developed by Ausubel is an instructional device that uses this aspect of the theory to allow instruction of materials to learners. For instance, making learning meaningful, present the learner with the image or picture of what you want them to learn about and asking them what they know about it and this isbasic pre-learning.Making learning meaningful is important to children's understanding of the learning concepts and the world around them. Teachers make learning meaningful when they link new learning to children's previous experience, relate concepts to children's lives and provide children with hands-on learning. This is what Ausubel called advance organizer by relating what students already know to the new content to be learnedand this increases retention. Ausubel theory of Subsumption is based on the idea that an individual's existing cognitive

structure is the principal and basic factor influencing the learning and retention of meaningful new material. He advocates student-centred discussion, making connections, increasing autonomy, building relationships and focus on literacy. Ausubel is one of the early advocate of advance organizer. He believed that when students use advance organiser they can bridge the gap between learning new information and information they already know. According to Ausubel meaningful learning,learned information is completely understood and can now be used to make connections(*Wikipedia.org*).

He stressed the value of prior knowledge in the learners' learning process. He was of the opinion that what a student already knew could aid or hinder new learning. He pointed out that meaningful learning occurs when there is appropriate link between prior knowledge and the new learned task. When such interaction is not there, rote learning occurs. He called the previous knowledge subsumer and described it as generalised knowledge that the learner already acquired that provide association or anchorage for the various components of the new knowledge. Another linkage relevant for meaningful learning is advance organiser. This involved organising the learning task in sequences from known to unknown using what is familiar to the learner and link it to the new idea. This is used where there is lack of previous knowledge. The teacher provides external linkage from where the learner will link the new knowledge. In other words, there must be set induction to get the learner ready for new knowledge meaningful learning can take place.

Self-Assessment Exercises 1

Enumerate the key concepts in Ausubel's theory of learning.

2.3.2 Jerome Brunner's Theory of Learning

Jerome Brunner was an American psychologist. He made significant contributions to human cognitive psychology and cognitive learning theory in educational psychology. According to him, instruction should address four major aspects: pre-disposition towards learning, structure knowledge so that it can be readily grasped by the learner, effective sequence in presenting knowledge and the nature ,pacing of rewards and punishments. According to him, it is better for the learners to construct their own knowledge. They do it by organising and categorising information using a coding system. Brunner believed that the most effective way to develop a coding system is to discover it rather than being told by the teacher. Jerome Brunner introduced the concept of learning by discovery. Discovery is an all forms of obtaining knowledge for oneself by use of one's mental processes. Brunner believed that

learning by discovery begins when a science teacher purposefully creates problem and present the problem to students by introducing some inconsistencies among sources of information which are given in the process of instruction. According to Brunner such inconsistencies lead to intellectual discomfort that will stimulate the students to initiate individual discoveries through cognitive restructuring.In his research on children's cognitive development, he proposed three modes of representation: Enactive representation (based on action), Iconic representation (based on images) and Symbolic representation (based on language) (*https://www.firstdiscoverers.co.uk*).Brunner initiated two forms of discovery processes namely assimilation and accommodation. He introduced the theory of scaffolding in which he said that children need support and active help from their teachers and parents if they are going to become independent learners as they mature. In other word student learn from experts by building on what they already know and how they think and learn derives from their culture with the help of adults. Children learn from building on what they already know to what they need to know. Many visual technology tools are designed to scaffold students' understanding.

Educational implications:
The main idea of the theory can be summarized as follows:

- Learning is an active process
- Learners select and transform information
- Learners make appropriate decisions and postulate hypotheses and test their effectiveness
- Learners use prior experience to fit new information into pre-existing structures
- Scaffolding is a process through which able peers or adults offer support for learning
- Intellectual development includes the three stages namely
  - enactive stage =learning through action
  - iconic stage =learners use pictures or models
  - symbolic stage =development of ability to think in abstract terms.

Self-Assessment Exercises 2

What are the implications of Brunner' theory to a science teacher?

2.3.3 Robert Gagne's Theory of Learning

Robert Gagne was an educational psychologist who pioneered the science of instruction in the 1940s. Gagne's condition of learning stipulates that there are several different types or levels of learning. The significance of these classifications is that each different type requires a different type of instruction. Gagne identifies five major categories of

learning: verbal information, intellectual skills, cognitive strategies, motor skills and attitudes and different internal and external conditions are necessary for each type of learning. For example, for cognitive strategies to be learned, there must be a chance to practice developing new solutions to problems. To learn attitude, the learner must be exposed to a credible role model or persuasive argument. Gagne suggests that learning tasks for intellectual skills can be organised in hierarchy according to complexity: stimulus recognition, response generation, procedure following, use of terminology, discriminations, concept formation, rule application and problem solving. The primary significance of the hierarchy is to identify prerequisites that should be completed to facilitate learning at each level. Learning hierarchy provide a basis for the sequencing of instruction (*Wikipedia*).

While Gagne's theoretical framework covers all the aspects of learning, the focus of the theory is on intellectual skills. The theory has been applied to design of instruction in all domains. Robert Gagne's theory of learning often referred to as Gagne's theory of learning hierarchy. The theory states that learning of a new concept or skill depends upon the mastery of pre-requisite concepts. This implies that previous knowledge determines what further learning may take place and that materials meant for learning must be sequentially structured. Gagne emphasized the importance of task analysis of instructional objectives(*https://www.instructionaldesign.org*). He also believes in the task analysis of the concepts, skills and knowledge to be taught. Gagne's theory believes that for the students to acquire the desired knowledge, the materials meant to be learnt must be sequentially structured so that the learning of one topic aids the learning of the next higher topic. This invariably implies that science must be sequentially structured from simple to complex until the desired objectives are achieved. In Gagne's hierarchy of learning, problem solving is the highest level while facts, concepts and generalization involved lower level.

Self-Assessment Exercises 3

What is the implication of Gagne's theory of learning for the scienceteacher?

2.4 Developmental Psychology

2.4.1 Jean Piaget Developmental Psychology

In our previous discussions, you have been taught some of theories of learning developed by ancient psychologists, their contributions to learning and implications and applications to learning. Mention two of those psychologists. Those psychologists include Gagne theory of

learning whose emphasis was on hierarchical learning structure and Brunner bases his learning theory on encouraging discovery learning by scaffolding of learning processes, then Ausubel who base his theory on linking previous knowledge as a base for learning new ideas. Today you will learn about another psychologist known as Jean Piaget.

Jean Piaget is a developmental psychologist who spear-headed the study on cognitive and mental developmental stages. Developmental psychology is the scientific study of how and why humans grow, change and adapt across the course of their lives(*https://en.m.wikipedia.org>wiki)*. Piaget's theory emphasized that learning ability corresponds to the level of intellectual development with its accompanying physical growth. Piaget identified four human intellectual developmental stages as sensory-motor stage (0-2years), pre-operational stage (2-7 years), concrete operational stage (2-11 years) and formal operational stage (11-15 years)

Sensory stage (0-2 years): The child's learning activities at this stage consists mainly of sensory and motor activities like seeing, sucking, tasting, touching, pushing and shaking the objects in his/her environment.

Pre-operational Stage (2-7years): 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.

Concrete operational Stage (7-11 years): At this concrete operational stage, the child's mental process is limited to thinking about things. The child is able to solve problems but limited ability to do so by nature. At this stage the child performs logical operation with concrete objects. The child can carry out logical processes like observing, describing, classifying and measuring real objects. The implications of the stage are that it is a period of exploration. This implies that studying of science in primary school should begin with the art of observation which uses basic senses of seeing, smelling, hearing, touching and tasting. Greater emphasis should be placed on doing than telling. Teaching at this stage should involve the use of models-specimens, real objects because the child depends on facts and theories.

Formal operational stage (11-15 years): Progression through the previous stages results in accumulation of experiences and development of mental structures which are necessary background for logical and pre-operational reasoning. This stage is characterised by freedom from reality. Reality provides starting point for thinking. At this stage the child develops abstract thinking. The child can follow logical

arrangements. At this stage more complex relationship of mathematics and science and hypothetical deductive nature of reasoning can be fully understood. The child can make deductions, compares and make inferences from ideas, solve ideological problems and relate symbols to concepts. Based on Piaget's developmental stage the period for the integration of science will be concrete operational stage.

Self-Assessment Exercises 4

What are the implications of Jean Piaget's theory of learning in Teaching basic science and technology?

2.4 Summary

The importance of psychological theories of learning and developmental operations to both science teachers and learners are obvious. In this unit, you learnt David Ausubel's theory of learning stresses: The value of prior knowledge in teaching ideas. It helps the learner to have strong base and desire to learn new ideas and it will enhance retention. Jerome Brunner's theory of learning centred on: Learning through discovery, constructive approach to learning where the learner participates in building his/her knowledge through activities. While Robert Gagne's theory of learning states that learning of a new concepts or skills depends on mastery of pre-requisite concepts. Then Jean Piaget's theory of learning emphasizes that learning ability corresponds to intellectual development. He established four stages of cognitive development with their corresponding years.

All these theories of learning have a lot of implications and applications in today's sequencing of learning at different stages of human development. They are all applied in the development and organisation of the BSTC. Visit this web for comprehensive and in-dept knowledge of the psychological theories: (https://fpmipa.upi.edu)

2.5 Glossary

Coding system-arranging learning in a way that the learner will remember the learned concept. According to Bruner this is achieved through discovery.

Scaffolding- structured step by step process to build knowledge
Hierarchy –sequence approach to teaching which calls for identification of pre-requisite that should be completed to facilitate learning.

2.6 References/Further Readings/Web Resources

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2.7 Possible Answers to Self-Assessment Exercises

SAE 1

According to Ausubel, subsume is the previous knowledge a learner has before coming into the class which serves as a linkage to the new knowledge to be acquired. The presence of subsume gets the learner ready for new knowledge and links learner to the new knowledge thus making learning of the new knowledge easier. Examples of subsume are experiences gained during coaching at home, exposure to educational events. Advance organiser is an external attraction introduced by the teacher that will link the learner to the new knowledge. Examples are set inductions learning materials.

SAE 2

Implications of Jerome Brunner's Theory to the science teacher are:

- Science teachers should place emphasis on the important of ideas and relationships of subjects that will allow students generate new concepts, ideas, relationship and principles
- Science teacher should create problems that can lead to discomfort that will result to students initiating individual discoveries through cognitive structuring
- Science teacher should encourage discovery learning to aid problem solving and develop creativity in the students
- Science teacher should encourage students to make intuitive guesses. This will help students have a chance to practice their ability beyond the information data
- Students should be taught inductive approach
- Radical re-organisation of science curriculum across all levels of all the subjects the student will study are presented in a very simple form

SAE 3

Implications of Gagne's theory for science teacher are:

- Content in science subjects should be arranged in hierarchical order such that simpler concepts are mastered first before the more complex concepts
- Science teachers should state the objectives for learning any topic
- Learning should be arranged in sequence such that learning one topic should lead to learning of the next higher topic

SAE 4

- Science teacher should promote exploration and interaction with environment using locally available materials
- Science teacher should ensure that the learner deals with concrete materials before going to complex, commencing teaching from simple to complex

- Present new ideas and knowledge at the level consistent with the child's present state of development, thinking and language
- Focus on problem solving rather than rote memorisation

UNIT3 METHODS OF TEACHING BASIC SCIENCE AND TECHNOLOGY

Unit Structure

3.1 Introduction

In the previous units, you learnt the psychological theories of learning. What are the applications of the learning theories? The learning theories are applied in the process of teaching and organisation of the learning in the class room. For instance, Gagne emphasised hierarchical organisation curriculum while Ausubel laid emphasis on discovery of knowledge and radical re-organisation of curriculum. Piaget talked about the presentation of knowledge at level consistent with child present developmental age. All these theories laid emphasis on the presentation of knowledge to the learner to aid learning.In this unit you will learn the different methods you can use to present materials to the learner. That is what is called *teaching methods*. Methods of teaching are the approaches or means adopted by the teacher to carry out the function of instructions (*https://www.academia.edu.*>). There are many approaches in practice which the Integrated Science teacher can apply in delivering BST instruction to early science learners. The best approach is learner-centred approach as specified in the BSTC.Also in this unit, you will learn the use of ICT as teaching tool for BSTC.

3.2 Intended Learning Outcomes

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

- apply the different methods of teaching in delivering BST instructions at different levels
- select child-centred teaching methods in BST instructions

- outline some teaching methods appropriate for teaching Basic Science and Technology curriculum based on the learning theories
- apply ICT as a teaching tool.

3.3 Methods of Teaching BSTC

3.3.1 Criteria for Selecting of Teaching Method

Different teaching methods will be discussed in this unit. Each teaching method is as good as the other. It depends on the teacher to select the method suitable for the topic to be taught. More than one teaching methods can be combined in teaching a topic. There are many other methods such as lecture, discussion, play method, inquiry, project method and so on. Before a teacher decides to use any method for instruction, there are a lot of things he/she has to bear in mind. Before selecting teaching method, the teacher should consider the following(*https://educarepk.com>selection*...)

- **Age of the learner:** The physical and mental development of the learner must be considered in selecting method for teaching. Here the teacher applies the Piaget cognitive developmental theory. This will help the teacher to understand the characteristics of the age of the learner.
- **Topic to be taught:** this is very necessary because even though every topic can be taught to any level of learner, all topics cannot be taught with the same method as earlier mentioned. The nature of the topic determines the type of method to be used in teaching it.
- **Competence of the teacher:** The teacher must select method she/he can easily and effectively handle in delivering instruction.
- **Size of the class:** The size of the class is very essential in the choice of method to use. Method used for small size class of 20 pupils cannot be suitable for 100 pupils.
- **Resources available:** Availability of resources is considered in selecting instructional method. It is wise for the teacher to select method of instruction she/he knows there is
- **Time for the teaching:** The time in the time-table allotted to the topics, influences the selection of the teaching method to use. The method used for two hours teaching cannot be used for 40 minutes teaching(Adhikari,2017).

Method of teaching Basic Science and Technology as stipulated in the curriculum is guided inquiry and activity-based approach. The curriculum advocates for child-centred approach in the teaching of Basic Science and Technology. Guided inquiry is a teaching approach where

the learner carries out the learning activity with the teacher as a guide. The learner from experience builds up his/her knowledge. The learner is in control of what he/she learns. Activity-based approach is the road to inquiry. All inquiry learning involves use of materials which the learner will use in the process of inquiry. Child-centred indicates that the learner is at the centre of the learning process. The learner is involved in his/her learning process. Some child-centred teaching methods recommended for BSTC will be discussed in the next units.

Self-Assessment Exercises 1

What Criteria will you apply in selecting teaching method for a topic in BST curriculum?

3.4 Selected Methods for Teaching BSTC

3.4.1 Inquiry Method

In the last class, you were taught the criteria for selecting teaching methods suitable for a topic you wish to teach. Supposing you decide to use inquiry method because it is stipulated in the BSTC, how will you use it? How is it used? This is the teaching approach where the learner plays the role of determining the solution to the problem. The learner builds his/her knowledge following the teacher's guide. It is a structured exploration of knowledge by the learner following the teacher's guide. It is child-centred approach to teaching. It helps the learner to interact with objects and thus develop science process skills.

Inquiry method can be applied in teaching all basic science and technology topics. It requires the teacher to plan ahead of what the learners will do and use for the inquiry activity. In inquiry-based learning, the learner plans the first phase of the inquiry process and thinks about the information they have currently and the information that they still need. There are four types of inquiry method namely:

Confirmation: the students are asked a question, its answer and the method of reaching this answer.

Structured: the student is giving an open question and investigation method.

Guided and open inquiry: the student is giving an open question.
These student-led learning methods can be used for all subjects from primary to senior secondary level. 5 steps in inquiry-based learning are:

- *Ask questions*: the first step in the inquiry process is to pose a question

- *Probe into various situations*: Conduct research
- *Conduct analyses and provide descriptions:* Interpret the information
- *Communicate findings, verbally or in writing*: Share the information
- *Think about the information and knowledge obtained:* Assess learning

An example of inquiry question is explain why Abraham Lincoln was a great President. The five elements of inquiry-based learning are essential questions, students' engagement, cooperative interaction, performance evaluation and variety of responses. Lesson begins with question that sparks curiosity and a sense of wonder. Students are encouraged to ask questions. Common elements between inquiry and problem solving include: asking questions or defining problems, exploring solutions or explanation, analysing or testing solutions.

Inquiry-based learning is a learning process that engages students by making real-world connections through exploration and high-level questioning. It is an approach to learning that encourages students to engage in problem solving and experiential learning. It is a shift from studying to doing. It provides the opportunity for students to put on the lenses of scientist to gain knowledge and deepen their understanding of the past and the world today. Advantages of inquiry-based learning include helping students make their own connections about what they learn. Their curiosity helps them engage and gain a deeper understanding of topics and contents, instead of primarily memorising and recalling rules, ideas or formulas.

Self-Assessment Exercises 2

What topic can you teach using inquiry-based learning?

3.4.2 Project Method

Project method is one of the methods recommended in the curriculum teaching of BST at all level in both primary and junior secondary school. It is a child-centred approach and inquiry based. It is a learning process that gives the learner the opportunity to apply what he/she learnt to real situation (*www.researchgate.net.*). It is a practical application of the knowledge acquired to real situation. Project is the integration of all that are learnt from BSTC to address the needs in the environment. It focuses on democracy and collaborative learning to solve purposeful problems, (Knoll, 2014). It helps the learner to develop critical thinking, manipulative skills as well as innovative, inventive and creative skills. It integrates knowing and doing (Markhams, 2011). A lot of projects are

recommended in the BSTC for the students. The teacher is to guide the learners to carry out these projects.

It is an educational enterprise in which children solve a practical problem over a period of several days or weeks. Project method is one of the modern methods of teaching in which the students point of view is given importance in designing the curricula and content of studies. it is based on philosophy of Pragmatism and principle of learning by doing. Project method was developed by William Heard Kilpatrick in 1918. The basic idea of the method is that pupil can learn a lot of things with the help of association and mutual co-operation. This method promotes purposeful activities through a group of pupils and the pupil will work co-operatively. Project aims at bringing out what is in the child and at allowing the child to develop himself or herself gives opportunity for self-expression and for relating self to the community. It plays crucial role informing the competitive person, which answers all requirements of modern society.

Major characteristics of project method include:

1. It has a definite attainable goal
2. it involves life-like and purposeful activities which promote learning
3. students can plan and perform their learning activities
4. It promotes learning by doing
5. It is a play-way activity which enhances learning

The role of the teacher is to supply clues and also provides information to the students about the sources of materials for the project. The teacher also helps the students in evaluating the project and to draw inferences. The relationship of the teacher and students is very close in project.

Examples of Project-Based Learning Activities:

- Planning a garden that meets specific objectives
- Launching a recycling program that solves an identified problem
- Analysing the five most popular social media
- Creating visibility for something beautiful, useful or deserving attention
- Helping local business increase environmental sustainability.

Self-Assessment Exercises 3

What is your role in project-based learning process?

3.4.3 Laboratory Method

Laboratory method is instructional procedure by which the cause, effect, nature or property of any phenomenon is determined by actual experience under controlled conditions. Laboratory teaching assumes that first-hand experience in observation and manipulation of the materials of science is superior to other methods of developing understanding and appreciation (*https://narst.org>research-matters).* It provides various practical experience starting from theory. The objectives of laboratory method are:

- Making use of power of observation and reasoning
- Manipulate learning equipment
- Make use of reality to make learning easier and more permanent
- Make use of scientific attitudes
- Use the laboratory method or procedure.

Laboratory method involves utilizing raw data or material things to produce better understanding of the subject matter or lesson, learning by doing, using reality instead of symbols, reality has more vividness and investigatory or experimental.

Advantages:

- Students learn by doing and come in contact with raw data or material objects in the teaching-learning process.
- Develop the power of observation and reasoning
- Develop scientific attitude
- Gives an understanding of what research is and how to apply the scientific method to research
- Gives training in organising data gathered from real material objects and how these objects are manipulated to attain the objectives
- Since students come in contact with real life situations, it can be a preparation for solving real life problems

Disadvantages:

- Uneconomical way of learning in time and material
- Does not give much training in verbal expression and when the same equipment is used most of the time, its use becomes mechanical.

This is an activity packed method for group or individual learner(s) targeted at making personal observations of processes, products or events. Laboratory method can either be laboratory exercise or laboratory experiment. All laboratory exercises are experiments but not

all experiments are laboratory work. Laboratory method is adequate for illustrating scientific principles, laws as well as inculcating in students how to write laboratory reports. It provides students opportunity to develop manipulative and practical skills. It inculcates in student habit of critical thinking and enables them imbibe the culture of replication. It develops in the students the scientific processes of observing, classifying, measuring, interpreting and inferring and develop in the learner the scientific attitudes. All BSTC contents are laboratory based but the teacher must always be present to guide the use of laboratory equipment and to avoid accidents.

Self-Assessment Exercises 4

List the components of an integrated science laboratory.

3.4.5 Field Trip

Field trip is a trip made by students or researchers to study something at first hand. For example, a trip to power plant. The purpose of the field trip is usually observation for education, non-experimental research or to provide students with experience outside their everyday activities. A field trip or excursion is a journey taken by group of people to a place away from their usual environment (*en.wikipedia.org*). In education, it is defined as visits to an outside area of the normal classroom and made by a teacher and students for purposes of first hand observation.

Benefits of Filed Trip

- Academic growth
- Deepened Engagement
- Real world experiences and cultural growth
- Enhance critical thinking
- Botanical garden
- Great outdoor activity
- Museum
- School excursion can be educating
- School excursion can be fun
- Field trip can raise the awareness of pupils on important topics
- Can be used to get back to the roots
- May broaden the horizon of students
- Pupils can relax
- Information can be presented differently
- Students can learn outside the classroom
- May improve the fitness of students
- Also teachers can expand their knowledge
- New ideas for future teaching projects
- Students may become more motivated

Even though students learn a lot in school, the topics that are taught in school are often quite theoretical and students can learn some practice and field application of what they already learned in theory. Hence school excursion can give students the chance to learn from a different angle.*Field trip is one of the child-centred and inquiry approaches adopted for the teaching of BSTC.*Field trip adopts excursion to places for educational purpose(*https://www.educationalschooltrip.com.*). It is generally outside the classroom for the purpose of making observation and obtaining specific information from original or natural condition. It brings the learner close to real life situation and creates positive attitude towards science. It involves many of the senses and help to create keen interest in the learner. It encourages team spirit which can be used in the discussion group.

Disadvantages of Field Trip

- It can be dangerous
- It can be costly
- May be difficult for large class
- Transportation issues related to school trips
- Insurance problem may arise
- Parents may not agree with field trip
- Excursion may not be in line with the preferences all students
- Teachers may be personally liable during excursion
- Students may get lost
- School kids may not show up for excursion
- Organisation efforts
- Field trips can be stressful
- Can be physically demanding
- Time cannot be used for other classes.

Self-Assessment Exercises 5

As an integrated science teacher, which method will you prefer to use in teaching; project method or field trip? Give reasons.

3.5 Summary

In this unit you have the different methods for teaching integrated science. These methods are recommended in the BSTC. As a teacher which of these methods is better for teaching integrated science? No single teaching method is exceptionally the best for teaching Basic Science and Technology. They are all good for teaching BST. It is left for the teacher to select the one to use based on the criteria set up for selecting teaching method. You will consider the age of the learner, the topic, size of the class. You can combine two or more methods in

teaching. However, child-centred approach as discussed is the best approach for teaching Basic Science and Technology. Suitability of method depends on the age of the learner, the topic and the competence of the teacher. Each method has its merit and demerit. An effective teacher combines two or more methods in the process of teaching and learning to achieve the varied objectives stated.

3.6 Glossary

Museum: A building in which objects of historical, scientific, artistic or cultural interest are stored and exhibited.

Botanical Garden: It is a garden dedicated to the collection, cultivation, preservation and display of a wide range of plants which are typically labelled with their botanical names.

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3.8 Possible Answers to Self-Assessment Exercises

SAE 1

Before selecting teaching method, the teacher should consider the following:

(i). **Age of the learner:** Both the physical and mental development of the learner must be considered in selecting method for teaching

(ii). **Topic to be taught:** All topics cannot be taught with the same method as earlier mentioned. The nature of the topic determines the type of method to be used in teaching it.

(iii). **Competence of the teacher:** The teacher must select method she/he can easily and effectively handle.

(iv). **Size of the class:** The size of the class is very essential in the choice of method to use.

(v**)** **Resources available:** Availability of resources helps in selecting teaching methods.

(vi). **Time for the teaching:** The time in the time-table when the topic is taught influences selection of teaching methods.

SAE 2

You teach any topic with inquiry method but you need to plan it well.You can ask the students to write about the life of lizard: find out how it feeds, sleep and where it can be found and how it reproduces.

SAE 3

The role of the teacher is to supply clues and also provides information to the students about the sources of materials for the project. The teacher also helps the students in evaluating the project and to draw inferences. The relationship of the teacher and students is very close in project.

SAE 4

It must be well ventilated and lighted
It must have at least two out doors
It must have running taps
There must be a store
There must be benches, shelves and cupboards

- Gives an understanding of what research is and how to apply the scientific method to research.
- Gives training in organising data gathered from real material objects and how these objects are manipulated to attain the objectives
- Since students come in contact with real life situations, it can be a preparation for solving real life problems

SAE 5

I will use field trip because:

- School excursion can be educating.
- School excursion can be fun.
- Field trip can raise the awareness of pupils on important topics.
- Can be used to get back to the roots
- May broaden the horizon of students
- Pupils can relax
- Information can be presented differently.

UNIT 4 RESOURCES FOR TEACHING BASIC SCIENCE ANDTECHNOLOGY CURRICULUM

Unit Structure

4.1 Introduction

In the previous unit, you studied the different methods for teaching BST. As a teacher, what will you use to teach BSTC ? Tools/materials are used in teaching. These tools/materials are called *Resource Materials.* In this unit you are going to learn the different tools you can use to teach BSTC. You will learn about Information Communication Technology (ICT) as a teaching tool. In this unit, you will learn the process of improvisation of teaching materials as well as learning procedure.

4.2 Intended Learning Outcomes

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

- enumerate some teaching resource materials that can be used to teach BST
- discuss the importance and factors that militate against improvisation in the teaching of BST
- explain one use of ICT as a teaching tool
- describe some of the characteristics of a good teaching resource materials.

4.3 Resource Materials

4.3.1 Meaning of Teaching Resource Materials

Learning resource materials are those materials human and non-human that facilitate learner's learning process. They are the medium through which the teacher concretizes and transfers knowledge and ideas to the learner. Resources materials are medium of instruction between the teacher and the learner. They are concrete materials the teacher uses to communicate ideas to the learner. A teaching resource material can take many different forms and will mean slightly different things to every teacher, parent and child. But the basic definition is that teaching resource material is designed to help facilitate learning and knowledge acquisition.

The question to be answered may be: how can we get the best out of the teaching resource materials and why do we use resource materials in teaching at all? let us explore the world of teaching resource materials and try and find some answers. What makes good teaching resource materials?

In order to make a good teaching resource materials, you need to design it with your mind. You have to have many resource materials available, making sure that any gap or problem are addressed so that you can teach your lesson the way you want. Secondly, check your resource materials before use, so that you can guarantee that the resource materials is accurate and never cuts corners. Thirdly, the resource materials must be easily accessible and available. It must be flexible because each teacher has their own style and each child has a unique way of learning. That is why as a teacher, you will make many resource materials available. Lastly, keep up and stay up to date with all the latest teaching trends and curriculum changes and be at home with latest technological advancements and putting them to use in the classroom. The importance of teaching resource materials in the delivery of BSTC cannot be over emphasised.The emphasis on environmental resources is clearly illustrated in the objectives of Basic Science and Technology which is to teach pupils how to tackle some of the questions that arise from observation of their own environment as it affects their daily life (Federal Ministry of Science and Technology, 1985). The National Curriculum for Basic Science and Technology Education (2012) in accordance with FGN (1985) suggests the use local materials for teaching BSTC which reflects the importance of getting children well equipped with resources in their environment which according to Abdullahi(1983) provides a greater human and instructional laboratory.
Here are some of the most popular types of resources materials for delivering quality teaching and learning process of BSTC:

- **Power Point:** this is perfect way to teach your class as a whole. Power point can be a great way to give some structure to your lesson and encourage discussions.
- **Worksheet:** A more individual way of working. Worksheets and handouts encourage children to practice what they have learnt and often use different types of exercise to cater to a wide range of learning styles.
- **Interactive Resource Materials:** this is great for getting the whole class involved in an exciting activity whilst reinforcing the knowledge and skills they have learnt. Encouraging some good-spirited competition is a great way to engage students and get them excited about their own learning.
- **Display Materials:** Everyone wants their classroom to look the best and for good reason. Decorating your classroom helps to foster a culture of learning within the classroom and provides as opportunity for your children to show off all their hard work.
- **Tests and Assessments:** This is a less enjoyable, but still incredibly important part of your teaching process. Being able to measure your children's process throughout the year helps you to set out specific learning goals for the children and provide them with the support they need.
- **Plan and Scheme:** Planning take up a lot of time in your schedule and can often feel like it is taking time away from supporting your children's learning. Our lesson plans help you save valuable time and support you when organising your future teaching schedule.

As mentioned in the previous unit, here are some other quick-fire questions that you can ask yourself about the relevance and suitability of your teaching resource materials.

- Is the teaching resource material culturally appropriate?
- Is the teaching resource material laid out in a way that is easy to follow and understand?
- Is the teaching resource material engaging for students?
- For teacher, in order to determine a teaching resource material's suitability, you must clearly lay out your teaching goals for the lesson and assess whether the teaching resource materials will help you achieve them.

Self-Assessment Exercises 1

How can you determine the suitability of a teaching resource material?

4.3.2 Types, Management and Characteristics of Teaching Resource Materials

You can make your classes really intriguing and more significant for the students by utilizing a few articles or materials to help their verbal depictions. Utilizing an enormous assortment of materials are found to improve better comprehension of ideas and for making learning seriously fascinating. Teaching resource materials are also called instructional material or teaching aids or teaching learning materials. In BSTC, emphasis is on student-focused methodology or child-centred, both the students and children need an increasing number of materials to improve their ability to learn together or independently.

Here are types of Teaching-Learning Materials:

- **Visual Aids:** Blackboard, Posters, Flashcards, Presentations, Printed textbooks, Graphs and Info graphic.
- **Audio Aids:** Radio, Tape-recorder and CDs.
- **Audio-visual aids:** Videos, Video recording Films and Documentaries, virtual Classrooms.
- Language Laboratory
- **Computer Assisted Learning:** Pre-recorded DVDs, CDs, online quizzes, eBooks, podcasts and blogs.

Characteristics of Good Teaching Resource Materials:

- Teaching resource materials (TRM) should be appealing to the kids. Sizes, shading, development and in few cases the smell or/and taste or sound are a portion of the properties of the materials which allure students.
- The familiarity with TRM will assist with presenting new ideas. The kid/students can likewise control these materials easily for significant learning of new ideas.
- The novelty of the material additionally draws in the kids/students. Surprising materials or novel use of natural materials are the appealing highlights of good TRM.
- The material ought to have utilitarian worth. It is in the appropriate utilisation that makes the material positive or negative.
- Materials of numerous utilities like dice, sticks, marbles, 3D shapes and blaze cards can have numerous utilisation in practically all branches of knowledge in primary school educational plan and are subsequently more popular as TRM in the schools.
- The simplicity of taking care of the materials which incorporate toughness, lightweight and wellbeing is a significant trademark for which such materials are liked in the educating learning measure.

Management of Teacher Resource Materials;

Below are certain methods to manage teaching learning materials

- Guarantee accessibility of adequate TRM for free utilization by students/kids
- If you are intending to utilize the locally accessible materials, ask few students to gather those and bring them to class
- Before the initiation of the period, gather every one of the materials from the school store or from different sources
- Use delivery exercise, floor exercise, materials arranged inside and outside the study hall like a nursery, jungle gym and so forth as wellsprings of learning
- Create a little gathering of students in the group who might be the forerunners in assortment, readiness and upkeep of the materials in the study hall. They ought to be given the duty to figure out the necessary materials before the beginning of the period and to supplant the materials in their individual places after the period is finished. Those that gather the materials might be changed every month.
- For better support, keep a record of TRM in your class. It would work within finding the harmed and lost articles in order to have a convenient substitution of those articles.
- Once in a month the TRM stock ought to be checked and the store tidied up appropriately.

There are other classifications of TRM into human resources, material resources and financial resources.

Human Resources

Human resources are persons including the class teacher who has helped students to understand the concept, ideas and knowledge presented to them. Human resources include the teacher, the pupils, experts from scientific establishment, personnel from factories, health workers, parents, scientists, local craftsman who may be brought to give the learner first-hand information and experiences in certain scientific skills and knowledge. A content analyst of the Basic Science and Technology curriculum recommended a range of human resources for teaching it.

Material Resources

Material resources are materials found in nature that can be used for practical. Materials resources abound such as wood, glass, rocks, chemicals, living things and non-living things. The material resources are those local materials within the school surroundings such as the school garden, school laboratory, science room or nature corner, ponds, streams, town or village market, stones, working spaces, hospitals, industries, museums, zoo and natural habitats. NERDC (1988), recommended materials resources for integrated science to include

resources within school laboratory and compound, visit to building sites, the zoo, the airport and big farms These are things that can help the learner to concretize the concepts exposed to them in the classroom and relate them to their life and used to solve the problems related to them in the society.

Financial Resources
These are materials that are bought either from factory, market or imported. They are not improvised materials. They are conventional materials, standardised and can withstand all environmental conditions.

Self-Assessment Exercises 2

To acquire teaching resource materials is becoming difficult. What are the means you will use to manage your resource materials?

4.4 Information and Communication Technology (ICT)

4.4.1 ICT as Learning Tool

In the previous class, you learn the different types and characteristics of teaching resource materials. You are going to look at a digital teaching resource material known as information communication technology (ICT). ICT is the mode of education that use information and communications technology to support, enhance and optimise the delivery of information. Worldwide research has shown that ICT can lead to improved student learning and better teaching methods. Report by National Institute of Multimedia Education in Japan proved that an increase in the use of ICT in education with integrating technology to curriculum has a significant and positive impact on students' achievement. The result showed that the students who are continuously exposed to technology through education has better knowledge, presentation skills, innovative capabilities and are ready to take more efforts into learning as compared to their counterparts. For the above reasons, in the National Policy of Education (2014) government proposed that integration of ICT into education in Nigeria begins from primary school. As result in BSTC, ICT is one of the major teaching and learning tools. Much emphasis was placed on the use of ICT in the teaching of Basic Science and Technology. It is the wish of the Federal government of Nigeria that ICT skills be inculcated in pupils from Basic Education. ICT is not only a learning tool but also a teaching tool. ICT support learning through four main effect: promoting cognitive acceleration, enabling a wider range of experience, increasing students' self-management and facilitate data collection and presentation. ICT provides environment for integration of school subjects and used to teach all school subjects. Anu, Kapil, Sameer and Seema (2011), opined

that the role of ICT in teaching process helps in solving many educational programmes. It can be used for tutorials, assimulations and drilling. It is very useful in handling large classes. According to Baishakhi and Karmal (2016), the role of ICT in the 21st century's teacher education is inevitable for usability of it in the teaching and learning process.

In the new trends, introducing ICT into education is the answer for those who ask; how can we increase the reach of our institution to a larger number of students. The Mobile learning is a rising trend where the education has outgrown the physical constraints of the classrooms and acquired mobility. Students access information whenever and wherever they want and institutions that provide such advanced technological terrains is rising in number day by day.

Various Devices in ICT for Learning and Teaching are:

- Access of course materials through remote devices.
- Online digital repositories for lectures, course materials and digital library.
- Online/cloud based academic management systems.
- Employing the flipped classroom concept.
- Making use of handheld computers, tablets computers, audio players, projector devices.
- Also the rising number of Massive Open Online Courses like NOUN tells us that there is a huge demand for off-the-classroom learning facilities (https://kenyayote.com>list of-ict-).

Impact of ICT on Education

- It enhances learning experiences and provide new sets of skills
- It reaches more students with Massive Open Online Courses
- It facilitates the training of faculties
- Minimise costs and saves time associated with information delivery and automating regular day-by-day tasks
- It improves the administration of institutions to enhance the quality and efficiency of delivering tasks

The role of ICT in education cannot be overemphasized. Information Technology (ICT) can impact students learning when teachers are digitally literate and understand how to integrate it into the curriculum. Schools use a diverse set of ICT to communicate, create, disseminate, store and manage information. Using information technology in education has made it possible for students to keep on learning, irrespective of where they are. Teachers and professors can send assignments to students and they can complete and submit them even

without physically stepping into the classroom and so learning never has a stop.

Advantages of ICT to Learning and Teaching

- It guarantees e-learning or Online Learning
- It brings inclusion
- It promotes high-order thinking skills
- It enhances subject Learning
- ICT use develops ICT literacy and ICT capability
- ICT use encourages collaboration
- ICT use motivates learning
- ICT in education improves engagement and knowledge
- ICT are making differences in the teaching approaches and the ways students are learning.
- ICT-enhanced learning environment facilitates active, collaborative, creative, integrating and evaluative learning as an advantage over the traditional method.

In other word, one of the main aims of ICT in education is to help students to become competent and confident users who can use the basic knowledge and skills acquired to assist them in their daily lives. It is supposed to prepare students for the future. It aims to help learners to have an open and flexible mind. ICT is relevant in teaching BST topics. Its advantages abound. It addresses most of the problems of teaching such as class size, lack of qualified teachers. The zooming packages which is used in conferencing and distant discussion was very useful during COVID-19 for lectures and teaching. Many institutions versed in ICT did not lose any academic session because of COVID-19. There are many other relevant of ICT in teaching BST topics.

Self-Assessment Exercises 3

Use your mobile phone and find out the application of the following in learning and teaching: Black Board, Goggle Classroom, Trello and Microsoft Team.

4.5 Improvisation

4.5.1 Improvisation of Teaching Materials

In the previous class, you learnt about teaching resource materials, types and characteristics. In your word, name one characteristics of teaching resource materials. Teaching resource materials or resource materials or teaching aids should be appealing to the kids/students. Sizes, shading, smell or taste are proportional properties of the materials which allure

students and kids. Today you will learn the process of improvisation. Not all the teaching resource materials are bought from the market or stores or imported. Many of the materials are produced locally by the teacher and students. This type of materials produced by the teacher or teacher and students are called improvised materials and the process is called improvisation. In the National Policy on Education for basic education, much emphasis was placed on improvisation of materials for the teaching of Basic Science and Technology. This implies that both the teacher and students/pupils should provide the materials for teaching BSTC using local materials. Improvisation is an art of the teacher providing alternative learning materials to facilitate teaching when the original materials are not enough or not available. Improvisation is the ability to take existing pieces and put them together in a new combination for a purpose (https://web.pdx.edu>). Process of improvisation involves the use of local materials to provide materials that can help students understand the concepts taught in class or elsewhere. It is generally initiated by the teacher but the learner can participate in the process of improvisation by collecting materials for the improvisation. It is a teaching tool because in the process of improvisation the students are learning. In the process of improvisation students/pupils learn the underlining principle of the concept by being part in the construction. It is also a teaching method. The process of improvisation is used by the teacher to teach topics of BSTC in a form of project. It is a construction process and is used to develop useful materials that can be relevance in solving problems in the society. It is a student-centred instructional process because students are involved in improvisation. One attribute of improvisation is that, it uses local materials from the environment of the learner to produce the learning material needed for learning and teaching process. Because it involves use of local materials, it introduces local milieu to the learning process. Improvisation though very important in teaching and learning, is time consuming and costly. But it develops in student skills of invention, removes the abstract nature of science and bring in cultural milieu of the learner into science. Holdhus, Hoisaeter and Mallard (2016), explained improvisation as basic tool for learning science.

Process of Improvisation:

In improvisation both students/kids and teacher participate in the process. The teacher takes the lead while the learner follows the teacher's directives. Generally, the students/kids collect the materials needed for the improvisation. At the beginning of the lesson the teacher introduces the topic, gives explanation of some concepts to be learnt in the process and directs attention to it. Each child/student bring out his/her notes. As the teach fixes the materials he/she explain to the students what he/she is doing, make clear the principles he/she is trying to make the learners understand. The students/pupils may be asked to

replicate the teachers sample on their own at home. The process of improvisation is an open form, in which participants may engage on their own terms. It is a process through which subjugated knowledge may become legitimised.

Importance of Improvisation

The importance of improvisation cannot be underestimated. Chukwunyeremnwa (2013) identified the following:

- It reduces the money spent on the purchase of equipment in educational institution
- Ensures the realisation of lesson objectives
- It encourages students toward the development of creative skills
- It gives room for teacher to demonstrate his creative skill and give room for use of cheap local materials.
- It provides a frame of reference on which students can key their attention during class period
- It enables the teacher to think of cheaper, better and faster methods of making teaching learning process easier for students and pupils.
- Affords students the opportunity of becoming familiar with resources in their environment.
- Helps in solving the problem of lack of equipment in educational institutions
- It strengthens enquiry, discovery and investigative methods in science
- It makes one a team player and makes one a better listener

Reasons for Teachers to Use Improvisation in the Classroom

Improvisation is fun for kids and students. It gets a class full of students moving, playing and laughing. Beyond simply engaging and entertaining students and pupils, there are many reasons for teachers to use improvisation in the classroom namely:

- **Change the vocabulary and change the behaviour:** Yes, is mantra of improvisation. In improvisation, we agree and we add. By making improvisation an important piece of the classroom culture, the vocabulary of behavioural expectations change
- **Free the mind now; judge later:** Students don't just get stuck saying 'no' to their teacher, they get stuck saying "no" to themselves as well. As teachers, we encourage them to say "no" to themselves. It is necessary. Saying no is a part of the discriminating processes of editing, self-correcting and coming up with the best answer. Improvisation is the best tool to teach it.

- **Build public speaking skills:** for students who are nervous about getting up in front of class to present, playing improvisation games and following direction with friends can be a great way to prepare. They have the safety of the group and can join in the fun as they feel comfortable. This can make the front of the class seem like a less scary place.
- **Foster collaboration in groups:** there is a place for assigning roles among group members. Improvisation teaches participants to step up when another idea is needed and cede the floor when another student wants to share.
- **Create something that's truly shared:** creating is high-level critical thinking skill and when you have created something as a class or group for which no individual can take credit, you have created something very special. It can develop an important new science concept which can be refined and changed as a unit progress.
- **Use multiple intelligences**: improvisation physicalizes learning, meaning that spatial learners benefits when it is used. Physicalizing learning through improvisation improves students' success with materials.
- **Present multiple points of view:** nothing is better than improvisation for seeing things from a different point of view. Through assuming the worldview of a character, students can change their perspective.
- **Discover new stars:** you will find there is group of students who excel at this kind of work and receive positive feedback from you and their peers. For many of these students, being a star in an academic setting will be a new feeling. That's a one kind motivator and can make a big difference in a child's life.
- **Practice what you preach:** improvisation will make you a more positive, creative teacher. Yes, and is a refreshing answer for students to hear from you too. Improvisation will make you a better listener in the classroom and more open to new directions your class might take.

Demerits of Improvisation

- It is terrifying: Anything you have never done before has an element of terror in it
- It is risky: Anything valuable is a risk at some level but we are competent enough to take risk. You too are.
- It is touchy-feely: There is a balance between fun and weird and we tilt heavily toward the fun. We are different and we are safe. It is on the spot and no one like to be put on the spot.
- It is abstract
- It is interactive. Trust your team

- It is fun.
- It is play
- It is not serious
- It is unknown

The process of improvisation gives teachers the knowledge of creativity, manipulative skills and critical thinking. It helps in saving cost of looking for ready-made instructional media which are more costly. It encourages self-reliance and feeling of confidence during instruction delivery. Though improvisation is advocated for use in teaching and learning processes, it has some constraining factors facing the teachers during improvisation to include: financial constraints, large class size, lack of skills and strategies on improvisation, time constraint, unavailability of tools and lack of exposure on improvisation.

Self-Assessment Exercises 4

Improvise the material you will use to teach a lesson on pollution.

4.6 Glossary

- **TRM -** Teacher Resource Materials
- **ICT -** Information and Communication Technology
- **MOOC -** Massive Open Online Courses

4.7 Summary

It is at the heart of Basic Science and Technology curriculum that it be taught using varied types of resource materials from the students' environment.

In this unit you have learnt the major resources used in the teaching and learning processes of Basic Science and Technology programme. You have seen how ICT has double role of teaching and learning tools. The role of improvisation, it's characteristics and benefits were made very clear and the relevance of human resources to the implementation of integrated science programmes. Local materials and human resources draw the learner to close observation of their environment. Improvisation in integrated science has a double role as instructional technique and a learning tool for beginners in science. It helps both the learner and the teacher to develop manipulative skill using materials from their environment to solve day to day problem.

4.8 References/Further Readings/Web Resources

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4.9 Possible Answers to Self-Assessment Exercises

SAE 1

By answering the following questions:

- Is the teaching resource material culturally appropriate?
- Is it easy to follow?
- Is it engaging to students?
- Is it meeting the teaching objectives?

SAE 2

- Ask few students to gather materials to school
- Gather the materials in the store
- Get students to be forerunners for sorting the materials
- Keep record of your TRM
- Have routine check of the materials

SAE 3

Use your mobile phone to find out the applications of the following in the teaching and learning: Black Board; Goggle Classroom; Trello and Microsoft Team.

SAE 4

Improvise the material you will use to teach pollution (air, water and environmental pollution).

MODULE 3 TECHNIQUES FOR ORGANISING BSTC, LABORATORY AND EVALUATION PROCEDURES

In this course EDU 754 (Method for Integrated Science) there are 3 modules. You have studied the first two modules namely historical development of integrated science and philosophy and psychological theories of learning as well as methods of teaching and selecting materials needed for teaching BST. In this last module techniques for organising BSTC, laboratory and evaluation procedures, you will learn the organisation of the BSTC into syllabus, scheme of work and lesson plans. In the module you will go into the BST curriculum, study it, break it into syllabus and schemes reflecting yearly and termly work to cover. After this, you will also learn to organise the scheme of work into daily lesson plan. It is at this module that you will bring into play all you have learnt in the first two modules. In this module also you will learn about integrated science laboratory, its organization and safety and be acquainted with the evaluation procedures. For without evaluation, you cannot be sure the objectives are achieved or not. The module is divided into three units:

Unit 1 Planning for Integrated Science Teaching
Unit 2 Integrated Science Laboratory, Design Safety and Management
Unit 3 Evaluation Procedures of Learning outcomes in Integrated Science

UNIT 1 PLANNING FOR INTEGRATED SCIENCE TEACHING

Unit Structure

1.1 Introduction

From all you have learnt from this course so far, you will realise that BSTC is being used interchangeably with integrated science. This is because BSTC is a replica of integrated science programme. BSTC is better used because of the UBE system being run in the country. It is planned and organised to be integrated science. It is often used here because that is exactly what you will teach and work with both in the primary, junior secondary schools and in higher degree. This unit provides information on documents that are available for Integrated Science and that is Basic Science and Technology Curriculum. You will study this curriculum and break it down into teachable form for the realisation of the overall objectives. You will break BSTC into syllabus, scheme of work, daily lesson plan and lesson note.

1.2 Intended Learning Outcomes

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

- break BSTC into syllabus from primary one to six and JSS 1 to 3
- develop the scheme of work for each term for the primary and junior secondary levels
- prepare the daily lesson plan for everyday teaching.

1.3 Syllabus and Scheme of Work

1.3.1 Breaking the Curriculum into Syllabus

What is curriculum? Curriculum is a stands-based sequence of planned experiences where students practice and achieve proficiency in content and applied learning skills. It is the central guide for all educators as to what is essential for teaching and learning so that every student has access to rigorous academic experiences (https://www.ride.ri.gov>). Curriculum typically refers to the knowledge and skills students are expected to learn, which includes the learning standards or learning objectives, the units and lessons that teachers teach, the assignments and projects given to students and the assessments (*greatschoolspartnership.org and https://www.academia.edu>basic).* From the curriculum, the syllabus is developed for each level of student for whom the curriculum is meant for. As a student you do hear about syllabus. Can you explain in your own word what you understand by syllabus? The curriculum as explained is a compendium of activities the learner will be exposed to. For instance, the BSTC from year one till the program is finished in junior secondary school year three. It includes both what the students will learn and do and what the teacher will also do to achieve the stated objectives of the programme. Syllabus is a

condensed outline of the main topics in the curriculum. It is the summary of topics to be covered during an academic course. It is prepared by an Exam Board like Science Teacher Association of Nigeria (STAN). It serves to outline the basic elements of a course including what topics will be covered (https://www.definitions.net>syllab). It is arranged in a logical, spirally sequence for the period of 9-years of basic science and technology education. It is generally done by experts. The teacher can build the syllabus.

Syllabus takes into account:

- The depth of coverage of the BSTC topic
- Sequence treatment of topics indicating the topics that require more time
- Guidelines for method of teaching
- Reference and materials needed for each topic.

In developing the syllabus, your first consideration will be to look at the BST curriculum, read the philosophy and objectives of the curriculum as well as the activities outlines for each topic. You will consider the level of the learner and their age. Then you consider the teaching approach you will use considering their age and also the appropriate materials to use. The next consideration is the curriculum content. Divide the content into the number of years, then the learners will be exposed to the syllabus such that each year has its own syllabus. This division is sequentially and logically arranged in a spiral form reflecting deeper in-depth coverage as the learner moves to a higher level. Here is an example of BSTC Syllabus.

Basic Education (Primary 1-3)	
Minimum of 6 subjects; Maximum of 7 subjects	
Subjects	**Explanatory Notes**
English Studies	i.Official National Language i.Medium of Instruction in schools i.The subject predisposes itself for the infusion of the following Road Safety Education, Disaster Risk Reduction Education, Consumer Education. v.Subject include Literature - in – English
Mathematics	i.Fundamental discipline for science and technological development i.Important for everyday life
Nigerian Languages	i.National Policy on Education (NPE) stipulates that the medium of instruction should be the language of the immediate environment of the child.

	i.Schools are free to select such Nigerian Language to be taught.
Basic Science and Technology (BST)	i.Each of the listed components will serve as themes for the Basic Science and Technology curriculum i.Climate change is part of Basic Science theme i.Disaster Risk Reduction Education and Consumer Education are infused into Basic Science and Technology Curriculum v.Create enabling environment for the subject in all schools by making computers available in schools
Religion and National Values (RNV)	i.Listed components will serve as themes in the Religion and National Values Curriculum i.Contents are planned for all children to take Social Studies, Civic Education and Security Education themes i.Separate classes should be run for CRS theme and IS theme v.Consumer Education, Disaster Risk Reduction Education and Peace and Conflict Resolution curricula are infused into the Civic Education, Social Studies and Security Education Themes. v.Create enabling environment for the subject in all schools
Cultural & Creative Arts (CCA)	i.Important for preservation of our cultural Heritage and fostering Creativity

Example of Basic Science and Technology First Term topics (Syllabus)

- Introduction to woodwork hand tools
- The human circulatory system - the heart
- Earth and Sky movement - the solar system
- Waste and waste disposal
- Waste disposal
- Environmental quality
- Changes cause by human activities – pollution – water pollution
- Changes in non-living things (https://lessonplan.edudelight.com.)

Self-Assessment Exercises 1

What are the importance of syllabus to the teacher?

You have just finished learning about curriculum and syllabus, the next step in the group is working out the scheme of work. Scheme of work is defined as the structure and content of an academic course. It splits an often-multi-year curriculum into deliverable units of work, each of a far

shorter weeks' duration. Each unit of work is then analysed out into teachable individual topics of even shorter duration. Good scheme of work map out clearly how resources and class activities and assessment strategies will be used to teach each topic and assess students' progress in learning the material associated with each topic, unit or scheme of work as a whole. Scheme of work is a weekly arrangement of topics from the syllabus to be covered during the academic year (*classhall.com.).* It is generally done by the class teacher. This is achieved by dividing the syllabus into 3 parts corresponding to 3 terms in an academic year. The topic in each term schedule are broken up to several weeks in a term, by doing so, the teacher has succeeded in drawing the scheme of work for BST showing day to day learning experience and the topics to be studied. The scheme of work is thus a written plan showing what BST topic are to be covered weekly 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 for each topic
- Number of effective teaching weeks in a term
- Number of teachings per a week
- Resource materials for teaching each topic.

A scheme of work should be ready by the beginning of the academic year. Some of the key issues to be included in the scheme of work are: class, period covered, number of weeks, number of lessons, objectives of the lesson, teaching aids and syllabus topics. There are some components that must be present in a scheme of work namely:

- An outline of what will be covered and in which lesson
- References to the topic chosen to cover
- Resources materials and activities to be used in lesson
- Guidance on best teaching method to use
- Room to grow and evolve as the school changes
- Organisation
- Training level
- Subject
- Date of preparation
- Syllabus topic
- Week
- Number of period
- Objectives
- Application – (student activities, assignment, homework and practice)
- Tools equipment/apparatus
- Notes
- Remarks (date when taught)

Preparing a Scheme of Work

You have learnt that scheme of work is a plan for something. The teacher's scheme of work is therefore, his/her plan of action which should enable him/her to organise teaching activities ahead of time. It is a summarised forecast of work which the teacher considers adequate and appropriate for the class to cover within a given period from those topics which are already set in the syllabus. A well prepared scheme of work among other things, should:

- Give an overview of the total course content
- Provide for a sequential listing of learning tasks
- Show a relationship between content and support materials
- Provide a basis for long range planning, training and evaluation of the course.

A scheme of work can be made to cover one week, one month and one term depending on the duration of the programme.

Some Considerations to Bear in Mind When Preparing the Scheme of Work

- *Understanding the Syllabus*: the teacher is expected to thoroughly understand the syllabus and content in order to achieve the objectives. The teacher must be conversant with the curriculum in order to implement it.
- *Preceding and succeeding syllabus content*: the teacher should not only identify the learning contents but should be able to arrange the content in logical teaching order.
- *Syllabus Contents of Related Subject*: The teacher should scheme the subject considering the content of related subjects.
- *Existing Scheme of Work for the Subject*: Where there is existing scheme of work, the teacher can revise and bring it up to date to suit the students
- *Reference Material and Examination*: The teacher should be familiar with reference material that is available for effective coverage of the topics in the scheme of work.
- *Time Estimation*: Number of effective teaching period varies.
- Effective teaching time must be estimated before topics are selected

A SAMPLE FOR A SCHEME OF WORK

Subject …….. Year……. Term…….
Name of Instructor……..
Date of Preparation…….
Date of Revision……..

Week	Lesson	Unit/ period	Topic	Specific Objective	Con tent	Met hod	Learner activities	Teaching aids	Reference/ remarks

Basic Science Scheme of Work for JJS1 Third Term

Topics	Week
• Revision of last term's work	1
• Force (i) Meaning of Force (ii) Types of Force (iii) Uses of Force	2
• Force (i) Calculation of Gravitational Force (ii) Meaning of Gravitational Force	3
• Force: Friction: (i) Uses of Friction (ii) Advantages and Disadvantages of Friction (iii) How to Reduce Friction (iv) Balanced and Unbalanced Forces	4
• Force –Gravitational Force and Weightlessness: (i) Meaning of Gravitation (ii) Effect of Gravitation of Objects (iii) Weightlessness	5
• Force –The Earth in Space: (i) The Solar System (ii) Earth's Rotation and Revolution (iii) Eclipse of the Sun and Moon	6
• Force-Space Travel: (i)meaning of Space Travel Purpose/Advantages of Space Travel Dangers of Space Travel	7
• Force-Satellites: (i) Meaning of Satellite (ii) Types of Satellite (iii) Uses of Satellite	8
• Revision	9
• Examination *(https://classhall.com.)*	

Self-Assessment Exercises 2

Shortlist five points to consider in preparing a scheme of work.

1.4 Lesson Plan and Lesson Note

1.4.1 Lesson Plan

In the previous lesson, you learnt how to prepare scheme of work. Today you will learn another important aspect of teacher's activity - preparing a lesson plan. Preparation of scheme of work, lesson plan and lesson note are the major aspect teaching professional. They are the major work of the teaching profession which the teacher must do before entering the class to teach. The effectiveness of a teacher is based on how the teacher prepared these events. Lesson plan is a teacher's daily guide for what students need to learn, how it will be taught and how learning will be measured. Lesson plans help teachers to be more effective in the classroom by providing a detailed outline to follow each class period. Lesson plan is a teacher's detailed description of the course of instruction or learning trajectory for a lesson. A daily lesson plan is developed by a teacher to guide class learning. Details vary depending on the preference of the teacher, subject to be covered and the need of the students. Lesson plan is the centre for teaching excellence. It is a guide to the teacher in presenting a good and effective lesson in class (*content.wepik.com/statics/66906).*

Lesson plan is said to be a guide to effective teaching as it directs the teacher in the same manner a compass gives a navigator his or her bearing. It is a daily outline of learning activity for students usually drawn up after the preceding lesson. Lesson plans are not prepared for a long time due to new innovative approaches which can be used. A lesson plan is the instructor's road map of what students need to learn and how it will be done effectively during class time. You can design appropriate learning activities and develop strategies to obtain feedback on students learning. Having carefully constructed your lesson plan, you will be able to enter the classroom with more confidence and maximizes your chance of having a meaningful learning experience with your students.

Six Steps for Preparing Lesson Plan

- *Identifying learning objectives:* before you plan your lesson, you will identify the learning objective for the lesson. A learning objective describes what the learner will know or be able to do after the learning experience. It is usually written in action verbs such as describe, draw, discuss, demonstrate and so on. The Bloom Taxonomy is a useful resource for crafting learning objective.

  Example: at the end of the lesson the students will be able to describe, draw, demonstrate.
- *Planning Specific Learning Objectives:* This is the type of activities the students will need to engage in, in order to develop

the skills and knowledge required to demonstrate effective learning in the course. It should be directly related to learning objectives.

- *Plan to Assess Students:* This include test, problem sets, assessment which will provide opportunities for students to demonstrate and practice the knowledge and skills articulated in the learning objectives.
- Plan to Sequence the Lesson in an Engaging and Meaningful Manner
- Create a Realistic Timeline
- Plan for a lesson Closure

Suggested Format for Basic Science and Technology Lesson Plan.

Subject; Basic Science and Technology Class: JSS1
Date: 17/9/91
Unit: Living Things in the Environment
Topic: Plants and Animals
Average age: 9 years
Time of learning: 9.05-9:45am

Instructional objectives: These are objectives stated in terms of what the student should acquire/gain during the lesson. It focuses attention on the learner's understanding of the concepts taught and usually stated using active verbs such as: differentiate, decide, draw, classify, demonstrate.

Resources: This explains the type of materials the teacher thinks are suitable for the topic and age of the learner.

Introduction: This is the set induction or manner the teacher finds suitable in introducing the topic.

Learning Activities: This shows step by step presentation of the topic to students
Time: Time each step of activity lasts
Evaluation: In a form of assessment, the teacher uses varied methods to determine the extent at which the students learned what was taught.
Summary: These are salient points the teacher put down on the chalkboard for students to copy as a reminder of the important points to record.

Self-Assessment Exercises 3

What are the components of a lesson plan?

1.4.2 Preparing Lesson Note

In the last lesson, you learnt about lesson plan. Can you explain what lesson plan is? In lesson plan the teacher displays his/her act of teaching. It is in preparing the lesson plan that the teacher shows his/her mastery of teaching profession. Bad lesson plan is bad teaching. In this sub-theme, you are going to learn another important aspect of lesson plan known as lesson note.

Lesson note is a detailed description of all learning activities by both the teacher and students selected for a particular lesson showing how the lesson will be produced, previous knowledge of the learner, descriptions of the different methods to be used as well as included questions to be asked. The form of lesson notes depends on the subject, category of learner and available resources.

A lesson note is a document where the teacher basically indicates the flow of lesson and its effect on the learners. Most often, lesson note is a handwritten document where the teacher documents what is being taught and activities the students are going to engage in. Preparing the lesson notes allows a teacher to understand and help the learner progress in the classroom. This is mainly because lesson notes expose how a particular lesson is progressing and to which extent the learners have acquired the knowledge imparted to them by the educator. In fact, lesson note demonstrates the impact of teaching on the learners in a particular classroom.

Differences between Lesson Plan and Lesson Note

Thus, the difference between lesson plan and lesson note is a matter of details. Integrated Science lesson plan is easier to write and short to be read quickly, but lesson note indicates clearly the content and method of the lesson and aids the teacher's memory. Lesson plan is an outline of the teacher's business and lesson note gives full account of step by step of the instruction. A lesson plan refers to step by step plan of how the teacher is going to conduct the lesson and includes the objectives, content and methods through which he/she plans to impart the knowledge to learners. In contrast, a lesson note is a note where the teacher documents the flow of a lesson and its effect on the learners.

In preparation, a teacher prepares a lesson plan before the lesson and the lesson note while the lesson is going on. Simply put, the main difference

between lesson plan and lesson note is that a teacher prepares a lesson plan before the lesson in order to increase the productivity of the lesson while a lesson note is prepared by the teacher while the lesson is going on in order to measure the level of comprehension of the learners and impact of the lessons on the learners.

Tips on Writing Lesson Note

Here are the six steps for creating a good teaching note

- Know your purpose
- Write your outline
- Plan your schedule
- Know your students
- Use different student communication designs
- Use different learning methods

A Specimen of Basic Science and Technology Lesson Note on Plant and Animal

Name of the School
Date: day/month/year
Subject: Basic Science and Technology
Class: JSSI

Step 1: The teacher asks the students to name different animals and the food they eat.

Step 2: The teacher asks the students to group the animals mentioned into the type of food they eat. The teacher uses the students' grouping of the animals to give each group its biological terminology - carnivores, herbivores and omnivores

Step3: From the students' list of animals, the teacher asks the students to group the animals into backbone and those without backbone. The teacher explains what is meant by backbone. The teacher builds on the students grouping to explain and give each group their terminology- vertebrates and invertebrates

Step 4: The teacher tells the students to look at their plants and decide if they can bear flower. The teacher uses their reply to group the plants into flowering and non-flowering plant

Summary: These are what the teacher should leave on the chalkboard for students to copy in their note:

- Both plants and animals show all characteristics of living things (they grow, feed, breathe, excrete, reproduce and respond to stimulus)

- Animals are grouped into carnivores (those that feed on flesh example - dog, lion) herbivores (those that feed on grass example - goat, cow) and omnivores (those that feed on both grass and flesh example - human being)
- Animals with backbones are called vertebrate animal example - fish, goat, man
- Animals without backbones are called invertebrates example - snake, spider
- Plants that can bear/produce flower are called flowering plants example - maize, paw-paw, orange
- Plants that cannot produce flower are called non-flowering plants example - palm tree.

Evaluation: The teacher asks the students the following questions orally:
(i) Distinguish between plant and animal
(ii) Name two invertebrates and vertebrate animals in your compound

Assignment: The teacher gives the students the following assignment as home work
List 10 herbivores, omnivores and herbivores animals in your village.

Self-Assessment Exercise 4

In your own words what do you understand by the term lesson note. Differentiate between lesson plan and lesson note.

1.5 Summary

In this unit, you have seen that teaching is a serious business that it has to be planned. It involves dedication and commitment to present quality teaching to the students.

In this unit, you learnt:
- The meaning of the concept syllabus and from where it is developed
- The description of Scheme of work and how it is developed
- The difference between lesson plan and lesson note

1.6 Glossary

- **Curriculum**: typically refers to the knowledge and skills students are expected to learn, which includes the learning standards or learning objectives, the units and lessons that

teachers teach, the assignments and projects given to students and the assessments.

- **Syllabus**: is a condensed outline of the main topics in the curriculum.
- **Scheme of work** is defined as the structure and content of an academic course.
- **Lesson plan** is a teacher's daily guide for what students need to learn, how it will be taught and how learning will be measured.
- **Lesson note** is a detailed description of all learning activities by both the teacher and students selected for a particular lesson showing how the lesson will be produced, previous knowledge of the learner, descriptions of the different methods to be used as well as included questions to be asked.

1.7 References/Further Readings/Web Resources

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1.8 Possible Answers to Self-Assessment Exercises

SAE 1

- It guides the teacher on what to teach, the age and level of depth to go
- It helps the teacher to determine the relative effectiveness of the programme in terms of students behavioural planning
- To make reliable decisions about educational planning
- To identify students' growth in acquiring knowledge and skills

SAE 2

List of considerations in planning the syllabus include:

- Understanding the curriculum

- Preceding and succeeding syllabus
- Syllabus contents of related subjects
- Existing scheme of work
- Reference materials

SAE 3

A lesson plan has the following components namely:

- Subject to be taught
- Date of teaching
- Unit of the subject to be taught
- Topic from the unit to be taught
- Age of the learners
- Time it will take to teach the unit
- Instructional objectives to be achieved
- Learning activities to be done by the learners
- Resource materials to be used
- Evaluation

SAE 4

Lesson note is a detailed description of all learning activities by both the teacher and students for a particular lesson a lesson note is a document where the teacher basically indicates the flow of lesson and the effect on the learner. It is usually hand written. It exposes how a lesson is going forward.

UNIT 2 INTEGRATED SCIENCE LABORATORY, DESIGN, SAFETY AND MANAGEMENT

Unit Structure

2.1 Introduction

In the previous unit, you learnt about the curriculum and how the syllabus is developed from the curriculum. From the syllabus, you can create the scheme of work from which you develop the lesson plan and lesson note. These are the tools for teaching. Without them the teacher will not be effective, coherence and will not have direction. In this unit, you will learn about the integrated science laboratory as an essential tool in teaching of integrated science. The unit has four themes namely: integrated science laboratory, design, safety and management and organisation of integrated science laboratory.

2.2 Intended Learning Outcomes

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

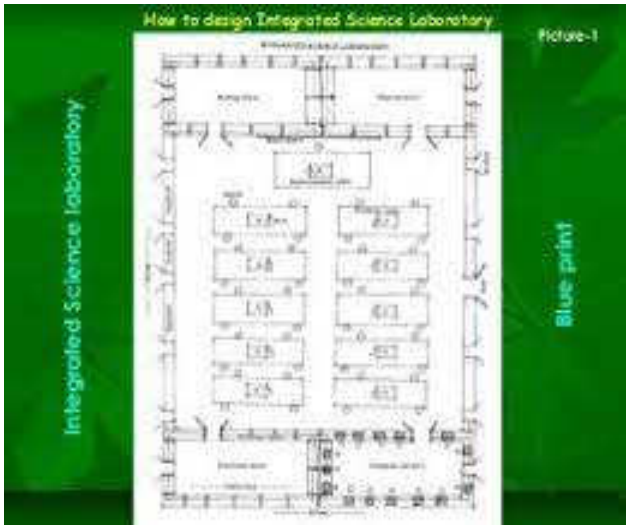
- explain what an integrated science laboratory is
- describe the designs of integrated science laboratory
- prescribe safety in the integrated science laboratory
- organise and maintain an integrated science laboratory.

2.3 Integrated Science Laboratory, Design and Safety

2.3.1 Integrated Science Laboratory

In the BST curriculum, it was recommended that integrated science should be taught in integrated science laboratory. Before we go into the day's lesson, what is a laboratory? Do you have laboratory in your area of work? Look around it and list the materials in it. Laboratory is a facility that provides control condition in which research, experiment may be performed. Its content shows it is being used for. There are different types of laboratory which depends on the use and the type of equipment kept in it. We have language lab, computer lab, darkroom lab and so on. We have science laboratory such as chemistry lab, physics lab and biology lab. Lab is a short form for laboratory. Science laboratory is a setting or place to try scientific information and test principles and theories. Laboratory training is frequently used to develop skills necessary for more advanced study or research. It is equipped to provide answers to scientific questions. Laboratory is an integral part of science education. Your concern in this unit is integrated science laboratory. Integrated Science has its laboratory as stipulated by NUC Benchmark. Just as there is biology, chemistry and physics laboratory, there is Integrated Science laboratory designed for the teaching and learning of Integrated activities of Basic Science and Technology curriculum.

An integrated science laboratory provides for an integrated study of the science for the students where they get the right impetus to learn by doing. It is a science laboratory which brings closeness of knowledge of various subjects, integration of physical structure, having lab items of all subjects in one lab. It is a place to inculcate and develop a scientific temperament and provide a perfect platform for scientific knowledge. It provides for an integrated study of the sciences for the students where they get their right impetus. In an Integrated Science class there is a small space designated as Nature corner where materials brought by students or from the lab for teaching in the classroom are kept. Integrated Science laboratory is one of the criteria for NUC accreditation of Integrated Science programme in the department of Science Education for degree programme.



Sample of Integrated science Lab.

Integrated Science laboratory is an instructional facility used by the Integrated Science teacher to help students learn about science and how scientists investigate and acquire knowledge about the world around them and use the knowledge to invent, create and innovate to better the conditions of the society in which they live. It is a school building set aside for scientific activities. Integrated Science laboratory is very important for the teaching of Basic Science and Technology because the curriculum emphasized students' full involvement in science practical works. The emphasis on laboratory work is to enable the students in the early stage of learning science develop scientific skills and attitudes. Nagaraj (2013), perceived integrated science laboratory as tool for holistic and constructive learning.

Self-Assessment Exercise 1

What is Nature Corner?

2.3.2 Designing an Integrated Science Laboratory

Science education has taken centre stage in primary and junior secondary schools as a result of 'no child is Left behind' and increasing emphasis on science, technology, engineering and mathematics (STEM). Science is around us from the air we breadth to the food we eat, to the objects in our environment, to the technology and the machine we use. Teachers have every opportunity to integrate science to their daily classroom, according to America Science Education (ASE), science education provides multiple students benefits. In addition to fostering

the budding scientists of tomorrow, a good science curriculum makes students:

- Makes students think beyond the classroom
- Inspires curiosity and wonder about the world
- Illustrates science in multiple dimensions

A good integrated science laboratory is required in the implementation of BSTC. As earlier said Integrated Science has its own laboratory as stipulated in the NUC Bench mark for accreditation of Integrated Science degree programmes. It consists of a lager hall well ventilated and lighted, equipped with laboratory benches fixed with burners, wash hand basin. In the large hall equipment is arranged according to what they are used to teach. For instance, physics-based materials are kept together to ease selection and use so also other integrated science programmes. Everything needed in science laboratory is in the Integrated science laboratory but are displayed in the lager hall in partitions. Integrated science laboratory has storage room where materials not in use are kept. It has technologist room where the technologist managing the laboratory stays. There is also a display room where students' projects or products are kept. In integrated science laboratory Mathematics has its own partition in the laboratory with rulers of different kinds, measuring equipment and other related materials are kept.

In the classroom at a corner there is a nature corner where materials brought by students are keep for easy accessibility and examination. The integrate science lab must be spacious and free movement. It must be well ventilated and lighted. Charts are displayed in the laboratory. Also placed in the integrated science laboratory are safety rules, diagrams. There must be fire extinguisher and bucket of sand in the laboratory.

2.3.3 Safety in Integrated Science Laboratory

In the previous class, you learnt about the design of science laboratory as an open hall well ventilated and lighted with store rooms attached and equipment and chemical as well as biological materials are kept. In today's class, you are going to learn safety in the integrated science laboratory. You know that excitement, wonder and fun characterises science learning and many students see it as a forum to seek answers to their numerous questions and seek satisfaction to their unending curiosities. But curiosity killed the cat and these students are apt to get themselves and others including the teacher into great deal of trouble and make science not exciting but dangerous. The use of integrated science in primary and junior secondary school where students' dispositions and material usage are organised for the sole purpose of facilitating learning with minimum exposition to hazard constitutes the

trust of this lesson (academia.edu>). After satisfying physiological needs, human beings as indicated by Maslow (1954) seek protection and safety from danger. Secondly, a learner will only learn best when danger is not built into learning environment. Thus, an environment perceived to be a potential danger will scare the learner who might otherwise have benefited from the learning experience (Okebukola, 1982). Since the major aim of integrated science laboratory is to use it to teach science in order to make the students and pupils develop skills in experimenting, observing and other processes of science. The teacher as a facilitator of learning should bring the learner and these objectives into meaningful harmony while blunting off the sharp edges of the transactions that can put the learner into danger (https://www.researchgate.net.).

Safety Considerations in the integrated science Laboratory

- It is wise to give students a safety talk when beginning to learn science in the first year. This is a forum for discussing with students the need for and how to ensure safety in the science laboratory. Periodically such safety talk should be held to refresh students' ideas about this important matter.
- Since at these ages students and pupils are playful when left on their own and often let their enthusiasm run wild, they should not be allowed in the laboratory unless a science teacher is present
- Except when needed for out-door studies, materials should not be taken out of the laboratory
- The teacher should ensure that:
    i. Solids are not put in sinks
    ii. Stock bottles of concentrated acids, alkalis and inflammable substances are locked in cupboards in the prep room.
    iii. All poisonous substances should be labelled and placed in locked cupboard, the key of which should be in the teachers charge.
- Care in handling glass vessels will guard against cuts. Burns and scalds will be avoided. Burners and vessels containing hot liquids are kept well away from the skin. By the same precaution eye injuries from the spilling of liquids can be minimised and further protection given by use of eye shield
- A set of laboratory rules should be discussed with students, reproduced and copied given to students to attach to their notebooks. The rules should include:
    i. Materials should not be taken out of the laboratory except as directed by the teacher
    ii. Chemicals should not be tasted but can be smelled with care if there is need to do so
    iii. Only small quantities of chemical should be used unless instructions to the contrary

iv. Water and gas taps should be turned off before leaving the laboratory
v. Dangerous gases should be generated outside or inside fume cupboard
vi. Avoid naked wires
vii. Vessels containing hot liquids should be handled with care
viii. Electrical apparatus should be connected using a 3-wire cord
ix. Bottle containing reagents should not be carried by the neck but at the base
x. No student should enter the laboratory except under the supervision of the teacher
xi. Do not eat in the laboratory
xii. Wash you're your hand before and after learning in the laboratory
xiii. Accidents must be reported immediately
xiv. The door of the lab should not be locked when it is occupied
xv. A safety poster be conspicuously placed in the lab.

The integrated science lab must have at least two fire extinguishers
First aid box must be kept in the lab and the science teacher should have knowledge of first aid. The science teacher should keep records of accidents that occur. He/she should keep records of all materials in the laboratory.

Self-Assessment Exercise 2

What are the relevance of integrated science lab to the learner?

2.4 Management and Organisation of Integrated Science Laboratory

2.4.1 Management of Integrated Science Laboratory

In the previous classes, you learnt about safety and design of integrated science laboratory. These depend on the management and organisation of the laboratory. The question now is: who manages the integrated science laboratory? With earlier discussion on safety of integrated science lab, there is need to ensure proper management of the laboratory. Integrated science laboratory need someone to manage it, either the teacher or a technologist. Preferably a technologist who will keep order and ensure cleanliness, servicing of equipment and arrangement of activities in the laboratory. The technologist records and keeps the inventory of all that are in the laboratory including unused ones. The technologist gets materials ready for the integrated science teacher. Like every other laboratory, integrated science laboratory is prone to accident. He/she arranges schedule for use of the laboratory to

avoid clash of programmes. More importantly, the management of the laboratory ensures the safety of both the equipment and the personnel using the laboratory including students and teachers. To ensure the safety of the materials and those using them the technologist will ensure that laboratory rules and regulations are observed when practical is going on and the equipment are arranged and stored properly. The following safety rules should be enforced in an integrated science laboratory:

- Do wait outside the laboratory until you are asked to come in
- Do only the experiment authorized by your teacher
- Do heat liquids slowly and rotate the tubes to avoid over heat
- Do wet the end of the glass tube before inserting it into rubber-tube
- Do report any gas leakage
- Do not run or play or rush in the laboratory
- Do not eat in the laboratory

It is a common thing that even when all necessary precautions and measures are taking and safety regulations are enforced, integrated science laboratory like other laboratories is still prone to accidents or accidents still occur. The common injuries in integrated science laboratory are:

- Bleeding due to cut glasses, broken glassware, sharp objects
- Burn from naked fire and chemicals
- Shock from electricity
- Suffocation from inhaling injurious vapour
- Eye injury from particles

It is the duty of the integrated science teacher/ technologist to educate the students on safety rule and regulations. It is also their responsibility to offer appropriate first aid mediation in case of any accidents in the laboratory.

Self-Assessment Exercise 3

What are the functions of integrated science laboratory manager?

2.4.2 Organisation of Integrated Science Laboratory

All these weeks you have been meant to understand the importance of integrated science in the teaching and learning of BSTC content. This is so because integrated science laboratory is one of the components in learning science. You have learnt the importance of safety in the lab as

well as its management. Today you will learn about the organisation of the laboratory. All these are to ensure the smooth running and safety in the laboratory and within our environment.

Organisation of the integrated science laboratory takes care of the placement of the laboratory equipment and materials in their proper places. Laboratory organisation is simply to divide the lab into its component sections and discuss each separately. Laboratory space is always at a premium so making the lab more organised is a great way to improve productivity and efficiency. The integrated science space can be issue especially if it houses large equipment. An organised lab does not just mean keeping the benches clean and tidy. It also establishes healthy habits, schedules activities such as cleaning, set practical rules for ordering materials and help to improve work flow and productivity. A tidy laboratory makes work more pleasant, less error-prone and much more time efficient.

Tips in Laboratory Organisation

- Schedule your tasks
- *Use vertical space:* just like your kitchen, shelves, wall cabinets and top-mounted cabinets are ideal for storing things that are not regularly used.
- Give everything a home
- *Labels:* label the shelves and cupboards, label samples, solutions, equipment
- *Keep track of your stock:* this involves having an inventory
- *Go digital with documents:* keep important documents such as guarantees and equipment manuals in a safe drawer
- *Perform audits:* carrying out audits every few months will help you understand if you need to stock up on any supply and check expired dates

2.5 Summary

In this unit, you learnt that:

- Integrated science has its own laboratory different from other science laboratories to suit the nature of activities that take place in it.

- It has all the facilities of a laboratory such as storage room, preparatory room, well ventilated and lighted, has source of water and heating instrument

- Safety in integrated science laboratory is paramount

- There must be a technologist to manage and organizes the activities in the laboratory. It can be the teacher or a technologist.

- It is a NUC requirement for accreditation of Integrated Science degree program. It was also one of the recommendations in Bench mark for BSTC.

2.6 Glossary

- **Laboratory** is a facility that provides control condition in which research, experiment may be performed.
- **Nature corner** is a space created at a corner in the classroom where materials brought by students and used for teaching Basic science and technology are kept for at least a week before they are taking back to the laboratory.

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2.8 Possible Answers to Self-Assessment Exercises

SAE 1

Nature corner is a space created at a corner in the classroom where materials brought by students and used for teaching Basic science and technology are kept for at least a week before they are taking back to the laboratory. Also, materials brought by students for teaching are allowed to remain at the Nature Corner a week before removal to the integrated science laboratory store if they are relevant. The benefits of Nature Corner abound:

- It reminds the students of the science topic taught that week
- It draws the attention of the students to the relationship between science in the classroom and their environment.
- It makes the materials easily accessible for teaching in the classroom
- It helps the students remember what they were taught for the week in Basic science and Technology
- It is child-centred because the students are involved in the building of the Nature Corner.

SAE 2

- Makes students think beyond the classroom
- Inspires curiosity and wonder about the world
- Illustrates science in multiple dimensions

SAE 3

The laboratory manager:

- Records and keep the inventory of all that are in the laboratory including unused ones.
- Get materials ready for practical
- Ensure laboratory rules and regulations are observed.

UNIT 3 EVALUATION PROCEDURES OF TEACHING AND LEARNING OUTCOME OF INTEGRATED SCIENCE PROGRAMME

Unit Structure

3.1 Introduction

Throughout the course of EDU 754, you are learning how to carry out the functions of a science teacher. In this last unit, you are going to learn how to evaluate the learning outcome of the learners, whether you as a teacher and implementer of BSTC has achieved the objectives set out for BSTC to achieve. One of the main duties as an integrated science teacher is to promote the learning of the fundamental tasks and principles of Basic Science and Technology Curriculum and develop in the students the abilities and skills needed to engage in scientific processes. However, as the acquisition of scientific knowledge is the ultimate criteria, it is imperative to regularly evaluate students' progress in their learning of Basic Science and Technology. Your role as a teacher in evaluation of students is very important and crucial. Thus, you should be well equipped for the performance of the task. In this unit you will be exposed to one of the commonly used methods of evaluation which is teacher's test.

3.2 Intended Learning Outcomes

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

- construct Tests
- establish Marking Scheme for the Test
- carry out Project-Based Assessment.

3.3 Tests and Measurement

3.3.1 Test Construction

Teaching and learning processes are incomplete without determining students' learning outcome (Obi, 1977 and Folagbde, 1988). From the expert's view, test is the most reliable method available to practicing teachers of education of early learners for assessing their learning outcome. Obe (1977), defined test as a series of activities purposely designed to measure learner's abilities to recall fact. According to Findley (1963), functions of test are categorised into instructional, guidance and administrative. There are two main forms of test namely: teacher made test and standardised test.

Instructional function—Testing of students' progress in the science class provides the teacher with the information on the students' rate of learning.

Guidance function—Reports of test are counselling tools for the teacher, guidance counsellors, parents, administrators in matters of career choice

Administrative function—It is a quality assurance for schools. It assists in grouping or placement of students.

Different Forms of Test
Test is an assessment model for determine students' learning outcome in a subject at mid-term or at the end of a session or after a topic. A test must be valid, reliable. There are four forms of test namely:

i. Essay type of test: This is used to evaluate the qualitative aspects of verbal instruction
ii. which requires the student to compose a response.
iii. Objective test: An objective test is one in which there is only one answer to each question
iv. Multiple choice test: In multiple test, each test item has a number of alternative answers from which one is correct.
v. Short answer item of completion test

Any of these forms of test can be used by the teacher, but the choice of which form to use lies on the teacher.

Principles of Test Construction
In constructing a test, the following points are considered:

- Identification of major concepts to be tested
- Identification of cognitive levels to be tested
- Decision on the number of test items to be included in the test

- Preparation of table of specification to guide the teacher on the number of test items from each concept

Table 1: Table of Specification for an Integrated Science multiple choice test

Specification for Theme	Knowledge	Comprehensive	Application	Analysis	Synthesis	Evaluation	Total
Family Traits	2	1	1	0	0	0	4
Environmental Hazard	6	5	2	0	0	0	13
Drug Abuse	2	1	1	0	0	0	4
Resources from living things	3	1	1	0	0	0	5
Resources from non-living things	2	1	1	0	0	0	4
Total	15	9	6	0	0	0	30

Table 1: Illustrates the specification required in terms of Basic Science for Theme 1 and the cognitive levels. The table shows that 5 Basic Science concepts are to be tested across the 6 cognitive levels as stated by Bloom (1956). The number of items to be selected from each concept is indicated and the number of items per concept is spread across the cognitive levels.

General Tips in Designing a Test

- *Start with the learning outcome:* choose objective and subjective items that match your learning outcomes and the level of complexity of the learning outcome.
- *Use a test blue print:* A test blue print is a rubric, document or table that lists the learning outcomes to be tested, the level of complexity and the weight for the outcome. (See a blue print above). A blue print will make writing of the test easier and contribute immensely to test validity.
- *Let your students know what to expect on the test:* Be explicit, otherwise students may make incorrect assumption about the test

- *Word questions clearly and simply:* avoid complex questions, double negatives and idiomatic language that may be difficult for students especially multilingual students to understand.
- Have a colleague to read through your questions.
- *Assess the length of the questions:* Unless your goal is to assess students' ability to work within time constraints, design your question so that students can comfortably complete it in the allocated time.
- *Write your exam key prior to students taking the exam:* the point value you assign to each question should align with the level of difficulty and the importance of the skill being assessed.
- Design your exam so that students in your class have an equal opportunity to fully demonstrate their learning (https://www.sciencedirect.com>).

Qualities of a Good Test

- *Reliability:* uniformity in measurement.
- *Utility:* must be cost and time effective.
- *Consistency*: free from extraneous source of errors
- *Validity:* how well a test measures what it supposed to measure (slideshare.net. test construction.).

Self-Assessment Exercise 1

What are the considerations of a good test?

3.3.2 Construction of Marking Scheme

Marking scheme is a system for awarding points for correct answers or for proficiency in an examination or competition. It helps students to view their exam papers to see how the marking scheme was applied. It is a plan or guideline used in the marking of school children's/students' written work by teaching staff. A good marking scheme makes marking less subjective. Separate the communication qualities from the spelling, grammar and word use. An example of a marking scheme can go like this:

0	**1**	**2**							**I can understand what you have written**
0	**1**								**The style is appropriate**
0	**1**	**2**							**Your use of words, grammar and spelling is correct**

NOTES:

- *Communication*: If you can understand what the student has written, then they get full mark for this section. Some difficulty in understanding 1. If you can only understand after rereading many times, then 0. Numbers understanding also scores 0.
- *Style:* If the student has used an appropriate style, then full marks. Otherwise 0
- *Word Use:* Correct use of words, grammar and spelling with 1 mark for 5-10 errors and 0 for more than 10 errors
- *Content:* This depends on the question. One way is to rank essays after a quick read. Decide on the lowest and highest mark. Then mark in detail.

One of the ways to be explicit about your expectation is to have well-defined marking scheme. A good marking scheme will help you make your marking less subjective. Separate the communication qualities from spelling, grammar and word use. If the reader can understand the writing task, then the student should be given credit. It is a principle to mark spelling, grammar and word use separately so that students will only lose a proportion of their marks for language use as opposed to content and communication. In a simplest form, marking guide provides broad outlines for success and allocates a range of marks for each component.
A marking scheme is a model solution prepared by the examiner with marks distributed across the different questions in the test. In objective test, the marking scheme requires correct responses and all correct responses carry equal marks despite the varying degree of difficulty associated with the different test items. Marking scheme contains the answer to the question prepared by the who set the question. Apart from objective test that have equal mark, marks are assigned to questions depending on the level of cognition tested. Low level cognition like knowledge carries low mark while high level cognition like application carries and so on carry high mark

In preparing a marking scheme rubic:

- Write a model answer for each question.
- Make each decision as straightforward as possible
- Aim to make your marking scheme usable by non-experts in the subject
- Aim to make it so that anyone can mark given answers and agree on the scores within a mark
- Allow for consequential marks
- Pilot your marking scheme by showing it to others
- Look at what others have done in the past
- Learn from your own mistakes

Self-Assessment Exercise 2

Design a marking scheme for the mid-test for your class.

3.3.3 Project Based Evaluation

The use of project-based assessment techniques has continued to grow within education curriculum as resources and concepts beyond traditional testing applications are involved. There can be extensive value to the student's overall learning process with the addition of project-based learning to supplement standard curriculum materials. Assessment that compile into project-based assessment are also a technique option for educators looking to review the ability of students to be creative, diverse and authentic with their course work and experience gained throughout the time frame of the class (https://www.igi-global.com>). Project-based assessments are an alternative to tests that allow students to engage with their learning in more concrete ways. Instead of merely studying theory, a hand-on project asks students to apply what they have learned to an in-depth exploration of a topic. Project-based assessment is an opportunity to utilize and measure the higher order thinking skills of students. This can be a singular project at the end of a grading period or it can be done at designed intervals throughout the marking period. The important thing is to design the project to encompass the lesson plans, teacher worksheets and any additional teacher resources which will provide a physical example of what has been learned and what can be applied by the students. The criteria for project-based assessment can be as specific or as generic as a teacher designates. Developing rubrics to define the class structure and curriculum design can be an effective means of applying project-based learning skills. Worksheet can help guide both the teacher and students in assessing project. In project assessment the teacher looks out for the application of science skills, the extent the student used them accurately to reach the end product. The key word in Project assessment is accuracy. Students have to go through a series of design activities and generate design solutions based on the project information given to them. Some areas for evaluation include content mastery, collaboration or participation and presentation style.

Samples of Project based Learning:

- Plant School Garden. A school garden is a fantastic opportunity for students of all ages to gain hands-on knowledge about growing food
- Pitch a business idea
- Film a Documentary

Benefits of Project-Based Learning
Project-based learning enables students to learn deeply and develop core employability skills through participating in real work projects and experiences. It has benefits for students, education institutions and industry. It is cost-effective and simple.

How to Evaluate a School Project?
Some areas of evaluation include content mastery, collaboration or participation and presentation or style. Additional considerations may include meeting deadlines or other elements specific to the topic (www.nature.com.).

Project Rubric
- State the project objective
- Explain required content
- Include state standards for the subject area
- Review the rubric with the class
- Portfolio rubric

Self-Assessment Exercise 3

What will you look out in project evaluation of students' project?

3.4 Summary

In this unit, you noticed that evaluation of teaching /learning processes is a continuous process and an integral part of curriculum development and classroom instruction. As a teacher, you need to understand the necessity of assessment of students learning outcomes and its importance in planning the life of the learners. You have also learnt that:

- Test is the most reliable method for assessing early learners' outcome
- Test is designed to measure the student' level of cognition.
- Marking scheme guides the teacher in scoring of students' test.
- Bloom Specification should be used to ensure the evaluation of all cognitive level.
- Students' projects are evaluated.
- Test construction has a guiding principle

3.5 Glossary

- **Bloom Specification** should be used to ensure the evaluation of all cognitive level

- **Project-based assessments** are an alternative to tests that allow students to engage with their learning in more concrete ways.
- **Rubric:** means introduction

3.6 References/Further Readings/Web Resources

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3.7 Possible Answers to Self-Assessment Exercises

SAE 1

- Reliability: uniformity in measurement.
- Utility: must be cost and time effective.
- Consistency: free from extraneous source of errors
- Validity: how well a test measures what it supposed to measure.

SAE 2

An example of a marking scheme can go like this:

0	**1**	**2**							**I can understand what you have written**
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SAE 3

Some areas of evaluation include content mastery, collaboration or participation and presentation or style. Additional considerations may include meeting deadlines or other elements specific to the topic.