COURSE GUIDE

EDU 240
MATHEMATICS METHOD II

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INTRODUCTION

Mathematics Method II EDU 240 is a one semester, 2 credits unit course. It will be available to all students reading for B.Sc.(Ed) in Mathematics Education.

The course consists of fifteen units, which involves brief history of mathematics, importance of mathematics in relation to other subjects, some mathematicians and their contributions, curriculum in

mathematics. Mathematics syllabus, scheme of work, lesson plans, individual differences in mathematics learning, some selected methods of teaching mathematics, introducing mathematical concepts, learning aids in mathematics, their objectives and characteristics, mathematics laboratory as an approach to teaching mathematics.

The material has been developed for students of NOUN by referencing some available works such as those of National Teachers Institute, Kaduna (NTI), the internet and other relevant text materials.

COURSE AIM

This course aims at equipping the student teacher with mathematical knowledge and skills necessary and effective for improving the teaching and learning of mathematics in our primary and secondary schools. This is expected to bring about improved performance in students' achievement in mathematics by rekindling interest in mathematics and the learning and teaching of mathematics in schools. Mathematics can be made very interesting, important, useful, rewarding and fun to be loved by most of the students if well prepared and presented in rich learning environment involving integrated methods and strategies inclusive enough to take care of every learner. There is no doubt that strong foundation in mathematics especially at the primary and secondary schools will improve the learning of other school subjects.

There is no doubt that the mathematics content is a good document and this can be poorly implemented if the mathematics teacher has not been adequately prepared especially in terms of teaching methods and strategies. The contents of this course have been carefully selected so that by the end, the student teacher will be competent enough to teach mathematics effectively at the primary and secondary schools.

COURSE OBJECTIVES

Toward effective realization of the broad aims set out above, the course sets overall objectives. In addition, each unit has specific learning

outcomes to be demonstrated in observable performance behaviours by the students. These are always included at the beginning of every unit. You should refer to them during your study of the units. It will be a good guide to check your progress. By the end of every unit, the student is advised to go back to the state learning outcomes. This type of reflective learning will make the student be in charge of his own study.

WORKING THROUGH THIS COURSE

To complete this course, you are required to read the study units, read reference books and read other materials, provided by NOUN. Each unit contains Self-Assessment Exercises (SAEs) At points in the course, you are required to submit assignments for assessment purposes.

This is a 2 credits unit course consisting of 15 study units

COURSE MATERIALS

Major components of the course are:

1. Course Guide
2. Study Units
3. Self-Assessment Exercises
4. Presentation Schedule.

ASSESSMENT

There are two aspects to the assessment in this course. We have the self –assessment exercises (SAEs) and the end of the semester written examination. You are expected to apply the information, knowledge and techniques gathered during the course.

The tutor-marked assignments in the course will be submitted to the course facilitator and this will account for 30%, while the end of semester examination will contribute the remaining 70%.

HOW TO GET THE MOST FROM THIS COURSE?

In distance learning, the study units replace the teachers. This is one of the great advantages of distance learning. You can read and work through specially designed study materials at your own pace and at a time and place that suit you best. Each of the study units has a common format. The first item is an introduction to the subject matter of the unit and how a particular unit is integrated with the other units and the course as a whole. Next is a set of learning outcomes that will guide you on what you should be able to do by the time you have completed the unit.

You should use these performance learning outcomes to guide your study of the course.

Working through the given SAEs will help you achieve the stated learning outcomes of the units and prepare you for the examination. There will also be some examples given in each unit. Work through these when you come to them.

The following is a practical strategy for working through the course.

1. Read the course guide thoroughly
2. Organize your personal study schedule (time table)
3. Stick to your study schedule strictly
4. Start with unit 1 and read the introduction and the stated learning outcomes for the unit
5. Assemble all study materials
6. Work through the unit
7. Do the Assignment and convince yourself that you have mastered the unit
8. Move to the next unit
9. Go on like this until you get to the last unit.

STUDY UNITS

There are fifteen study units in this course EDU 740/Mathematics Methods II as follows:

In this module, we will be discussing the history of the development of Mathematics. The contributions of early great mathematics of the Greek nation will be treated. The module will also discuss the importance of mathematics. The module will be treated in six units.

Module 1

Unit 1	Brief History of Mathematics and contribution of Early Greek Mathematicians to the development of Mathematics
Unit 2	Great Mathematicians and their Contributions
Unit 3	Importance of Mathematics in Relation to Other Subjects
Unit 4	Curriculum Development in Mathematics as a Subject in Nigeria
Unit 5	Criteria for the Selection of Goals and learning outcomes in Mathematics
Unit 6	Mathematics Curriculum

Module 2

Unit 1	Scheme of Work and Weekly or Unit Plan
Unit 2	Features of a lesson Plan or Note of Lesson

Module 3

MAIN COURSE

CONTENTS

MODULE 1

INTRODUCTION

In this module, we will be discussing the history of the development of Mathematics. The contributions of early great mathematics of the Greek nation will be treated. The module will also discuss the importance of mathematics. The module will be treated in six units.

Unit 1 Brief History of Mathematics and contribution of Early Greek Mathematicians to the development of Mathematics
Unit 2 Great Mathematicians and their Contributions
Unit 3 Importance of Mathematics in Relation to Other Subjects
Unit 4 Curriculum Development in Mathematics as a Subject in Nigeria
Unit 5 Criteria for the Selection of Goals and learning outcomes in Mathematics
Unit 6 Mathematics Curriculum

UNIT 1 HISTORY OF MATHEMATICS AND CONTRIBUTIONS OF EARLY GREEK MATHEMATICIANS TO THE DEVELOPMENT OF MATHEMATICS

CONTENTS

1.0 Introduction

Good day to you all. You are all looking beautiful. It is well. Today in Nigeria we have some men who we read about in books who made great contributions during the struggle for our independence. We see these as history. In the same way we are going to look at some Greek mathematicians and their contributions to the development of mathematics. Please pay serious attention so that you will be able to discuss the history of mathematics and the contributions of some Greek mathematicians to the development of mathematics.

2.0 Intended Learning Outcomes (ILOs)

By the end of this unit you will able to:

- Discuss the history of the development of Mathematics.
- discuss the contributions of any five Greek Mathematicians to mathematics development.

3.0 Main Content

3.1 History of Mathematics

In different communities we still see people who count and write in different ways. This is common where we still have very old people. So it was in early days with different civilizations. Our present system of counting and writing numbers was developed from the Hindu-Arabic system i.e. 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.

The earliest type of Mathematics was "Earth Measurement" which developed in Egypt by the river Nile. It was the partitioning of land for farming year by year. This was the beginning of survey or rope stretching.

The first writing material was the papyrus. They were made of reels of papus which grew by the river Nile. They were difficult to make. Later, writing was done on parchment paper from skins of animals. Can you imagine that? Writing on animal skins. We are lucky today.

Printing did not start until the 14^{th} Century. The first discovered book was written by Amos an Egyptian in 1500 B. C. It was titled "Rules for Inquiry into Nature and knowing all that Exist".

Simple Arithmetic –Addition and Subtraction did not begin until as late in the 15^{th} Century. You may ask why? See the why. The clumsy way of

writing numbers, the absence of symbol for zero and the lack of positional value.

3.2 Early Greek Mathematicians and their contributions.

3.2.1 Thales of Miletus (624-548 BC)

This man lived from 624 to 548 BC. He was counted among the first of seven wise men. A merchant politician who visited Egypt and Babylon to buy and sell wares. In Babylon, he came in contact with the people and got their ideas of Astronomy and learnt geometry from Egypt. When he retired from active business, he devoted his time to the study of Astronomy and Mathematics. He started the study of Deductive Geometry. He was able to predict the date of eclipse of the sun that took place on May 28^{th} in 585 B.C. Thales discovered that the whole year has 365days He also founded the Ionic schools. What did Thales do when he retired from active business? Are you there? He went into the study of Astronomy and mathematics. Thank you.

3.2.2 Pythagoras

This name should be familiar to you I think? Do you still remember your secondary school mathematics? The great Pythagoras and his triangle. He was born in 580 B. C. on the Island of Samos. Later, he moved to Crotona in Southern Italy, where he did most of his Mathematics. He studied under Thales. He founded a school in Crotona and lived with his students like in a brotherhood of mathematicians and philosophers (the Pythagoreans) (Bennett, Borton & Nelson,2010, p 215).They believed that numbers had special meanings that could account for all aspects of life. Some of their knowledge were treasured orally but later became written. Their specific contributions to Mathematics included:

1. Discovery of harmonic progression
2. Invention of the terms odd and even numbers (Can you mention the first three positive odd numbers? Does your answer agree with 1,3, 5, Thank you?
3. Pythagoras theorem (first proved in ca 540 B.C.A)
4. They were the first to use the word parabola, ellipse, hyperbole, and Apolonius borrowed these words in conics
5. He was the first to discover that the world was a sphere.
6. He studied the following number types, primes, composite, perfect, deficient and amicable numbers. What is amicable numbers? Does your answer agree with this?

Two numbers are said to be amicable if each number is the sum of the proper divisors of the other. A proper divisor is the only divisor of the

number.(www.javatpoint.com) Example.220 and 284 are amicable first obtained by Femat in1636(www.ams.org)

Divisors of 220 are; 1,2,4,5,10,11,20,22,44,55and 110.If you add these divisors your result will 284.Are you there? Similarly, the divisors of 284 are 1,2,4,71and 142.Now add these divisors to get 220.Thank you.

They were also the first to offer a mathematical approach to nature (Udegbe,2010)

3.2.3 Plato (c. 428-347 BC)

I think we are all still together? Yesooo.We are still discussing some great Greek mathematicians who made possible some of the mathematics we are enjoying today. Another such ancient Greek philosopher whose ideas formed the basis of much western ideology is Plato. He was a student of Socrates. He founded the largest institute called the Academy. His philosophy was that anyone who would become a leader of men should learn and do Mathematics. This philosophy influenced the great American leader Abraham Lincoln to learn the thirteen (13) books of Euclid, the "Elements". He believed that Mathematics was the best discipline for the human mind. His ideal was that Mathematics should be taught with amusement and pleasure and made very interesting. (how can we achieve this in the present mathematics class in our schools?) He wrote at the entrance of his school "Let no man destitute of Mathematics, enter my door". Can you see that? Destitute as used here can mean poor or lack of mathematical knowledge. Plato made a number of contributions according to Saugat (,2019), Plato,

1. established the first university in Europe
2. gave insight into the philosophical teachings of Socrates
3. Formulated the theory of forms
4. Formulated Epistemology or theory of knowledge
5. came up with division of labour
6. developed Politics
7. came with the influential Platonic Love
8. Formulated the Craftsmanship and Verse
9. Came up with Purposeful Anecdotes
10. was a leading mentor of Mathematics of his time
11. Developed the Dialectic rule
12. Established Laws and Timaeus (dialogue by Plato written in 360 BC) you can see plato.stanford.edu

3.2.4 Euclid (ca. 350 B.C.E)

We are still studying about some great mathematicians of the old some of whom we are using their contributions to solve our everyday problems. Another such great man is Euclid. His name was first met in the records around 300 B. C. He taught Mathematics in the Royal School of Alexandria. Before him, mathematical knowledge was in fragments and pieces. What a good job he did and started for the us who do mathematics today? He assembled all these and documented them in 13 volumes known as "Euclid Elements". This served as a model of deductive reasoning for over 2000 years. (Bennett etal , p569). It was a master document that collected all the available mathematical Jigsaw and puzzles together that gave a clearer and beautiful picture of the contents. All the proofs in the Elements were based on deductive reasoning. These were based on 10 basic assumptions called axioms. All the books contain over 600 theorems that were logically arranged. It was a mark of the quality of a genius.

3.2.5 Apollonius of Perga (262-190 BC)

I hope you are still enjoying the labours of these great men and women. You remember a line in our pledge which says " the labours of our heroes past shall never be in vain"We study them to be properly guided. Apollonius was born some 50 years after Euclid. He also studied in Alexandria where Euclid taught. He developed a completely new approach to the treatment of the conic sections far better than his fellow Greek Mathematicians of his time. So good were the methods of Appollonius that they dominated the study of Mathematics for about 18 centuries until 1637 when Descartes completely revolutionized the study. Below are the reasons why his labour shall not be in vain.

Achievements.

1. He wrote eight books of comics
2. Discovery of Apollonius circle (a circle that is tangential to three objects, which could be points, lines or circles).
3. He is known as the 'Great Geometer'

3.2.6 Archimedes (ca 287 – 212 B.C.E)

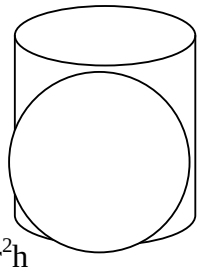
This is another old house name. Why do I say so? Have you forgotten your study of integrated science? Finding the volume of irregular object by throwing it inside a glass filled with water. Yesooo. There you are. We can now continue. Pay attention and pick the points.

Archimedes was born in Syracuse in 287 B. C. He was perhaps considered the world's greatest creative genius of the ancient world. He

studied in the Royal School of Alexandria. His father was a Mathematician and an Astronomer. He was so much a man of ability, energy and power of application that he brought the Mathematics of his time to such a height that not much further progress were made until new mathematical tools were invented. He was said to have remarked, "Give me a place to stand and I will move the earth". He wrote a number of books on spheres, cylinder and cones. His tomb was inscribed with a figure of sphere and cylinder to commemorate his discovery. (I can hear you)

The following are his achievements.

1. Calculation of an approximate value of π to two decimal places. (ie π=3.14)
2. Invention of a method for finding square roots
3. Discovery of how to find the area of an ellipse.
4. discovery that the volume of a sphere is two thirds the volume of the inscribed cylinder.



$V=2/3\pi r^2h$

5. launching of a large ship using pulleys (Bennett & etal,2010, p 714)

3.2.7 Diophantus

We are still studying the works of people who did not waste their talents. They laboured so that we can have what to lay our hands on. What will me and you leave behind for people to study? Food for thought.

Diophantus was a Hellenistic Greek mathematician best known as the father of algebra. (do you remember your junior secondary school mathematics? Have you forgotten, Let the number be x?) That is part of algebra. He wrote a series of books. His equations can be defined as polynomial equations in several unknowns. The compilations of his books were called Arithmetica. Can you recognize this? $a_0x^n + a_1x^{n-1} + a_2x^{n-2} + \ldots + a^n$ Example of a polynomial

3.2.8 Eratosthenes

During our primary school days, one of our teachers taught us that Christopher Columbus travelled round the world. Do you think he knew the distance he covered then? But today, it is possible. Thanks to Eratosthenes.

He is credited with the calculation of the circumference of the earth.($2\Pi R$) Also the first to calculate the tilt of the Earth's axis. The axis of the earth tilts at an angle of 23.5^0 The two calculations were remarkably accurate, and was therefore famous for his incredibly accurate calculations.

3.2.9 Hipparchus (190 BC- 120 BC)

Hipparchus was an ancient Greek astronomer, geographer and mathematician He made many mathematical contributions throughout his lifetime. He was the founder of trigonometry. What is trigonometry? Do I hear you say something like this? Branch of mathematics concerned with functions of angles and their applications to calculations. (www.britannica.com) He was the first to develop a reliable precession of the equinoxes and the appearance of a new star, a nova.(www.famousscientists.org). He also was the first to compile the first known star catalogue. He produced the first mathematical trigonometric table.(abyss.uoregon.edu)

3.2.10 Hero of Alexandria

In the last discussion we treated the contributions of Hipparchus whom we learnt was the founder of trigonometry. He also developed the first trigonometric table. We are going to look at another individual who made some contributions in the development of mathematics. .Hero of Alexandria. He was a mathematician, engineer and an inventor.

He was a specialist in a branch of mathematics called geodesy. The present aspect of this mathematics is concerned with how to measure and understand the earths geometric shape, gravitational field, and orientation in space..(www.thefamouspeople.com)

Summary of Hero's achievement

1. Transformation of landscape of mathematical sciences'
2. Invention of steam powered device called an aeolipile
3. Invention of wind wheel that harnessed wind for agricultural and other purposes
4. Lectured at museum and famous library at Alexandria
5. Wrote books in mathematics, mechanics and physics'

6. Introduction of the study of cybernetics.
7. Modifications of aeolipile as the Hero's engine machine.
8. Constructions of first vending machine for dispensing holy water etc

3.3 Antiphon 480 BC -411BC

Thank you for your patience and interest you have demonstrated in learning the contributions of some early mathematicians who made remarkable impact in the development of mathematics.

Antiphon was the first to give an upper and lower bound for the values of Pi. He achieved this by inscribing and then circumscribing a polygon around a circle. He used the process to calculate areas of the polygons. The method was applied to squaring the circle. He made comprehensive changes in the world of mathematics through his profound knowledge of the subject. His ideas are still applied in the modern day. Mathematics (www.cuemath.com)

3.3.1 Aristotle (384 -322 BC)

What has a beginning will surely have an end. We still have other individuals who made remarkable impact in the development of mathematics. Some were however selected for our discussion in this unit. In the next few minutes, we shall be discussing Aristotle and his contributions.

Aristotle had a diverse knowledge in many disciplines including mathematics, geology, physics, metaphysics, biology, medicine and psychology. He was a pupil of Plato therefore it's not a surprise that he had a vast knowledge and made contributions towards Platonism. He tutored Alexander the Great and established a library which aided in the production of hundreds of book. His main area in Mathematics was logic. He is credited with the Aristotelian syllogistic argument based on two premises and a conclusion. He was more realistic.You can visit www.history.com for more information. Thank you.

Self-Assessment Exercise(s)

(1) Three major areas of Hero's specialization in which he made contributions were……
(2) What are the three areas of Hipparchus specialization?
(3) Mention any three major contributions of Hipparchus in the development of mathematics

4.0 Conclusion

This unit looked at the development of Mathematics, from early man through to the 1st Century. It discussed the contributions of some Greek mathematicians. Theirs was referred to as the Golden Age of Greek mathematicians

5.0 Summary

We have discussed the early history of the development of mathematics. Some great Greek mathematicians and their contributions were also treated Since the 9th Century till now, Mathematics has witnessed a great development quantitatively and qualitatively. .

6.0 References/ Further Readings/website

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7.0 Possible Answers to SAEs

1. three major Hero's area of specialization are; mathematics, engineering and invention.
2. Three areas of Hipparachus, astronomy, geography and mathematics.
3. Three major contributions oh Hipparachus are foundation of trigonometry,compilation of star catalogue and production of the first trigonometric table.

UNIT 2 GREAT MATHEMATICIANS OF THE RENAISSANCE PERIOD AND THEIR CONTRIBUTIONS

CONTENTS

1.0 Introduction

This unit will be discussing another set of great mathematics who are referred to as the mathematicians of the renaissance period. The unit will also look at the activities of some few early Nigerian mathematicians.

Today is another beautiful day our creator has made, we shall rejoice and be happy in it. How many of us are happy today? I can see that on your beautiful faces. Thank you.

In unit 1, we studied early Greek mathematicians and their contributions to the development of mathematics. In unit 2, we will discuss the contributions of later mathematicians beginning with Napier John. Most of the people here belong to the renaissance period. (Udegbe, 2011). It marked the period of knowledge and revival of learning. You can read many others.in any history book on mathematics

2.0 Intended Learning Outcomes(ILOs)

By the end of this unit the learner will be able to:

- the invention of logarithm.
- Give brief account of the development of differential calculus.
- Explain the discovery of probability
- Compare the contributions of Napier and Fermat Prierre in the development of mathematics
- evaluate the extent to which the renaissance period influenced the development of mathematics.

3.0 Main Content

3.1 John Napier (1550-1617)

May I once more invite you to another interactive discussion. I employ you to be present in every sense of learning so that learning outcomes can manifest naturally. In the first unit we discussed the contributions of some Greek mathematicians. In this unit, we will be discussing the contributions of some mathematicians who were referred to as the renaissance period.

One of such individual was Napier (also spelled Neper) a Scottish, born in 1550.He published his first work on Logarithm titled. “A Description of the Marvellous Rule of Logarithm” in 1614 A.D. (Napierian logarithm) What we called the four figure table in our junior secondary school class three.

Though Napier was not a professional mathematician, but he had interest in writing certain aspects of mathematics. His work was related to computation and trigonometry. He invented Napier “roles or bones”. This device was created before the slide rule. They were sticks on which items of multiplication table were carved. This facilitated multiplication.

He also made common the use of the decimal point in arithmetic and mathematics. This made the computation of roots, products and quotients faster with the help of the table. Other achievements credited to Napier were; the “Napier Analogies” and “Napier’s rule of curricular parts” The analogies are four formulas that give the tangents of half the sum or difference of two of the angles or sides of a spherical triangle in terms of the others. The Napier curricular parts are five parts of a right spherical triangle including the two legs and the complements of their opposite angles and of the hypotenuse. (https://www.merriam-webster.com/dictionary/Napier%27s%20circular%20parts.) These were devices of memory on spherical trigonometry. His system of logarithm differed from what we have today because his base is different from the present one. He died in 1617.

3.2 Fermat Prierre (1601-1665)

Gooday to every one of you. I always get excited whenever I am to have you in my class.

What was our topic of discussion in the class? Thank you for that beautiful attempt.

In the next one hour we shall be discussing about Fermat Prierre.

He was a lawyer by profession. His greatest achievement was the establishment of the foundation of number theory. (Bennett &co2010, p236). He made discoveries in Mathematics, especially in analytical geometry (coordinate geometry), probability and optics. Can you think of one thing he never enjoyed? You are far from it. Most of his works were published after his death.

Fermat was one of the first to find a systematic way of getting a straight line which best approximates a curve at any point. (The tangent to curves of the form y = mx.) In 1629, he came up with a theorem on the areas under these curves.

Fermat did not relax. The above discoveries led him to establish the study of differential calculus by studying "rate of change". Fermat also came up with the method of finding maximum and minimum points of curved lines. (www.britannica.com) His last theorem states that there are no positive integers x, y and z such that $x^n + i^n = z^n$ for all n>2.

3.3 Blaise Pascal (1623-1662)

I will begin this section by voicing out my satisfaction on your level of participation so far. You people have been wonderful. Our last discussion was about Fermat and his contributions in the development of mathematics.

Today we will be discussing the contributions of Blaise Pascal. His main areas were Theology, Mathematics, philosophy and physics. (www.britannica.com) At the age of sixteen, the young Blaise (in 1640) published one of the most fruitful papers in history called "Essay pour les Comques" It states, that opposite sides of a hexagon inscribed in a conic intersects in three collinear points.

Also in 1642 Paschal developed one adding machine for computing sums. It operated by dialling a series of wheels with digits running from 0 to 9.

In 1654, Pascal and Fermat solved a certain probability puzzle from Chevalier de Mere The result became the effective starting point for the modern theory of probability? Neither Pascal nor Fermat wrote up their result. But these were published in 1657 by Huggens in a book titled "De ratiociniis in ludo aleac" (Reasoning in Games of Dice).(Udegbe ,2011)The two are known as founders of mathematical theory of probability.

Pascal was also instrumental to connecting the study of probability with Arithmetic. Thereby, he formed what is known as Pascal Triangle today. This is used to determine the coefficient of Binomial Expansion.

The theory of probability attracted many mathematicians in the early 18th Century. One of them was Abraham De Mourre. He published more than 50 problems on probability as well as questions relating to life and annuities.

Pascal also discovered the theory of permutation and combination from the principles of probability. Probability theory grew into a very useful subject having applications in Engineering, games of chance, Business and Science. If Blaise Pascal was not created by God, could all these discoveries have been made? Your answer is as good as mine. Thank you

3.4 Rene Descartes (1596 -1650)

Thank you for making our discussions of the history of some great mathematicians interactive and interesting. In our last contact, we discussed the contributions of Blaise Pascal. Our joy will continue as we discuss the activities of Rene Descartes.

Descartes was a French mathematician who is referred to as the father of modern mathematics. He made important contributions in chemistry, physics, physiology and psychology. His greatest creation is the rectangular coordinate system. It is stated that the idea came to him while he lay in bed and watched a fly crawling on the ceiling.

The above discovery made it possible to study geometric figures using algebraic formulas It is regarded as the greatest mathematical achievement of all times. (Bennett& co, 2010 p 83) The Cartesian rule was also used in describing three dimensional shapes such as cubes .Descartes, also developed the standard notation for exponents. His work had great influence on Isaac Newton.(study.com)

3.4.1 Some Early Nigerian Mathematicians

It is with great joy that I welcome you as we look at the contributions made by our own people in the development and pursuit of mathematical knowledge.

We shall look at few of them.

Chike Edozien Umezei Obi (7th April 1921- 13th March 2008)
From an **account by** O'Connor and Robertson (2019), Obi started his education at St Patricks primary school Zaria. He attended Christ king college Onitsha and obtained the west African certificate in 1939. In 1940 he began studies at Yaba Higher college Lagos. In 1946, he obtained B.sc in mathematics with special honours from university of London through correspondence courses.

Also in 1947, he obtained M.Sc. from university college London. In the same year he began research at Pembroke college university of Cambridge. In 1950, he obtained his Ph.D. with specialities in Periodic solutions of non-linear Differential Equations of second order. He is the first Nigerian to get a Ph.D. in mathematics.

Contributions and work experiences
Chike Obi as he was popularly called, worked briefly at Massachusetts Institute of technology USA. When he came back to Nigeria, he was appointed lecturer in the department of mathematics university college Ibadan. For some years, Obi was out of the education system and ventured into politics. When he returned to active education service, now at the university of Lagos, he published an article titled Analytical theory of non-linear oscillations. He is credited with ten other publications on analytical theory of non-linear oscillations. He became a professor of mathematics in 1971 from the university of Lagos. In 1985 Professor Obi was awarded the Sigvard Eklund Prize by the International Centre for Theoretical Physics(Sweden). The award was in recognition of his contributions in the study of non-linear ordinary differential equations with several parameters. While in the school, Obi lectured in Real analysis and differential equations. At Onitsha he established the Nanna Institute for scientific studies.

James Okoye Chukwuka Ezeilo (1930-2013)
Another early Nigerian mathematician was Ezeilo. In an account by Raymond (2019), Ezeilo was regarded as the second best mathematician in Nigeria. He is also regarded as the country's father of modern mathematics. It may interest you to appreciate this first professor of mathematics in Nigeria in 1964 from university of Cambridge. He also obtained his B.sc in 1953 and M.sc all from London university.

Achievements
Okoye Ezeilo published not less than 87 scientific papers in academic journals. His early research works were on problems of stability, boundedness and convergence of solutions of third order ordinary differential equations. He is also known for the construction of Iyapunov-like functions etc.

This great Nigerian who obtained a Ph. D in mathematics was the founding director of National Mathematical Centre Abuja. Nigeria. He served as visiting lecturer to some universities outside Nigeria. He served as vice chancellor in two universities in Nigeria. He belonged to a number of professional bodies and had some awards during his active years in service.

Adegoke Olubummu (19th April 1923-26th October 1992)
Academic studies.
He obtained his B.A from Fourah College, Freetown Sierra Leone in 1950 and his M.A in mathematics in 1952 from King's college Newcastle-Upon-Type, in the university of Durham. UK. Also in 1955, he got his Ph,D from the same university with speciality in the theory of Linear space.

He initiated the forum for functional analysis and its application and the Nigerian mathematical society.

Self-Assessment Exercise(s)

(1) Who developed Napier bones?
(2) Who discovered the rectangular coordinate system?
(3) Mention any three major discoveries made by Fermat

4.0 Conclusion

In this unit, we have successfully discussed some renaissance mathematicians and their contributions to the development of mathematics. Some of these contributions influenced commerce, business, engineering, agriculture and all other branches of science.

5.0 Summary

In this unit, you have been introduced to the following mathematicians in addition to those in unit one. The unit also discussed some early Nigerian mathematicians who some contributions in the development of the subject in the country.

(i) John Napier as the founding father of Logarithm
(ii) Pierre Fermat and his work on differential calculus and modern use of rate of change.
(iii) Blaise Pascal and the theory of probability.

6.0 References/Further Readings/website

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Steven G. Krantz (2012). A mathematician comes of age, The Mathematical Association of America, ISBN 978-0-88385-578-2

Stewart, lan (2017). Basic Books. Significant figures: the lives and work of great mathematicians. New York: Basic Books. ISBN 978-0-465-09612-1. OCLC *to* modern time1030547312

Udegbe G,I (2011)History of mathematics from ancient time. Printers Corner 75 Old market road. Onitsha.rinters Corner,75 Old market road Onitsha

7.0 Possible Answers to SAEs

1. Napier bones was developed by John Napier (1550-1617)
2. The coordinate system was developed by Rene Descartes.
3. Three major discoveries of Fermat
   (a) Naperian logarithm
   (b) Napier roles or bones used sticks to develop mathematical table.
   (c) Napier rule of circular parts and Napier Analogies

UNIT 3 IMPORTANCE OF MATHEMATICS IN RELATION TO OTHER SUBJECTS

CONTENTS

1.0 Introduction

From our discussions of the history of mathematics development in the world and that of the early Nigerian mathematicians, we can make some reasonable discussions on the usefulness of mathematics in our daily living. It is almost very difficult to find any aspect of human activities where some elements of basic mathematics knowledge and skills are not needed Mathematics has long been accepted as a veritable tool of communication of knowledge. It is the language of science, technology and other related disciplines. It has long been referred to as the Mother and Queen of all subjects.

2.0 Intended Learning Outcomes(ILOs)

By the end of this unit you be able to:

- Illustrate with at least five examples the areas of importance of Mathematics.
- Discuss the importance of mathematics in relation to other school subjects.

3.0 Main Content

3.1 Importance of Mathematics

Mathematics is viewed in different ways by different individuals. It is a matter of perception and belief. It is a man-made subject which arose as a tool to the solution of practical problems. (Udegbe,2011) There are three main considerations for which a child is sent to school. Education must contribute towards the acquisition of these values:

(i) Knowledge and skills.
(ii) Intellectual habits and power.
(iii) Desirable attitude and ideals.

The above values can be called utilitarian, disciplinary and cultural values of education respectively. (do you agree?)

I think that you will agree with me that the acquisition of Mathematics knowledge and skills is helpful in the realization of these values. The important thing in the study of Mathematics is not only to learn facts, but also to understand how to learn facts.

In addition to these three values, mathematics possesses other educational values such as Social value, Moral value, Aesthetic value, Intellectual value, International value and Vocational value. *Pick any of these values and discuss how mathematics knowledge and skills will enhance its realization.*

I want you to be active in generating ideas as we discuss the various ways in which the knowledge and skills in mathematics is very important to an individual, the society, an industry, banking, in business activities, in agricultural activities, in construction works, in sports,

In-Test Question(s)
State any two areas where the study of mathematics is important to an individual.

3.2 Mathematics is Fundamental to the Study of other Subjects

Without the knowledge of Mathematics, many other subjects may not have been developed beyond the descriptive level. This is particularly true of the physical, and social sciences. Mathematics provides the explicit and precise language for better understanding of concepts in all other related disciplines.

You will agree with me that the society is dynamic. There has continued to be expansion in knowledge. As these occur, the interconnection between disciplines continue to increase.

It is in this regard that the FRN (2013) in the national policy on education made mathematics compulsory at the Secondary School level. It is a tool for the architects, engineers, agriculturists, economists, geographers, sociologists, business administrators and computer/scientists. The inter disciplinary-relationship between mathematics and other subjects is very obvious.

In many school subjects, mathematical skills and knowledge are needed in such activities as Data collection and analysis, graphical representation of information, research studies, etc

The National Research Council (2013), while projecting the mathematical sciences in 2025, observed the connections between the mathematical sciences and other fields. The community listed the following as the mathematical sciences with increasing interface between the various disciplines.

Economics, Computer science, Electrical engineering, Civil engineering, Mechanical Engineering, Geosciences, Astronomy, Physics, Materials, Chemistry, Biology, Ecology, Medicine, Social Networks, Entertainment, Information Processing, Communication, Defence, Manufacturing, Marketing, Finance, etc (www.nap.edu)

Discussion

Case Studies

In-Test Question(s)

Mention any three areas of the importance of mathematics in the study of other subjects.

Self-Assessment Exercise(s) (SAEs)

(1) State any two ways the study of mathematics helps in the study of Physics

4.0 Conclusion

There is no doubt that mathematics is very important to every individual.

It is used in our everyday activities, in business transactions, banking, agriculture, etc Mathematics also plays useful part in better learning of most science and social science subjects.

5.0 Summary

This unit discussed the importance of mathematics generally and its usefulness in the learning of other school subjects.

6.0 References/ Further Readings/website

FRN (2013) National Policy Education 6th edition National Research Council (2013*) the mathematical sciences in 2025*.Washington, DC National academic press doi: 10.17226/15269.

Udegbe G,I (2011)History of mathematics from ancient time. Printers Corner 75 Old market road. Onitsha.rinters Corner,75 Old market road Onitsha

7.0 Possible Answers to SAEs

1. How mathematics helps in the study of Physics.
2. Physics concepts, laws and principles are clearly expressed in mathematical terms and equations.
3. Most computations in physics are carried out using mathematical tools and formula.
4. Mathematical language makes physics contents simplified and more comprehensible

UNIT 4 CURRICULUM DEVELOPMENT IN MATHEMATICS AS A SUBJECT IN NIGERIA

CONTENTS

1.0 Introduction

In this unit we shall be discussing curriculum in the pre-independent period and during the oil boom in Nigeria. This unit will also discuss the activities of NIGERIAN EDUCATIONAL RESEARCH COUNCIL(NERC) 1969

2.0 Intended Learning Outcomes(ILOs)

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

- discuss the development of Mathematics curriculum during the pre- independent era
- Analyse the mathematics curriculum during the oil boom period (1970-1976)
- Discuss the development of Mathematics curriculum from end of "modern" Mathematics (1977) to the present period.
- (Iv) evaluate the "modern" mathematics controversy in Nigeria

3.0 Main content

3.1 Pre-Independence Mathematics Curriculum

I want to draw your attention to the purpose of education before and during the white man's colonial administration in Nigeria. The need then if can hear you very well, was to produce people who could only read

and write. The need of the time determined not only the text materials, but also level of knowledge and skills required.

In line with the above, during the pre-colonial period, the mathematics education in Nigeria schools included using three textbooks. The Efficiency Arithmetic, A Shilling Arithmetic and Lacombe Arithmetic for the primary schools in various parts of Nigeria. For the Secondary level, three types of syllabuses existed. They were(i) Alternative A; it contains topics in arithmetic, algebra, Euclidian geometry and trigonometry. (ii) Alternative B:it consists of alternative A with some additional topics in coordinate geometry. (iii) the third syllabus consists of additional mathematics with topics from pure mathematics mechanics and statistics. The grade two teacher training colleges consisted of arithmetic and was compulsory for all students.

The aim of mathematics during this period was to equip the pupils with basic numerical competence. One major problem of the texts and methods was the inability to relate content and examples to the learners' environment and learning was by rote method. The text books were written by foreign authors. Because of the demand for mathematics in so many areas of activities in the society, it soon became evident that the contents of the Secondary School mathematics were inadequate. The large number of students taking mathematics made the few number of mathematics teachers inadequate. Mathematics was taught poorly as the other science subjects. Efforts were not made to teach concepts, patterns and principles.

3.2 Mathematics curriculum during the Oil Boom (1970-1976)

We have discussed the nature and content of most mathematics text materials during the pre-colonial period. What then changed? The period of Oil Boom led to some major mathematics curriculum innovations. However, the mathematics curricular could not meet the technical needs of mathematicians and the scientists. Secondary school mathematics curricular was not adequate enough to prepare the students to cope with modern sciences. (Udegbe, 2011.p130).

A number of measures were taken to provide for the educational needs of the Nigerian children. One of such initiatives was the introduction of the Universal Primary Education (U.P.E) in 1976. It made it compulsory for all children of school age to go to school. This led to an astronomical increase in student enrolment without the attendant increase in teachers and infrastructure. This negatively affected the teaching and learning of Mathematics.

The outcome of 1960 conference in Israel, was the establishment of African mathematics programme. Two of them were the Entebbe Mathematics Experiment and the School Mathematics Project (SMP). The schools were allowed to choose the curriculum they preferred and the examining body WAEC examined both projects. The change created more problems in the teaching and learning of Mathematics. Each of the projects included elements of "Traditional" and "Modern" Mathematics. The problem between the two Mathematics projects made both students and parents more confused about the subject. The situation was addressed in April 1977 when the then Federal Minister of Education Col. Dr. A. A. Ali abolished the modern mathematics in all Nigerian Secondary Schools. The following year the National Critique Workshop was set up by the Federal Government of Nigeria released a new Mathematics Curriculum for the Secondary School in April 1978 in Benin. It covered both the Junior and Senior Secondary Schools Mathematics.

3.3 Activities of Nigerian Educational Research Council(NERC) 1969

We are still discussing various efforts made by the government of Nigeria in order to fashion out effective education system that will serve the specific needs of the nation. Nigeria opted out of west African regional mathematics programme and created the Nigerian Educational Research Council which in collaboration with the Comparative Education Studies and Adaptation Center (CESAC) played a great part in fashioning the new Primary, Secondary School and the Teachers Grade II – 5 years' mathematics curricula. There were two syllabuses for junior and senior school levels.

Considering all the problems which contributed to the failure of the two previous mathematics curricula, NERC (2009) reviewed modern mathematics syllabus and developed a new syllabus for secondary schools. According to NERC (2009), all necessary materials which had no connection with the day-to-day life of the Nigerian children were removed from the modern Mathematics syllabus. In their place, relevant materials which reflect the environment and the background of the children were placed.

In addition, some relevant topics from the old Traditional Mathematics syllabus were also incorporated into the new Mathematics syllabi that gave birth to new Mathematics curriculum called General Mathematics.

3.4 General Mathematics curriculum:

It was introduced in secondary schools in the year 2009 according to NERC. The curriculum was reviewed the same year. There was no pilot testing of the new curriculum. Hence, it experienced some challenges.

Self-Assessment Exercise(s)

Mention any one contributions of NERDC and CESAC in the development of Mathematics curriculum in Nigeria.

4.0 Conclusion

Mathematics has been shown as a veritable tool for the development of virtually all other subjects. The progress in its development in this country has been traced from pre-independent period till 2009. The mathematics curriculum now in use dates back to 2009. NERDC is the body which is charged with responsibility of review and effective implementation of senior secondary school curriculum at all levels in Nigeria.

5.0 Summary

We have discussed the importance of Mathematics as a subject and its relationship to all other subjects. We have traced its development to modern times. The contributions of NERDC/CESAC and the National Critique Workshop of 1978 have been highlighted. The latest review of the year 2009 was also discussed.

6.0 References/Further Readings/website

Bessong, F. E. & Felix, O. (2018). Evaluating Secondary Mathematics Education in Nigeria. *International Journal of advanced Research in Public Policy, Social Development and Enterprise Studies*, 3(1), 90-99.

Consult Kulbir, S. S. (2012). *The teaching of Mathematics.* New Delhi: Sterling

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O'Connor.J,J and Robertson. E,F(2019) *Biography,Quik Info of Chike Edozien Umezei Obi.* DJF/JOC/EFR. School of mathematics and Statistics. University of St Andrews.Scotland

Raymond, J (2021) *Best mathematicians in Nigeria of all Time.* Infobusstop.

7.0 Possible Answers to SAEs

Contributions of CESAC.

1. Contributed in developing new mathematics curriculum for primary, secondary and grade II for 5-year program.
2. NERC Contributions.
3. Review of modern mathematics syllabus.
4. Development of new syllabus for secondary school. Mathematics contents was made to relevant to everyday life activities.

UNIT 5 SELECTION OF GOALS AND LEARNING OUTCOMES IN MATHEMATICS

CONTENTS

1.0 Introduction

We may begin this unit by asking a very simple question. You can personalize the question so that the true meaning of the" why" can be obvious. Why have I taken the pain to go to school? As we try to generate reasons in response to the question above, we can now be in a better position to discuss the major goals for Mathematics teaching and learning in our schools.

We will also discuss the competencies to be demonstrated by the learners who are the expected beneficiaries of the teaching of the subject at the primary and secondary school levels. Specific Behavioural learning outcomes will be discussed also in this unit.

2.0 Intended Learning Outcomes(ILOs)

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

- state the major goals of teaching Mathematics in Nigerian.
- discuss at least any four goals for teaching mathematics in the primary schools.
- Discuss any four goals for learning mathematics in secondary schools in Nigeria.
- discuss with any three relevant examples the concept of learning outcomes
- Discuss any four criteria for stating measurable learning outcomes

3.0 Main Content

3.1 National Goals for Teaching Mathematics

May I use this thought provoking question presented in a related context by the National Curriculum in England (framework document,2013, p103) to inspire us into active and productive discussion." What does the National Curriculum say about the teaching of mathematics, and its importance across the curriculum'?

In the Nigerian context, the revised mathematics curriculum for the 9-year basic education has the following major goals.

1. equipping the children with mathematical literacy necessary to function in an information age.
2. help children cultivate the understanding and application of mathematics skills and concepts necessary to thrive in the ever changing technological world.
3. Assist the children develop the essential element of problem solving. communication, reasoning and connection within their study of mathematics.

Help the children understand the major ideas of mathematics bearing in mind that the world has changed and is still changing since the first National mathematics curriculum was developed in 1977etc

As stated in the 1997 National Policy on Education, the following are the goals or general aims of teaching mathematics in the primary and secondary school levels. Goals or general aims refer to long-term educational expectations while the learning outcomes guide the classroom instructions.

(i) To generate interest in Mathematics and to provide a solid foundation for everyday living.
(ii) To develop computational skills and foster the desire and ability to be accurate to a degree relevant to the problem at hand.
(iii) To develop precise, logical and abstract thinking competencies.
(iv) To develop ability to recognize problems and solve them with related Mathematical knowledge
(v) To provide necessary Mathematical background for further education
(vi) To stimulate and encourage creativity.(www.researchs.com.ng)

There is no doubt that these broad goals and intended learning outcomes, are learner centred. They are stated in active verbs and the competencies can be manifested. Hence, they are measurable.

3.2 Utilitarian Goals of Mathematics

Mathematics is a very useful tool for everyday living. It is used when counting, buying and selling. Everybody makes use of it daily. We talk of times, days of the week, month or year. In these days of modern technology, almost everyone owns a mobile phone. We dial numbers, read credits, used or remaining. The computer and calculator are tools in the hands of pupils/students. Mathematics is fundamental to the use of all these gadgets and facilities.

There is no doubt that good knowledge of mathematics especially mathematical literacy, influences the level and competency of one's engagement in mathematical discussions. In such local activities as metal construction, land measurement, time telling, buying and selling, sports and games, tailoring, carpentry work, etc, some form of mathematics abilities and skills are required

3.3 Primary Mathematics Goals

The primary school level is an important basic foundation in any nations education system that need not to be played with. The success of this stage of education especially in mathematics will provide a strong base on which other levels will anchor effectively for growth and development. According to timesandpiris.bc.edu (2021), primary mathematics learning outcomes / objectives will include:

1. Make the learners demonstrate interest in the learning of mathematics.
2. Teaching should ensure that students demonstrate reasonable level of understanding and acquisition of basic mathematical concepts and computational skills.
3. helping students demonstrate creative and critical thinking ability, communicate and solve problems.
4. helping students demonstrate development of number and spatial sense ability and appreciation of patterns and structures of numbers and shapes.
5. enhance students lifelong learning abilities through demonstration of acquisition of basic mathematical knowledge. (published by Curriculum development centre, CDC)

3.4 Goals of secondary mathematics curriculum

The secondary school level no doubt is another essential basic form of education. It ensures an enabling base for tertiary forms of education and for other services if effectively and productively engaged with.

Similarly, timesandpiris(2021) stated goals of secondary education to include:

1. enabling students to develop mathematical conceptualization through inquiry and critical reasoning.
2. Students will also demonstrate effective communication skills and the ability to use mathematics to formulate and solve problems in everyday life.
3. enabling students manipulate numbers, symbols and other mathematical objects.
4. helping students manipulate numbers, symbols, and show spatial ability as well as sense of measurement. They will also be able to show capability to appreciate structures and patterns.

Helping students demonstrate positive attitude towards mathematics and the ability to appreciate the aesthetic nature and cultural aspects of mathematics.

3.5 Specific learning Outcomes and Importance

Any teaching and learning activities engaged in by both the teacher and learner or the learner Working independently, is considered productive if the learners are able to demonstrate the intended learning outcomes in observable and measurable ways.

When you carefully watch any classroom, teacher and the students engage in a number of activities for the purpose of achieving predetermined instructional observable learning outcomes. These are stated in students' measurable behavioural action verbs.

They can also be referred to as statements that describe results in terms of knowledge, attitude, skills, aspirations and behaviours, participants' performance, rather than trainers' performance or instructional procedures (etc.ucf.edu)

A number of criteria or conditions determine correct measurable learning outcome. BOB PIKE GROUP (2018), identified five steps in writing clear and measurable learning outcomes to include:

1 identification of the level of knowledge necessary to achieve the learning outcomes.
2 selection of action verbs to express the learning outcomes
3 creations of the learning outcomes.
4 cross checking the learning outcomes
5 Repeat, repeat, repeat.

To ensure conformity with global trend in stating the change in behaviour on the part of the learners, learning outcomes was used to replace objectives as used in the original document.

The domains of the learning outcomes include the affective (attitude), psychomotor (skills) and cognitive (knowledge). The group above listed some measurable verbs or terms that can be used for each of the domains.

Attitude: These include;
Accept, agree, allow, analyse, approve, assess, believe, choose, collaborate, comply, Conform, convince, corporate, decide to, defend, endorse, evaluate, pick, recommend, select. support, tolerate, volunteer, etc

Knowledge: These include such terms as,
Compare, defend, describe, designate, discover, distinguish, explain, identify, itemize, label, list, name, recite, recount relate, retell, specify, spell out, state, tell, write etc

For skills, the likely action terms can be any of the following, adjust, actuate, align, administer, alter, change, copy, demonstrate, design, calibrate, develop, draft, execute, handle, manipulate, measure, mend, perform, prepare, process, record, regulate, remove, repair, replace, set service etc

Instructional Learning Outcomes serve a number of Purposes.
Roma in teacher education (www.slideshare.ne) observed that it is a point, or end in view of somethings towards which actions are directed. It is a planned change sought through any activity. They help the teacher bring behavioural changes in leaners. they indicate the desirable knowledge, skills, or attitude to be gained by learners. They are pointers to learning experiences, types of teaching materials, methods and strategies etc that can be employed by the teacher during the instructional stage.

Western Kenkucky university(WKU) observed that instructional learning outcomes are specific, measurable, short- term, observable student behaviour. They also argued that they are tools that can be used to make sure you reach your goals. They are they arrows you shoot towards your target(goal)

3.6 Parts of any well-stated learning outcomes

Every well-stated learning outcomes has five parts.

(a) The condition under which the change in behaviour is to take place must be stated. The classroom environment, the direction to be given to the learner so as to make him change his behaviour must be stated.

(b) The person whose behaviour has to change must be stated. It is usually the learner in the class-room situation.

(c) What specific behaviour will the learner exhibit. These specific behaviours must be stated in operational (i.e. measurable) terms. This is done by using action verbs as stated above.

(d) What should be the end product or outcome of the change in behaviour? This is also called the performance product.

(e) To what level is the learner expected to perform for this performance to be considered acceptable to the teacher.

Example of such well-stated learning outcomes can be as follows.
By the end of the lesson, the pupils will be able to:

Demonstrate in writing the first ten multiples of any number from 1 to 5 inclusive.

3.7 Types of Specific measurable learning outcomes

Under What Condition	**Who**	**What Behaviour**	**What result**	**To what level**
By the end of the lesson	The pupils	Demonstrate in writing	First ten multiples of numbers 1-5	First ten

The most correct classification of specific behavioural objective is that of B.S. Bloom (1956) and his associates. They called this classification "The Taxonomy of Educational Objectives" This is an attempt to arrange instructional objectives in behavioural classification. It starts from simple behaviour easy to achieve to highly complex groups of behaviour. There are three categories (domains) of instructional learning outcomes.

(i) Cognitive Domains
(ii) Affective Domains
(iii) Psychomotor Domains

Cognitive Domain

This refers to the thinking area of the student behaviour. This includes the following:

(a) **Knowledge(remembering)** This includes simple recall of knowledge of specific facts, terminologies, generalizations, theorems, structures or algorithms.

(b) **Comprehension:(understanding)** Which includes ability to translate, interpret, explain correctly, extrapolate.

(c) **Applications:(applying)** i.e. use of ideas, theories, principles or concepts learnt in other situations.

(d) **Analysis:(analysing)** it involves identification of relations and organizations or order in a concept.

(e) **Synthesis:(creating)** It includes organization of ideas into reports, plans or systems

(f) **Evaluation:(evaluation)** Implies passing judgment on basis of internal or external evidence.

Affective Domain

Affective domain of behaviour relates to student's feelings and biases.
These are:

(i) Receiving or attending
(ii) Participating or responding
(iii) Organizing values into a system
(iv) Valuing or believing in the worth of a thing
(v) Characterization by a value. This domain is difficult to measure but the Federal Government of Nigeria has mapped out a system of continuous assessment for teachers to measure affective achievement in the classroom.

Psychomotor Domain

This domain is easy to identify and measure. It involves the ability to use our loco motor sensory organs such as:

(i) ability of a child to write a number
(ii) Draw straight lines
(iii) Make an arc or a circle or ability to use the protractor correctly to measure an angle.
(iv) Use any of the construction equipment to make any 2 or 3 dimensional geometric shape with defined dimensions.
(v) Use an improvised clinometer to demonstrate the process of finding angles of elevation and depression.

Give an example of a psychomotor learning outcomes in any Mathematics topic of your choice.

Self-Assessment Exercise(s)

State the five important aspects of a good learning outcome

4.0 Conclusion

The primary and secondary school mathematics curricula was discussed in line with the major goals expressed in broad observable outcomes. The importance of the two levels of education in the country's education system were also discussed.

Also emphasis was placed on the use of learning outcomes instead of specific objectives to enable the teacher plan instruction so that learners will become productive learners not passive recipients of static knowledge.

If mathematics is taught in this way, the National goals and the learning outcomes can be achieved. In addition, the learning outcomes for any lesson must address the domains in terms of learners measurable and observable performance behaviour.

The teacher needs to evaluate how effectively he is achieving these by looking at and grading student's assignments, homework and tests with well-prepared marking guide in line with the stated learning outcomes.

5.0 Summary

The Goals and learning outcomes in mathematics were discussed in this unit. The utility value of Mathematics was also treated.

Essential properties or parts of a well stated learning outcomes was also was also discussed The learning outcomes must be stated in measurable terms using action verbs. The broad three domains of (behavioural objectives) the learning outcomes are given in the main content.

6.0 References / Further Readings/website

Anderson, L. W. (2013). A Taxonomy for Learning, Teaching and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives, Abridged Edition.

FME (2013) National policy on Education. Revised editions Nigeria: Federal Republic of Nigeria Policy on Education. Federal Ministry of Education 2014.

Kumar, A. (2018). General objectives of Primary and secondary Mathematics Education. Retrieved 12th September, 2019. https://www.google.com.goals and objective of T-L Mathematics.

Obienyem,C(2019) Basic General Mathematics for Primary Education Studies. Annyco publishers Umunze, Anambra state

7.0 Possible Answers to SAEs

1. The specific condition under which change in behaviour is to occur.
2. The audience or person whose behaviour will change
3. what is the expected specific behaviour change.
4. level of performance of the expected behaviour change.
5. what is the performance product. (outcome of behaviour change)

UNIT 6 MATHEMATICS CURRICULUM

CONTENTS

1.0 Introduction

We shall start this unit by reflecting on some questions that are related to the present topic. In December,2005, the National Council on Education(NEC) directed the Nigerian Educational Research and Development Council (NERDC) to……..and ……..the existing senior secondary school curricular to fit the reform programme of federal government of Nigeria. Does your response agree with, "to review and realign".? Thank you for that attempt.

NERDC therefore came up with a Mathematics curriculum which described the sequential arrangement of Mathematical topics and other related learning experiences and materials designed to bring about desired learning outcomes that will manifested through the learners' activities under the guidance of the teachers.

This unit will therefore discuss the features of the 9-year Basic education programme, some selected NCE mathematics courses designed for the production of NCE teachers.

2.0 Intended learning Outcomes(ILOs)

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

- discuss the Mathematics Curriculum for the 9-year Basic education programme in Nigeria.
- Identify the main subheadings of the new revised curriculum.
- Mention at least five NCE mathematics courses relevant for the preparation of the NCE graduates for teaching at the primary school level.

3.0 Main Content

3.1 Mathematics Content for the 9-year Basic Education programme

Before the 1960s, Mathematics was taught as Arithmetic. Emphasis was on the four rules of addition, subtraction, multiplication and division. The new curriculum now emphasizes teaching Mathematics as activities – doing, writing, talking, manipulating objects and experimenting with them. Also FME (2013), observed that teaching in the primary level shall be participatory, exploratory, experimental and child- centred. The NERC (2007) referred to the new mathematics revised curriculum as the Basic Education mathematics curriculum. The new revised curriculum places emphasis on affective domain and qualitative reasoning unlike the previous curriculum.

The curriculum is referred to as the teaching curriculum because it has greatly facilitated the teaching task of the teacher. The curriculum now has provision for content (learning experiences, performance objectives or learning outcomes, teacher and learner activities, teaching and learning materials and evaluation guide.

The curriculum has provision for the following, topics, objectives stated in measurable terms, pupils and teachers' activities instructional materials and adequate evaluation guide. The curriculum has six main themes. These are Number and numeration, Basic operations, Measurement, algebraic processes, Geometry and Mensuration and Everyday statistics.

Major Goals of mathematics curriculum for the 9-year Basic Education Programme.

1. Equipping the children with mathematical literacy necessary to function in an information age.
2. help the children cultivate understanding and application of mathematics skills and concepts necessary to thrive in the changing world.
3. Assist the children develop the essential abilities in problem solving, communication, reasoning and connection within their study of mathematics.
4. Help the children understand the major ideas of mathematics bearing in mind that the world has changed and is still changing since the first National Mathematics curriculum was developed in 1977.(Obienyem,2019,p136)

3.2 Senior Secondary School Mathematics curriculum

We can begin this section by reflecting on a part of the statement of Forward made by then honourable minister of education Dr Sam Omiyi Egwu," With great expectations, I gladly recommend these curricula to all For the purpose of producing the best textual materials, the best in Teaching performance and the best learning outcome, and most Importantly, for attaining the goals we have set for ourselves in Education in line with Millennium Development goals.

The Features of the Curriculum:
The revised curriculum has some remarkable features.
Horizontally, the curriculum states the topics followed by the performance objectives (learning outcomes), contents (learning experiences), teacher and learner activities, teaching and learning materials and evaluation guide. Vertically under each of the above headings are the details.

Many good textbooks have been written in line with the approved curriculum. A number of mathematicians, mathematics educationists and state governments have commissioned its teachers through workshops and seminars to write books for the pupils/students. Some of such text materials include MAN Mathematics for all secondary school levels, the concept mathematics, STAN Mathematics etc.

At the Senior Secondary School level, a curriculum has long been written called "Further Mathematics" to replace the Additional Mathematics. To take care of this, we now have the further mathematics project textbooks for SS1 to 3. It should also be noted that some topics have also been added in secondary school mathematics curriculum. Some of these include Introduction to Differential and Integral calculus, Binary Operation, Logic, Modular Arithmetic etc A number of reasons have been given for inclusion of these new topics.

One of such is to provide for necessary and sufficient base for further tertiary mathematics and prevent great disconnect between secondary and tertiary mathematics. It is also important that students in Secondary Schools who have the aptitude for mathematics and mathematics related-careers or programmes such as Engineering, Economics, Geology, Computer/Information technology etc be adequately prepared for the tertiary levels such as University, Polytechnic or Colleges of Education. Topics covered in further Mathematics include:

(i) Differential and Integral Calculus
(ii) Elementary Statistics,
(iii) Probability etc.

3.3 Mathematics in Teacher Grade II

In the Grade II teacher Education Only Arithmetic process was taught. Just as the name implies, Arithmetic comprising Addition, Subtraction, Multiplications and Divisions were taught. Later on Basic Mathematics was incorporated. But in 1978, the National Teachers Institute (N.T.I) was mandated by Decree No. 7 to organize programmes for upgrading practicing teachers at all levels. This task NTI has done creditably well. Since then over 300,000 unqualified teachers have been upgraded by the institute. A look at all the states shows that the number of unqualified teachers in the primary schools has been reduced. They have also embarked on training NCE teachers by the same Distance Learning System. This is to upgrade TC II Teachers to NCE which is now the minimum teaching qualification in the Nation's Primary Schools. This is as stipulated in the 1979 National Policy on Education Section 9 Subsection 61

3.4 The N.C.E Programmes with mathematics courses relevant for the preparation of primary school teachers.

At the NCE level, a number of programmes have been put in place by the National Commission for Colleges of Education (NCCE)for the purpose of preparation and production of NCE graduates especially for the nations primary schools. These programmes are considered adequate enough for the preparation of NCE teachers. Some of these include Primary Education Studies, Early Childhood Education Studies, Adult and Non Formal Education, etc. All other NCE programmes contain course contents and materials relevant for the preparation of the NCE teachers to some reasonable degree. Some of these are in the forms of Basic General Studies.

The table below presents some programme courses and brief discussion in line with their adequacy in the effective preparation of NCE teachers for the nations primary schools.

Note: In the table the comments under the remark are as perceived by the reviewer.

Some Mathematics courses offered in Some NCE Programmes

Course code	**Title**	**Brief content description**	**Remark**
PES 121	Primary math& methods	**Teaching of** basic number and numeration, measurement, simple everyday statistics, simple geometry, with emphasis	**Contents** and suggested methods are reasonably adequate.

		on methods and strategies for teaching primary mathematics,etc	
PES 113	**M**athematics In Primary Education Studies	**Concept**s of binary numbers. elementary set. basic operations, etc suggested strategies for teaching, partial sum, column addition, short algorithm, addition without carring, etc	**Contents and strategies are adequate for preparation of the teachers.**
PED 324	**Mathematics in primary Education.**	**Emphasis is on different methods& strategies for teaching basic concepts in mathematics, use of discussion methods etc were suggested**	**Very adequate for primary school teacher preparation.**
CPE 325	**Methods of teaching math.in Primary Edu.**	**Emphasis is on basic math. Concepts. use of concrete** materials for teaching. learner-centered approaches, need for interactive teaching using discussion method, creation of effective learner friendly Learning environment ,etc	**Contents and methods of teaching will ensure effective preparation of NCE teachers.**
Math 124	**Mathematics Laboratory. Practicals**	**The** course emphasis practical exploration of mathematics concepts.Investigation of rules,formular,construction of simple geometric shapes,use of different math.games,techniques of improvisation of instructional materials, etc	**The** course is offered by NCE math.students.The contents and suggested methods and strategies are very adequate for the prepasssssssration of primary and secondary school teachers.
GSE122	**Basic** General Math.	**The** course content includes algebraic processes, simple word problems, ratios, percentages, simple and compound interests etc	These concepts are also taught in the primary schools.
GSE 212	**Basic**	**Some** of the course	**Most** of the topics

	Gen.Math (iii)	contents are, change of subject, units of measurement, frequency distribution, measures of central tendency, mean median and mode. Measures of dispersion, range, mean deviation and standard deviation etc.	are found in upper primary mathematics content.
Math.212	**Problem-**Solving	**E**mphasis is on such areas as, types of errors committed by students in problem solving, methods of teaching math. in primary and secondary schools, use of questioning skills in teaching, the teaching of some secondary and primary school topics perceived to be difficult by both students and teachers.etc	**Contents**,methods and strategies are very adequate for the preparation and production of NCE primary school teachers.

Self-Assessment Exercises

1. Mention the main themes of the new Basic mathematics curriculum
2. Mention any one feature of the 9 year – Basic Education Programme of Nigeria

.

4.0 Conclusion

The new Basic Education Mathematics curriculum and its major features have been identified. The new curriculum is a teaching curriculum because it simplified the major activities of the teacher were lacking in old curriculum.

5.0 Summary

We have discussed the new 9 Year Basic Education mathematics curriculum. Also some areas of NCE programmes with mathematics contents relevant for the production of primary school teachers were discussed. Development in Mathematics should be a continuous process.

The reason is that Mathematics is a dynamic subject. The growth of Mathematics content and the development of ICT are impacting on the subject in both content and method of teaching and learning.

6.0 References/Further Readings/website

Federal Republic of Nigeria (2013): National Policy on Education; Lagos: Federal Ministry of Education.

Pratibha, S. P. & Megha, S. J. (2013). Roles of Teachers' in Curriculum Development for Teacher Education. A conference paper presented at the Kolhapur, Maharashtra, India (416004).

Macrae, M. F., Kalejaiye, A. O., Chima, Z. I., Channon, J. B., McLeish, A. & Head, H. C. (2005). New General Mathematics for Senior Secondary Schools Book 3.Longman.

7.0 Possible Answers to SAEs

1. The main themes are;
   Number and Numeration, Basic Operations, Measurement, Algebraic Processes, Geometry and Measurement and Everyday Statistics

2.(i) Emphasises mathematics as activities- doing, writing, talking, manipulating objects and experimentation.
   (ii) Stressed the importance of affective domain and qualitative reasoning.
   (iii) Arranged as a teaching curriculum.
   (iv) divided into themes
   (v) Provided for content, learning outcomes, teacher and learner activities, teaching and learning materials and evaluation guide.

MODULE 2

INTRODUCTION

In module two we shall be discussing the following concepts, scheme of work, unit plan, the features of lesson plan and lesson notes. The module will also discuss a number of Psychological theories that influence the teaching and learning of mathematics. We will also discuss the concept of individual differences in learners in mathematics classrooms. Lastly, the module will discuss strategies for developing positive attitude towards the learning of mathematics.

Unit 1 Scheme of Work and Weekly or Unit Plan
Unit 2 Features of a lesson Plan or Note of Lesson
Unit 3 Psychological Theories and Mathematics Education: The Contribution of Piaget, Burner and Gagne to the Teaching and Learning of Mathematics
Unit 4 Individual Differences in the Mathematics Classroom: Causes and Strategies for Care
Unit 5 Strategies for Developing Positive Attitude Towards Mathematics by Students

UNIT 1 SCHEME OF WORK AND WEEKLY OR UNIT PLAN

CONTENTS

1.0 Introduction

We have discussed the various mathematics curricular provisions for pre-primary and primary in unit 5. We need to look at the break down of the curriculum to determine how much of it is to be taught in each of the three terms of the six years of secondary school. The topics to be taught

each term usually in weeks is the "Scheme of work". The weekly breakdown of the scheme of work is called the "Unit lesson plan" or "Weekly lesson Plan"

2.0 Intended learning Outcomes(ILOs)

By the end of this unit you be able to:

- break the mathematics curriculum into weekly scheme of work
- break down the weekly scheme into unit lesson plans
- write good lesson notes on any mathematics topics using the curriculum provided.
- use the present Basic education curriculum for effective classroom teaching

3.0 Main Content

3.1 Scheme of Work

If you recollect all that transpired when you first arrived the school where you carried out the Teaching practice exercise. You were probably assigned to a class? Yes. The class teacher received you and after, assigned some responsibilities to you. Beautiful. He or she may have given you the scheme of work for the class to guide you. The scheme is the expected mathematics topics to be covered for the term. It runs for twelve weeks in most cases.

The teacher is expected on receiving the curriculum for each year to break it down into each term's weekly scheme of work. The scheme of work is drawn up so as to take care of other school programs such as mid-term breaks and school examination period. These should be considered when sequencing the topics according to weeks.

Ofsted. (2014) observed that scheme of work is an outline of an entire course. The scheme can be influenced by a number of factors during the implementation period. Hence it can be adjusted due to some unpredictable factors.

(i) It shows the sequence of the topics of the scheme of work to follow.
(ii) Helps the teacher to assess what progress has been made in respect of the coverage of the work intended for a given term
(iii) Helps the supervisors to assess the extent and quality of work done

In writing the Scheme of Work, the sequencing of the topics should go from simple to complex, and known to unknown. Topics taught at the beginning of the term should not be as difficult as those to be taught at the end.

The format of the scheme of work for a term in secondary school Mathematics can be as given below: SS 1(the topics are hypothetical)

(i) 1st week Resumption tests/revision of terms work and general compound work
(ii) 2nd week: Writing numbers in the standard forms with simple basic operations
(iii) 3rd week: Indices and basic operations involving expressions in index forms
(iv) 4th week: Evaluating expressions using the logarithm table or calculator
(v) 5th week: Laws of logarithm and simplification of expressions involving logarithms
(vi) 6th week Simplification and evaluation of algebraic expressions
(vii) 7th week: Mid-term break /tests
(viii) 8^{th} week Graphs of simple expressions and values where the fraction is undefined
(ix) 9^{th} week: Factorization of quadratic expressions
(x) 10^{th}week: Solution to quadratic equations using factorization method
(xi) 11th week: Graphical solution to quadratic equations.:
(xii) 12th week: General revision and examination.
(xiii) 13th week: examination and closure.

The topics should be related, sequential and reinforcing each other.

3.2 The Role of the Teacher

The success or otherwise of the curriculum or the scheme of work at the classroom level depends largely on the teacher. Even in the present new Basic education curriculum that has been carefully arranged into content area, learning outcomes, teachers and pupils' activities, materials and evaluation guide. The effective implementation with reasonable success still demands the commitment of dedicated, creative, and innovative teacher who is passionately in love with teaching as profession The teacher must effectively plan his lessons every day bearing in mind the learner, their individual and general characteristics, psychology of learning and the learning environment.

According to Gagne (1970), informing students on what to do serves as direction that can facilitate students' achievement. Planning helps the teacher break the content of his teaching to manageable sizes so that

they are just appropriate. That is, not too much and not too little. It also assists him to identify the sequence of thought, activities and content development of the topic. He will have readymade questions to direct the pupils to the expected learning outcomes.

3.3 Weekly Plan or Unit Plan

This is part of the scheme of work intended to be covered in a week. The objective is broad. It specifies what is to be done, how and with what. It does not necessarily involve specific teachers and learner's activities. It is not detailed. It is a guide.

After breaking the curriculum into scheme of work, the next thing is for the teacher to further identify learning units. A unit is a broad unit of basic concepts capable of being broken into more than one daily lesson content. For example, from a learning unit in the primary school curriculum is "Addition of Fractions" This can be in three lesson periods involving such sub topics as, fractions with common denominator, addition of fractions with different denominators and addition of decimal fractions. This may not be effectively covered in one lesson. It is good if one learning unit fits into the number of lessons for one week. In this case, the learning unit can then be said to be the Weekly Plan. With proper planning, the mathematics teacher will be able to find out if the intended unit lesson can be adequately and effectively covered in the lesson periods provided for mathematics on the school time table

3.4 Format of Unit Plan

The broad pieces of information of a Unit Plan or Weekly Plan are set out below:

(i) The topic to be covered for the week.
(ii) The class for which the topic is being planned
(iii) Broad learning outcome. They are stated in measurable and observable broad learning outcomes in the curriculum
(iv) Entering behaviour: It is the pre-requisite behaviour necessary or essential for the new lesson topic. They are also measurable
(v) The plan involves a breakdown of the main concepts to be covered into the number of lesson periods for the week. They are not detailed as the teacher will develop these in the lesson note.
(vi) Each broad learning outcome in the unit plan can be treated in each lesson period per day.
(vii) Some suggested teaching aids may be identified at the planning stage. This makes the planning of the daily lesson easy. Evaluation and teaching techniques are not necessary at this planning level, but these are necessary at the daily lesson plan or note of lesson plan level.

Self-Assessment Exercise(s)

1. State any five points in the format for a unit lesson plan.
2. The Scheme of work is developed from the lesson plan. True or False

4.0 Conclusion

The scheme of work is very important in the effective implementation of any curriculum. Well-developed scheme of work helps the teacher in the weekly unit lesson that guides the teacher in his daily classroom instructional activities.

5.0 Summary

In this unit you studied the following; meaning and importance of the scheme of work, meaning and format of the unit lesson plan.

6.0 References/Further Readings/website

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Musingafi, M. C., Mhute, I., & Kaseke, K. E. (2015). Planning to Tech: Interrogating the link among the Curricula, the Syllabi, Scheme and Lesson Plans in the Teaching Process. Journal of Education and Practice.

Ofsted (2014). Teaching, Learning and Assessment in further education and skills: what works and why. Retrieved on 28th May, 2020.

7.0 Possible answers to SAEs

1. These can include the following
   (i) topic for the week
   (ii) learning outcomes stated in broad measurable terms.
   (iii) entry behaviour relevant to the topic stated in observable performance behaviour.
   (iv) teaching aids can be suggested.
   (iv) class to be taught.

2. False.The scheme of work is developed from the curriculum and the lesson plan developed from the scheme of work.

UNIT 2 FEATURES OF A LESSON PLAN OR NOTE OF LESSON

CONTENTS

1.0 Introduction

The writing of a lesson note is the duty of every teacher or prospective teacher in our primary and secondary schools. It is essential for every mathematics teacher to be very good in this "art" for effective teaching and learning of Mathematics. Writing good lesson note involves creativity, being innovative and careful planning. It is at this stage that the teacher gives meaning to the content which determines materials to be used, skills and strategies to be emphasized and the learning environment.

2.0 Intended Learning Outcomes

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

- Discuss any 8 essential features of a good lesson note.
- Write a lesson note for a given lesson topic from JSS Mathematics content.

3.0 Main Content

3.1 Daily Lesson Format

A note of lesson differs from a daily lesson plan in terms of details. A daily lesson plan is a write up that spells out clearly the class being taught for a specific time or period usually 40 minutes, the learning outcomes (specific objectives) of the lesson, the entry behaviour, the activities involved for both the teacher and pupils, the teaching aids, the

teaching strategies, the development of the content sequentially, evaluation techniques and the closure of the lesson.

The reasons for writing a lesson note by the mathematics teacher are as follows:

(i) It directs his attention to realize the specific learning outcomes.
(ii) Helps to identify and select or improvise the needed teaching materials suitable for the lesson topics.
(iii) Assists him to identify and organize the entry performance experiences which will help to introduce the new concept or topic.
(iv) It helps him define the sequence of thought and actions needed to develop the content and allow time to achieve the learning outcomes.
(v) Facilitate the anticipation of the types of questions that can be asked by both the learners and the teacher himself during class activities.
(vi) Makes room for student activities and encourage learner participation and interactive discussion.
(vii) Helps to ensure that teaching and learning is learner-centred as much as possible.
(viii) Helps the teacher to end the lesson with a summary and assignments.

3.2 What the Teacher should note

A number of factors influence effective preparation of lesson notes by teachers. To achieve this the teacher should have good understanding of these three factors:

(i) the content
(ii) the child and
(iii) the curriculum

A well written lesson note is evidence of the teachers' content and pedagogical competency. It also shows that the teacher has good knowledge of psychology of how children learn. Let us briefly discuss the following:

Each of them as stated must be borne in mind while teaching in both Primary and Secondary Schools. Barhr and de Garcia (2010, p372), observed that classroom teachers are experiencing a difficult population of children than in decades past as it is not uncommon to have children with language, poverty, and learning issues all within the confines of the general education class.

(i) **Content:** The teacher must be a master of the subject content of what he wants to teach. He must know the concept he is teaching and how it relates to other concepts. He should be able to arrange the content sequentially, step by step so as to succeed in achieving the learning outcomes he has stated. He should move from simple to complex, known to unknown. The concepts should be related to the immediate environment. The entry behaviour, that is, what the child has learnt and can do will be used to facilitate the learning of new concepts.

(ii) **The Child:** The Teacher must understand the child he is teaching. He should know his maturity level so as to know which teaching aids he will like and appreciate. The child's age will show his level of intellectual development. In the primary **schools,** majority of them are in the concrete operational stage and so must be taught using concrete objects such as stones, counters, matches, stick etc.

After this, pictures, drawings on card boards etc. and then symbols before abstractions in the Secondary School level.

De Garcia and Bahr(2010) while discussing the contribution of Kamii(1984),observed that children can develop intellectual potentials only when all ideas including wrong ones are respected. Most importantly the teachers must value, appreciate and respect the learner and their views.

Many teachers neglect consulting the curriculum. The new Mathematics curriculum should be consulted at all times. It is very comprehensive and good. It contains a wealth of information for the teaching of any concept. The column for the learning outcomes(objectives) indicates the necessary learning outcomes that the learners will be able to demonstrate by the end of the lesson. The teacher can revise the learning outcomes that will lead to the realization of the general goals or aims during each lesson.

The content column gives other topics relating to the concept being treated and allows relational awareness on the part of the teacher. The column for the materials/activities suggests the method to be used, activities to be carried out in the class, the aids to be used and experiments to carry out. The column for remarks specifies the scope of what is to be covered for any concept. The area for emphasis and area not to be treated and special teaching strategies or aids to be used.

The curricular provision is just the minimum guide. A teacher can make adjustments when it is most convenient and does not necessarily create tension for the learners in a given area or time and the type of learning environment they find themselves.

3.3 An Example of a Lesson Plan or Note

Topic: A lesson on subtraction involving smaller fraction from a bigger fraction with differēnt ḏenominators.

Class: Primary 6
Intended Learning Outcomes
By the end of this lesson, the pupils will be able to.
i Demonstrate understanding of the mathematical problem given
ii find the l.c.m of the denominators of the given fractions.
iii express the fractions in the same denominator before subtraction
iv correctly subtract a smaller fraction from a bigger fraction.

Entering Behaviours
The pupils will be able to do the following based on their previous learning outcomes or experiences.
(i) find the l,c,m of the denominators of any given fraction
(ii) express the fractions in a common denominator using the l. c.m.
(iii) write three more equivalent fractions based on a given fraction.
(iv) add correctly two fractions with common denominators.
(v) distinguish smaller fractions from bigger fractions comparing the numerators of the given fractions with common denominators.
(vi) add correctly two fractions with different denominators
(vii) change improper fractions to mixed numbers.
(viii) write fractions in their lowest terms.

Teaching Aids
(i) Fraction charts
(ii) Equivalent fraction boards
(iii) Division and multiplication tables

Content Development and Learning Activities
Step I: The teacher assesses the level of readiness of the learners in terms of their entry behaviour. Some mathematical tasks related to the topic and experiences are presented to the learners to determine level of readiness to learn the new mathematics topic.

Write on the board any mathematical task that will give them opportunity to demonstrate the required behaviour: example. Simplify the tasks below

2/7 +4/7.

(1) $\frac{2}{3}-\frac{1}{4}$ (2) $\frac{3}{5}-\frac{2}{3}$ (3) $\frac{3}{4}-\frac{1}{5}$

Give enough wait time and go round and check their works.

Step II: Simplification of fractions with different denominators
If any two fractions have different denominators, what can you do to add them together?

Pause a little for them to think. The same problem can be reframed as they are still working.

Remind them of the need to express the fractions in a common denominator:

Step III: The teacher can now present a chart showing the first 20 multiples of numbers 1 to 10 each. Ask the pupils to identify the first three common multiples of any set of three numbers.example.2,3,4.

Teacher: From your response, which of the common multiples is the smallest?

Pupils: The pupils study the chart showing the multiples. They try to write down the common multiples. They also write down the lowest of the multiples.

He goes round to supervise and help those who are experiencing difficulty.

Teacher: Use the l..c.m to simplify the given task in your exercise books.

Teacher: He moves round the class to supervise their works and gives attention to those experiencing difficulty.

Pupils: The pupils attend to the task and ask questions where they are having difficulty

Teacher: He checks the pupils works, scores them as he encourages them with interesting words

Teacher: He presents another similar task; simplify the following. 7/8 – 5/9
Teacher asks students to follow the same method as above to arrive at the answer.

Assignment
Subtract the following fractions:
Hint (i). find the l.c.m of the denominators. (ii)express them in the same denominator (iii)now do the subtraction.

$(i)\ \frac{1}{3}-\frac{1}{4}$

$(ii)\frac{1}{2}-\frac{1}{3}$

$(iii)\frac{3}{5}-\frac{1}{6}$

As the pupils are working, the teacher goes round to supervise and mark each individual's work.

3.4 Teaching Practice Lesson Plan Format.

PART A

1. Date:…… Matric. No:……. Course Combination:…….
2. Name of Student-Teacher:……
   ……
3. Practicing School:……
   ……
4. Class:…….. No. on Roll:…… Average Age:……..
5. Subject:……
   ……...
6. Topic:……
   ……
7. Sub-Topic:……
   ……
8. Time:……..Duration:……
   ……..
9. Resources/Instructional Materials: .....

PART B

1. Intended Learning Outcomes

By the end of the lesson the pupils should be able to:

Cognitive domain……

psychomotor domain……

Affective domain……

2. Instructional Materials

……

3. References(s)

.....

4. Leaners' Entry Behaviour

……

5. Set Induction (Introduction)

.....

6. Lesson Presentation

Steps I

……

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Step II

……

……

Step III

……

……

Step IV

……

……

Step V

……

……

7. Summary and Closure

……

8. Evaluation

……

9. Home Assignment

……

Cooperative Teachers Comment on Lesson Presentation:

……

10. Supervisor's Remarks:

……

……

Supervisor's Name…… **Supervisor's Signature & Date**

Self-Assessment Exercise(s)

What is the difference between entry behaviour and learning outcomes?

4.0 Conclusions

The necessity and importance of the note of lesson has been given and stressed. It is a useful guide to both the teacher and the learners towards the achievement of the learning outcomes of the lesson. It helps in getting each one in the teaching learning process to be adequately and actively involved.

5.0 Summary

In this unit, we have learnt the characteristics and meaning of a Lesson Plan or Note of Lesson. The lesson note is very important to the teacher. The features and format of it have been discussed.

A well prepared lesson note is a reasonable evidence of a planned lesson. It is an evidence of readiness to work. An essential tool in the hands of a committed and dedicated teacher.

6.0 References/Further Readings/website

Adeoye, E. A. (2017). Curriculum Development: Theory & Practice (A study guide for PGD Ed) Students.

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7.0 Possible answers to SAEs

Entry behaviour refer to experiences, skills and knowledge that Can facilitate learning of new lesson topics or tasks while learning outcomes are performance measurable behaviour to be demonstrated by the learner to show level of change in behaviour.

UNIT 3 PSYCHOLOGICAL THEORIES AND MATHEMATICS EDUCATION: THE CONTRIBUTION OF PIAGET, BURNER AND GAGNE TO THE TEACHING AND LEARNING OF MATHEMATICS

CONTENTS

1.0 Introduction

In Educational Psychology, we are concerned with the study of human behaviour. In teaching mathematics, teachers must learn to cope with the problem of children learning and the conditions that enhance maximum learning. You therefore learn how educational psychology can be applied to make good teaching and learning possible in our primary and secondary schools.

In this direction we shall consider the two basic psychologies of the 20^{th} century. (behaviourism and constructivism). This agrees with the instructional models contained in Bahr and de Garcia(2010,p159)

Behaviourism: The major theorists are B.F Skinner, R.F Mager, R.M, Gagne and M.D Merril.

Philosophy: These theorists hold that meaning exists in the world separate from personal experience. The instructional goals are framed in specific behavioural and observable terms. It focuses on the immediate recognizable changes in behaviour. The goal of understanding is set as exists in the objective reality.

Learning outcome: The theory describes the following:

1. conditions under which the behaviour is to take place.
2. the task(s) to be performed
3. the series of tasks to be performed expressed in active verbs to indicate levels of acceptable performance or evaluation criteria.
4. Instructor role: it describes the structured activities to be performed and assessment to be done. It describes the form of interaction between the teacher and the students.

Students role:
It states what the learner will do, absorbs the materials by listening so as to perform to show that learning has taken place.

Activities: The students read, review and analyse the materials and texts provided. They submit individual works to be assessed by the teacher. There is little or no room for discussion.

Assessment: students attend to tests, quiz, projects etc to show the level of mastery of materials, skills etc Few emphases on summative assessment of products.

Constructivism: The major theorists are J. Dewey, J. Piaget and Vygotsky.

Philosophy: Learners impose meaning on the world and hence construct their own understanding based on their personal experiences. Instructional goals are stated in experiential terms. It states types of learner problems addressed, type of control the learner has over their environment. The type of activities the learners are engaged with; the ways the activities can be shaped or controlled by the teachers. It is also concerned with the ways the learners reflect on the results of their activities together.

Intended Learning Outcome: It defines or states how learners will be able to think or solve problem differently by the end. It states the activities or interactions and conditions under which the learners will perform the expected behaviour. It states that:

1. Learners need opportunity to define for themselves the goals and learning outcomes of the course work.
2. Attention is on process and interaction rather than on specific result to be accomplished.
3. Outcome is concerned with new ways of doing something not on particular tasks to be completed. It believes that learners are motivated by common interest in some problems or issues.

Instructors Role: Constructs the learning environment. Assists learners as they explore the environment. Designs experiences that encourage and facilitate assimilation and accommodation. Believes that learning is due to activities that students see to be meaningful and are context based. Teacher, colleagues, learners are regarded as facilitators.

Students Role: They explore the environment with other learners and construct meaning from their personal experiences. Application of knowledge is based on personal meaning as viewed in the situation at hand.

Activities: Discussion and collaboration by learners. They apply knowledge and principles to solve problems and case studies and projects. Assignments are practical and problem based. Etc

ASSESSMENT: It is based on active, authentic experience and projects. It stresses interactions, reflection and collaboration and grouping of learners etc

2.0 Intended Learning Outcomes

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

- State the four stages of Piaget's intellectual development
- Discuss briefly the implications of each stage in the teaching and learning of mathematics in primary schools in Nigeria.
- Discuss the Bruner's stages of learning.
- Discuss briefly the implications of each stage in teaching and learning of mathematics concepts in schools.
- Explain the hierarchies of learning according to Gagne
- Briefly explain the implications of the hierarchy in the teaching and learning of mathematics in schools.

Give brief comparative analysis of the three theories of learning in terms of how learning occurs

3.0 Main Content

3.1 Piaget's Theory of intellectual Development

Jean Piaget was a French-Swiss Psychologist who was originally a trained biologist. His research along with those of other psychologists spanned more than fifty years. They were based in Geneva. Piaget researched into intellectual and cognitive development of children. He was not the only contributor to this field. Others include Bruner and

Gagne and many more. Piaget and others studied and analysed the growth and development of children thinking.

According to Piaget, there are four stages of intellectual thinking and development. The stages are sequential. His school was noted for the study of psychological or intellectual problems underlying the learning of mathematics. His work has the greatest value for teachers of mathematics especially at the primary school level. Piaget saw cognitive or intellectual development in terms of well-defined sequential stages in which a child's ability to succeed in terms of his biological readiness (heredity) for the stage and partly his experiences with activities and problems in earlier stages.

According to Piaget, the four stages of Intellectual development are:

The Sensory-motor stage: Age (0-2) years
At this stage, the child relates to his environment through its senses only. By the end of the second year of life, children have a rudimentary understanding of space and are aware that objects exist apart from their experience of it.

Pre-Operational stage: Age (2-7 years.)
This generally covers the cognitive development of children during pre-school years, normally referred to as pre-nursery and nursery (kindergarten) years. At this stage, children are able to deal with reality in symbolic ways.

Their thinking at this stage is based on centration and conservation. Concentration is the act of focussing all attention on one characteristic com4pared to others. This is why they do not have the ability of conservation of certain activities. (Osuji,2015)

At this stage, most of them are not able to understand Reversibility: - the ability to think back to the causes of events. Because of these inabilities, they cannot conserve – retain important features of objects and events. They cannot therefore engage in logical thinking in any coherent sense. The child is said not to possess the concept of conservation of number, volume, quantity or space.

Piaget Demonstrated the Lack of Conservation in Two Experiments.
The implication of children not understanding conservation at the pre-operational stage is for the mathematics teacher not to waste his time presenting mathematics tasks that the pupils are not ready for. That is through seeing, feeling as well as hearing. Abstract mathematical ideas should therefore not be introduced at this stage. Teaching and learning at

this stage should make use of a lot of manipulatives. Children at this stage should be provided with enough concrete objects or manipulatives and symbols so as to be able to appreciate reality.

Mathematically-oriented recreational activities such as mathematics games, plays, use of counters, blocks, stones and marbles etc are important materials for learning mathematics at this stage. Osuji (2015 p.187) observed that the child at this stage is not able to perform operations, thinking is still egocentric. The child also finds it difficult to accept other people's viewpoints.

The Concrete Operational Stage (7-12 years)

This stage is very important especially to every primary school teachers and parents since most of the school children are in this stage of development. This stage is the beginning of what is called the logico-mathematical aspect of experience. At this stage, pupils understand the conservation of objects, counting a set of objects from front to back, back to front or from the middle give the same answer. This is also part of logico-mathematical. A number of processes characterize this stage. They include:

Seriation This is the ability of the child to sort (group) objects in order of size, shape, or colour (Sattler,2010) Another feature of this stage is Transitivity. Here the learner is able to recognize logical relationship among objects, items and even numbers. The learner is able to use the transitive property of composition. If A is greater than B, and B is greater than C, then A is greater than C.

Ability to classify objects, items according to size, appearance or other characteristics. The child is also able to classify a set of objects under another larger group. One other feature of this stage is overcoming centration and he now has the ability of Decenteration. He is capable of using multiple views of a problem situation in order to provide solution or solve the problem. Ability to conserve volume/capacity of any shape irrespective of their height and sizes. The child can now understand the concept of reversibility of numbers or objects. Example If a certain quantity of clay is used to make a cone and later recast into a solid cylinder. The child is able to recognize that the quantity of clay did not change with respect to shape. The child understands that quantity length or number of objects or items do not change due to shape, location, arrangement or displacement.

The concrete operational stage is also marked with the elimination of egocentric thought. The child begins to see things from another person's perspective even if they are wrong.

The implication of this is that mathematics concepts should be correctly demonstrated with objects. Very good attractive manipulatives of different colours, sizes should be provided in good numbers in very rich learning environment for the learners to use freely for learning.

Piagets theory is still relevant in the teaching and learning of mathematics. Obienyem, Obienyem and Okolo (2019) in a study titled, Assessment of Early Mathematics Ability of lower Basic Education pupils. Practical use of the Piagetian tests, revealed that pupils within the ages of (5 -6) years tend to be confused if the relative position of objects is changed in terms of length. Greater percentage of the pupils also could not recognize that changes in the shapes of identical objects equal in size and weight does not affect their weights.

This logico-mathematical also underlines the physical act of grouping and classifying in the algebra of sets. Conservation of invariant is usually illustrated by the pouring of equal amount of liquid into two equal jars of cups. One of the two cups is then emptied into a thinner cup. When asked which cup contains more liquid, the child says the new cup, because the height of the liquid in the thinner cup is higher even though he saw that the liquid poured is the same as in the first case. At this stage, there is one limitation children have, difficulty from hypothetical assumptions

Formal Operational Stage (12+ years)
This is Piaget's last stage of intellectual development. At this stage, children are capable of abstract reasoning, if they did not experience any developmental problems at the concrete operational stage. The child now reasons or hypothesizes with ideas or symbols rather than needing objects in the physical world as a basis of his thought. He can think scientifically and logically too.

He can draw conclusions from available information. He is capable of applying the process to any hypothetical situations. The young adult is capable of verbal problem solving ability. He solves problems using trial and error method. At this stage, they can reason deductively.
He is no more tied by his thoughts to existing reality. He can construct new operations. The ages separating the stages are approximate and they differ slightly according to cultures.

3.2 Contributions of Jerome Bruner

He was an educational psychologist whose work has also influenced the teaching and learning of mathematics. Kang and Lee (2017) observed that Brunner's educational theory is largely divided into former and later

theories. Former centred on the structure of knowledge and later on narrative.

The transition was based on the issue of the period in education. He was of the view that if there is structure of knowledge, it can be taught.in the right way to the children in any developmental stage in any subject. This author observed that discovery learning and spiral education curriculum facilitate structure of the knowledge.

In a later theory(1980s), Brunner expressed that school education should take into account the political and cultural contexts. He argued that education is part of culture and that schools should be able to organize educational experiences and knowledge via culture. To Brunner, narrative is a way of thinking, a structure of organizing knowledge and a tool for the process of education. He finally referred to it as constructivism.

Brunner maintained that learning in general depended on four factors:
(i) the structure of the concept that is to be leant
(ii) the nature of learner's intuition
(iii) the desire or willingness of the learner to learn
(iv) the readiness (as well as biological) for learning

According to Bruner, a theory of instruction is prescriptive in the sense that it outlines rules concerning the most effective ways of attaining knowledge or skills. Also, a theory of instruction sets up criteria and states conditions for them.

He argued that theory of instruction is needed since psychology already contains theories of learning and developments descriptive rather than prescriptive. He opines that the theory should provide a means of leading the child to the path of reversibility. Instruction is concerned mostly with how a teacher wants to teach. How to present the learning materials so as to achieve learning. According to Bruner, the stages or processes by which learning occurs in a child are as follows:

(i) **Enactive Stage:** The child thinks only in terms of action. He enjoys touching and manipulating objects as teaching proceeds. Specifically, no learning occurs at this stage. Topics can however be introduced to the child using concrete materials.

(ii) Iconic Stage
The child manipulates images. He builds up mental images of things already expressed. Learning at this stage is usually in terms of seeing and picturing in the mind any objects which transform learning using pictorial presentations.

(iii) The Symbolic Stage

Here apart from action and symbols, the child uses language. This he calls the highest stage in learning. The individual engages in reflective thinking to consider proposition and concrete examples to arrange concepts in a hierarchical manner. By this, acquired experiences are translated into symbols form.

Bruner opined that the progressive development of the three stages and further elaboration vary from one individual to another and depend on the inter play between psychological maturation, experience and socio-cultural factors.

3.2.1 Implications of Bruner's work to the Teaching and Learning of Mathematics

He observed that teachers should stimulate children's readiness to learn. Like Piaget, Bruner believes that mathematics can be learnt by discovery approach by starting early in life using concrete materials relevant to concepts which are to be learnt at a higher stage.

This implies that learning mathematics should start from known to unknown. It should not be learnt in abstract. It should be learnt first with concrete materials, then pictorial, symbols and then abstract.

The home and school environment are very important in mathematics education and they help the mathematics teacher to do effective teaching if properly prepared and utilized. A child exposed to a rich environment will do well in mathematics.

Teachers of mathematics must make their lessons child-centred. The use of teaching – learning materials should be emphasized. As much as possible rote learning should be discouraged. Teaching and learning should be practical, interactive and loaded with reinforcing and interesting activities.

3.3 Works of Robert. M Gagne (August 21,1916 –April 28,2002)

He was an American Educational Psychologist best known for his conditions of learning. As a behavioural psychologist, his model is a prescription for teachers and learning is quickly described. He believed that children have learned when they performed acts which they could not perform before; the acts can be analysed to sub-acts. His theory is built on learning hierarchies. With other people they simplified and explained what is called good instruction. He gave the hierarchies of his learning theory as stated below:

GAGNES HIERARCHY OF LEARNING

Problem solving	**Highest level, ability to invent something, A rule, algorithm, procedure**	**Application of rules in problem solving.**
Rule learning	**Very high level cognitive process. learning relationship between concepts and apply the relationship in different situations,**	**Ability to understand when to apply such formula as πr^2 or $2\pi r$ etc**
Concept learning	**Ability to consistently respond to different stimuli that form a common class or group.**	**Generalization, classification on the basis of certain features.**
Discrimination learning	**Ability to make appropriate different responses to a series of stimuli that differ.**	**Ability to respond to different situations or tasks differently.**
Verbal learning	**Good in language learning. formation of links between items.**	**Teaching. correct pronunciations of letters, words etc**
Chain learning	**More advanced learning. ability to connect two or more past learned S-R bond into a sequence.**	**Playing piano, riding bicycle**
Stimulus, Response learning	**Based on the use of reward and punishment presented after response.**	**Operant conditioning**
Signal learning	**Simplest form of learning**	**Training animals etc**

Some authors summarized the hierarchies into four to include:

i. Stimulus Response (S-R)
ii. Multiple Discrimination Learning
iii. Concept Learning
iv. Principle Learning (process skills). These include observing, using space/time relationship, using numbers, measuring, classifying, communicating and predicting, inferring. These skills are especially desirable for primary school pupils.

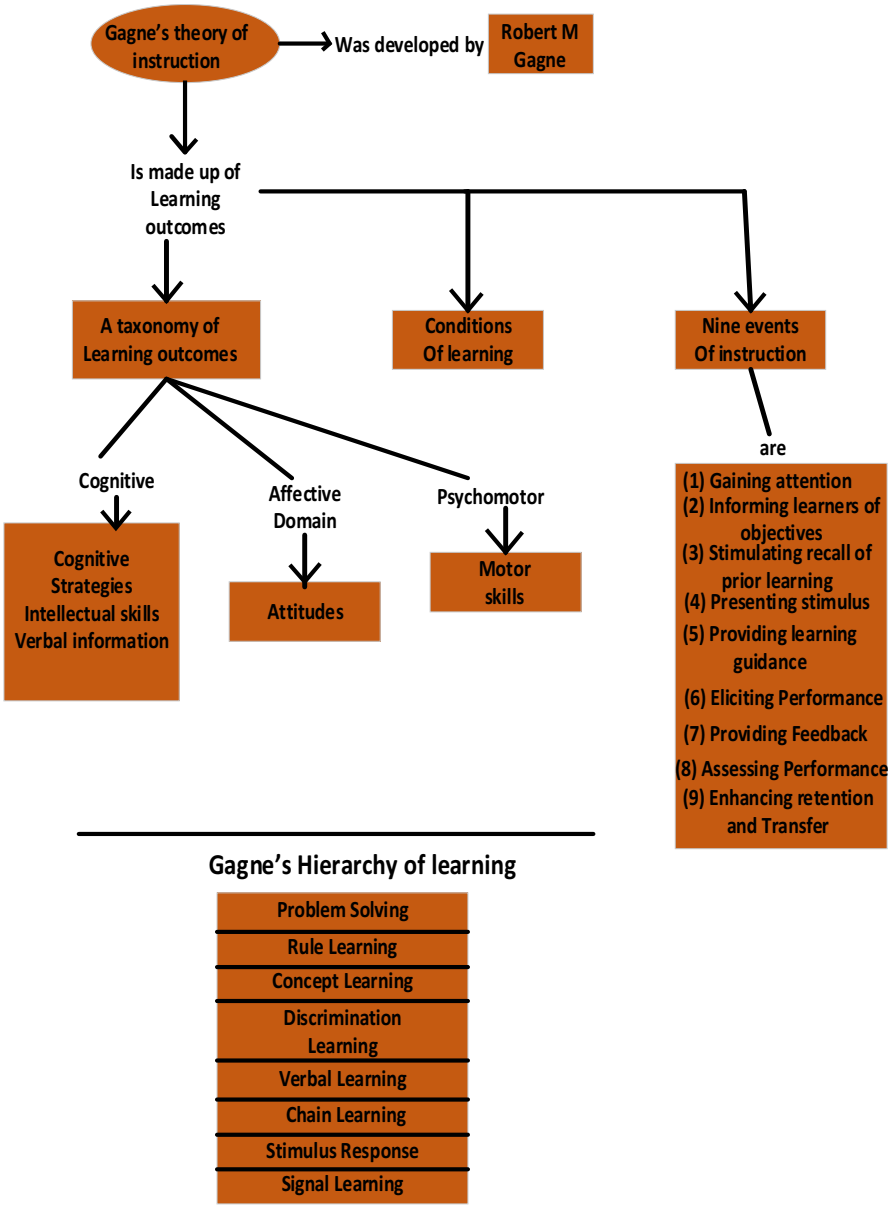
To him, a concept is defined as "a unique feature common to a number of objects, processes, phenomena or events which are grouped according to these unique properties.

Five additional process skills are proposed for the intermediate grades at JSS such as: -

i Formulating hypothesis
ii Controlling variable
iii Interpreting Data
iv Defining operations and
v Experimenting

All five processes are indispensable in Mathematics and the Sciences.

Robert M Gagne's Theory of Instruction



Gagne's Hierarchy of learning

3.3.1 Implication of Gagne's work to the Teaching and Learning of Mathematics

The theory of learning by Gagne has a number of implications to the teacher of mathematics, learning the teaching of mathematics and teaching mathematics.

Gagne emphasized the importance of prerequisite knowledge or entry behaviour in the learning of mathematics. For the teacher to achieve successes in the stated learning outcomes, the level of the learner readiness must be established.

An individual cannot master complex concepts without first mastering the fundamental concepts. He introduced the "principle of programme learning and the idea of learning set" to mathematics instruction. He emphasized "guided discovery" which is useful in the teaching of mathematics and science. He also worked on:

(i) Planning of Courses, Curricula or Lessons

a) needs and interests of the child
b) the child's readiness

(ii) Conduct of Instruction

For effective conduct of classroom instruction, the author observed that the teacher should do the following:

1. Gain the attention of the learners by presenting stimulus such as asking questions.
2. Inform students of the learning outcomes before instruction.
3. Stimulate recall of past learning using any strategy e.g questioning.
4. Present the content using a number of skills and strategies
5. Provide learning guidance. This can be in the form of advice on how to learn or get information
6. Elicit performance(practice). this can be done by activating the learners using questions, asking for clarification etc
7. Provide feedback. Students need to be informed about their progress and then be encouraged.
8. Assess performance. The teacher can do this in any of the following ways such as pre-test, post testing, use of questions, etc
9. Enhance retention and transfer to the job. The teacher can do this through questions, making concept maps

(iii) Assessment of instruction

Adequate assessment of the child should be carried out based on the stated learning outcomes of the lesson. The pupils should be given a feedback so as to motivate them for progress and readiness to learn new things and new concepts.

Self-Assessment Exercise(s)

1. Mention any two of the psychologists whose theories influenced the study of Mathematics.
2. Mention the stages in the Piaget's theory of learning.

4.0 Conclusion

We have studied the psychological theories of Piaget, Bruner and Gagne with their implications for the teaching and learning of mathematics at all levels of our education. There other psychologists that made contributions to the psychological theories but these three are the ones considered most relevant to the course.

5.0 Summary

In this unit, we have studied Piaget's theory of intellectual development. He postulated four stages beginning from childhood to adulthood. At the early stage, the pupils interact with the environment through their senses and at the pre-operational stage which covers the pre-nursery and nursery (2-7 years). Then the concrete stage (7-12 years) and lastly the formal operation state (12+ year) when adult reasoning – abstract and logical, scientific thinking start. The child can go from possibility to reality. The implications for teaching and learning of mathematics were explained.

The theories of Bruner and Gagne were also treated with the implications of their theories for the teaching and learning of Mathematics.

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7.0 Possible answers SAEs

(1) Psychologists whose theories influenced the teaching and learning of mathematics. Piaget, Jerome Bruner and Robert, M. Gagne

(2) Stages in the theory of learning by Piaget are

- Sensory-motor stage(0-2years)
- Pre-operational stage (2-7years)
- Concrete-operational stage (7-12 years)
- Formal operational stage (12+years)

UNIT 4 INDIVIDUAL DIFFERENCES IN THE MATHEMATICS CLASSROOM: CAUSES AND STRATEGIES FOR CARE

CONTENTS

1.0 Introduction

The typical Nigerian classroom is usually a collection of individuals with diverse characteristics. No two people are exactly alike. Every individual is unique. Even identical twins differ in many ways. People differ in intelligence or academic ability, interest, sex, attitudes, attention span, maturation motivation etc. These observed differences have a number of implications especially to the teaching and learning of mathematics at the primary and junior secondary school levels. The teacher has to plan adequately and comprehensively too to ensure a rich learning environment with varied materials that will facilitate learner active participation.

2.0 Intended Learning Outcomes(ILOs)

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

- Explain the concept of individual differences among learners
- Mention any five factors that cause or sustain individual differences among learners in a Mathematics classroom
- Identify useful strategies for accommodating individual differences in any mathematics class
- Teach mathematics effectively guided by these observed differences

- Identify traits that cannot be measured and
- Suggest specific ways of providing for individuals with such learning difficulties as poor attention span, lack of interest in any mathematics activity, fear of mathematics.

3.0 Main Content

3.1 Ability Relevant to Mathematics

The following areas of differences are important to Mathematics, the mathematics teacher and to the teaching and learning of mathematics. They include:

(i) Mental Ability: - This includes ability to think or reason reflectively or ability to solve problems. The general ability possessed by the child. Mental Ability test scores show a child's repertoire of knowledge.

(ii) Mathematical Ability: - Ability to compute, ability to do logical reasoning.

(iii) Knowledge of Mathematical concepts, structures and processes.

These three traits are measurable. The mental ability is measured by Intelligence Quotient (IQ)

MA – Mental Age Psychologist use M.A. to measure differences in mental ability, for example a child of five years of age may be able to perform a task designed or suitable for children of four years old. In this case his mental age is 4 years while the chronological age is 5 years. The mental age is a measure of cognitive functioning or also level of achievement. It shows a child's readiness to learn and a level of cerebral development. (Jensen,1979)

The relation below gives the Intelligence Quotient of any child:

$$IQ = \frac{\text{MENTAL AGE} \times 100}{\text{CHRONOLOGICAL AGE}}$$

The chronological age refers to a child's actual age.
In a typical classroom, we expect I.Q. to vary from 75 to 150.
Uses: (i) The MA gives an age –equivalent for the child's raw score.
(ii) IQ indicates a child's performance relative to children who are at his/her own chronological

3.2 Abilities that are not Measurable

Other differences that are not measurable are:

i Motivation, Interest, Attitude and Appreciations.

ii Physical, Emotional and Social maturity of the learner.

iii Special Talents or Deficiencies such as creativity, inability to read properly or retention span.
iv Learning habits, attentions, self-discipline and organization of written work. Mathematical Aptitude Tests (A test of quantitative thinking) teacher made achievement test. This can be administered early in the year.

Knowledge of Mathematical concepts, structure and processes is related to the previous educational experiences of the learner. It determines the readiness of the learner for the content of a new course. A diagnostic test or pre-test determines the area of difficu lty of the learner.

Traits listed in (iv) to (vii) cannot at present be measured precisely as at now. They are usually measured by interviewing the learner. These methods of measurements are now being perfected in some countries of the world.

The Universal Basic Education curriculum include the Mathematics Curriculum for Nursery, Primary and First three years of Junior Secondary School, J.S.S. 1-3

3.3 Meaning and causes of individual differences among learners

The concept of individual differences refers to the idea that learners learn differently in terms of rate of learning, success or failure in learning activities, lack of interest etc (Mulwa, 2012). These differences among learners can easily be noticed in terms of gender, physical characteristics, approach to learning rate, reaction to learning resources. and situations.

There are some psychological factors that may cause and sustain individual differences among learners in a given classroom. These includes the following among others: interest, attitude, motivation, home background, learning, intelligence, and aptitude. The factor can also be physical disability and emotional disabilities

3.4 Methods for Identifying Individual Differences among Learners in a Mathematics Classroom

A number of methods can be employed by the classroom teacher in identifying individual differences in the mathematics classroom. This can be through any of the following strategies. (Mulwa;2012)
(i) observation in and outside the classroom
(ii) use of tests
(iii) written questionnaire
(iv) Use of teacher – student conference

(v) Study of official students' records
(vi) interview
(vii) Physical deformity
(viii) Physical appearance
(ix) Use of open days

3.5 Strategies for Managing Individual Differences among Learners in a Mathematics Classroom

(i) The teacher should encourage social interaction among learners
(ii) The use of homogeneous grouping in terms of gender, interest, goals, needs, aspirations.
(iii) Using differential ability grouping
(iv) Grouping friends together using some factors such as relationship, religion, etc
(v) Interest grouping, learners who share common areas of interest.
(vi) Through the use of variety of instructional materials
(vii) By making the learning environment very attractive
(viii) Through the use of suitable curriculum
(ix) Introduction and use of variety of learning activities
(x) Use of special help for specific learners needs.

Since individuals differ so much in terms of certain traits, effort should be put in by the teacher in teaching. Efforts put in by the learners may not yield significant change in expected behaviour if the same time duration, strategies and methods are uniformly employed if these observed areas of differences are not addressed.

These areas of differences as much as possible, should be timely and adequately addressed to ensure that resources including time, are not wasted unnecessarily. The traits may be inborn, inherited, acquired or learnt. The first step in addressing the differences is for the teacher to gather as much information about the pupils as possible. This is to help the teacher take appropriate decisions towards reducing the impact of the observed areas of differences on learning and achievement potentials of the pupils

Individual differences among learners can be managed in any of the following ways.

Special curriculum with learners assigned to classes on the basis of abilities and interests is desirable. Such programme might include:
(i) accelerated class for gifted students
(ii) remedial instruction courses
(iii) special course for slow learners. Classroom activities can be modified according to learners needs. Such as:

(a) vary daily learning activities according to ability or achievement levels
(b) organize the class into small group and give each group special instructions and assignments.
(c) Provide supervised study time so that the work of individuals can be observed and help given when needed.
(d) involve the pupils in many of the classroom activities such as writing on the chalkboard, collecting papers etc. Each learner needs to feel he has a place in the class and participates in some activities without frustration.
(e) Provide textbooks that are suitable to the level of the learner.
(f) provide and use teaching-aids, and models etc appropriate to the needs and interests of the students.
(g) use methods and instruments of evaluation appropriate to the course or pupils involved. For instance, do not give the same work or assignment to the group of weak students and those of the gifted ones.

Self-Assessment Exercise(s)

1. Mention any two methods that can be employed in managing individual differences among learners in a mathematics classroom?
2. State any two ways the mathematics teacher can use to identify individual differences among learners in his class?

4.0 Conclusion

There are individual differences among learners in the mathematics classrooms and this calls for the awareness of the teacher and subsequent search for strategies for managing these differences. Some of these differences and traits are measurable and others are not measurable. Some of these strategies can be in the form of breaking into smaller groups and using special times such as break times for remedial teaching. Efforts should be made to carry along the majority of the students in the class.

5.0 Summary

Consideration of the differences between pupils is very important especially in a mathematics classroom. The basic idea is that every child should be given the opportunity to display his abilities as fully as possible. This requirement is not specific to mathematics but is particularly important here. There are a variety of ways of organizing the mathematics programme and a variety of materials for use in meeting individual needs. The teacher is still the key since his

understanding of the learner is the first step towards providing for the learner's special needs.

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7.0 Possible answers to SAEs

1. (i) Use of special curriculum where learners can be assigned to on ability level and interest.
   (ii) encouraging social interaction
   (iv) varying daily activities due to ability level
   (v) variety of different class activities
   (vi) supervised class activities
   (vii) use of varied teaching aids
   evaluation tools and methods should be appropriate to the learner's level.

2. To identify individual differences, use any of the following; observation, interview, tests, teacher-student conference, use of open day, study of official report of the student, physical appearance etc

UNIT 5 STRATEGIES FOR DEVELOPING POSITIVE ATTITUDE TOWARDS MATHEMATICS BY STUDENTS

CONTENTS

1.0 Introduction

There is no doubt that the development of interest in the learners is rooted in achieving the affective learning outcomes. It is an inner force that can manifest by strong desire, commitment and willingness to engage in an activity with strong belief to succeed.

In this unit, we are going to discuss the concept of attitude, factors that influence the type of attitude learners develop towards mathematics and the learning of mathematics. We will also discuss causes of individual differences in the learners, strategies for identifying these differences.

2.0 Intended Learning Outcomes(ILOs)

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

- explain the concept of positive attitude towards mathematics and the learning of mathematics.
- mention any five strategies the mathematics teacher can adopt to facilitate the development of positive attitude towards the learning of mathematics by the pupils
- mention any five indices of positive or negative attitude towards mathematics and the learning of mathematics.
- appreciate the teaching of mathematics love and enjoy doing and learning mathematics.

3.0 Main Content

3.1 Types of Learning/Strategies that Encourage Development of Positive Attitude

There is no doubt that interest is a strong psychological inner force that ignites desire and strong willingness to engage in a certain activity. This can be inspired and sustained through a number of carefully identified and implemented methods and strategies. One can be interested in mathematics as a subject, interested in the learning of mathematics and interested in the ways mathematics is taught in the schools even as a learner.

A number of factors have been identified to influence students' willingness to engage in and participate actively in any mathematical activities. One such factor is attitude. This psychological construct has been defined from different approaches by various authors. Kibrislioglu(2016) in Mazana eta l(2019) defined attitude towards mathematics as liking or disliking of the subject, a tendency to engage in or avoid mathematical activities; a belief that one is good or bad at mathematics; and a belief that mathematics is useful or useless. Similarly, Sarmah and Puri (2014) defined attitude towards mathematics as learned tendency of a person to respond positively or negatively towards an object, situation, concept or another person .

From the discussions presented above, the following can be summarized as factors or indices that inform positive attitude towards mathematics.

i. Pleasure (derivation of satisfaction)
ii. Having confidence towards the knowledge of mathematics
iii. Identification of the usefulness of mathematics
iv. Low level of anxiety (Rojas and Associates, 2017)
Also, Garcia etal (2017) (identified the following as variables of negative attitude towards mathematics
v. Belief in the ability to understand the topics, experience that cause their teaching, conditions and circumstances where they are taught and emotions and reactions that cause their content.

Bahr and Garcia (2010), on equity and phobia in mathematics stated" you are choosing to teach children in a very interesting time in history. Today we know more how children learn mathematics than we have ever known before. We now realize that children are capable of far deeper mathematical thinking than had previously been thought and that, fundamentally, children think differently than adults do. The authors argued that teachers must be adequately prepared to be able to make the learning of mathematics interesting. 'They observed that great mathematics teachers should possess a view and engage in a practice of

teaching that integrates important notions about ***content, pedagogy, development, and student thinking***.
A number of learning strategies have been identified by researchers, educationists, teachers etc for developing positive attitude in the learners especially towards the teaching and the learning of mathematics. We will discuss some of these learning strategies.

One of these strategies is the discovery learning. Children are inquisitive and always wanting to be engaged. This natural tendency to explore and manipulate the environment should be sustained and encouraged. This practice should be maintained and fostered from the nursery schools.

(i) Individual differences should be recognized and managed. Children learn different things from the same experience .so opportunity should be given for self-expression just as it is done in pre-nursery and nursery schools.
(ii) Enrichment of children's experience in the various stages is recommended. It should be pointed out here that through the availability of teaching aids and other instructional materials in nursery schools, enrichment of children's experience is achieved.

Piaget advocates a system whereby children could develop at their own pace with the teacher fostering cognitive development rather than forcing it.

Early childhood education should provide the foundation for later learning. Teachers should capitalize on the optimal period in children's life for certain kinds of learning to avoid difficulties in later stages. The early years being those in which children gain the experience which form the basis of future logical thought is extremely crucial to all children. The close attention given to pupils in nursery schools by their teachers is in line with this observation.
Positive learning environment in our classrooms can ensure the development of positive attitude toward the learning of mathematics.

Blogger (2018) in Service Guest, (service.ascd.org) suggested that the teacher can achieve this through the following:
1. building classroom rules and procedures collaboratively and in the positive. Get the students involved in the rules. These apply to all including the teacher.
2. let the students know that you believe in them
3. Get the students to examine their mind sets. Do they believe in their ability to learn, grow and succeed?
4. Talk sense into the students that they are learning for their own benefit.
5. Be honest in your feedback to the students.

6. During resolution of students' conflict or behaviour issue, be objective, do not attack or accuse unnecessarily.

3.2 Developing love for Mathematics

There is a need to develop a love for mathematics by most of all our pupils and students. It is this love for mathematics that gives them a positive attitude rather than a negative attitude towards mathematics. In order to do this, mathematics should be taught practically, purely and in a pleasurable manner. Students should be taught to discover mathematical truths, facts, principles and patterns.

Discovery methods as done in laboratory approach are highly recommended. It is this type of learning of mathematics that leads to intrinsic motivation. This type of motivation helps to develop a love for mathematics and the development of positive attitude towards mathematics. The setting up of "mathematics club" for all secondary school students has been recommended. It should be made voluntary for all students from Junior Secondary one to six. The following can serve as aims:

(i) To develop a love for mathematics
(ii) To help them develop positive attitude toward the subject
(iii) To learn the "History of Mathematics" by showing its slow and progressive development from ancient times till today
(iv) To show its relevance to everyday living thereby emphasizing its utilitarian value.
(v) To show its basis for technological development
(vi) Career guidance in mathematics and in mathematics-related professions such as engineering, survey, physics, computer, statistics etc.
(vii) To introduce the learner to computer technology.

Activities and Programmes in the Mathematics Club would include

(a) Debates on Mathematics-related topics
(b) Excursions to places of mathematical interests such as Mathematical Centre, Abuja etc.
(c) Talks by invited Mathematicians, Mathematics – Educationists and other experts in Mathematics-related disciplines on specific topics of interests to the students.
(d) Competitions between members of the club and between mathematics clubs of different schools in debates and in the playing of mathematics games and puzzles. Medals and cups, trophies or prizes could be donated to be won in such competitions.
(e) Teaching computer language and technology.

3.3 Gender Differences in the learning of Mathematics

A number of recent researches conducted in different parts of the world reveal that gender disparity in achievement in mathematics is not significant. There may be differences in the mean achievement scores but these were not statistically significant due to gender. However, mathematics teachers in their instructional practices should be conscious of a number of factors that can impact on differential learning in pupils such as, language, gender, attention span, emotional state, attitude, etc Denes Szues(2012) in a study involving secondary school students in Britain revealed that girls had higher mathematics anxiety , however, the study showed that there was no gender difference in mathematics performance, despite girls having higher mathematics anxiety.

This calls for use of good methods, materials and teaching strategies. Mathematics teachers should as much as possible be gender sensitive in any mixed class especially in their use of language, general class conduct etc. All these directly or indirectly influence learning.

Gender disparity should not be allowed to be a significant factor hindering achieving the nations philosophy based on one of the beliefs of maximizing the creative potentials and skills of the individual for self- fulfilment and general development of the society. (FME;2013)

Also since the environment in which a child grows has effects on cognitive development, the home as a variable has an important role to play. Parents and guardians should endeavour to provide challenging environment in the home so as to aid appropriate cognitive development. Such should include provision of stimulating educational materials such as toys, books, magazines, mathematical games and puzzles. Parents should encourage their children to read and play these games and puzzles. They should even play with their children.

Primary and secondary school teachers should be encouraged to attend seminars, workshops and conferences. Here their knowledge can be updated through results from current researches in mathematics/mathematics education. Teacher's promotion can also be tied to attendance at such seminars, workshops and conferences. The relevant agencies concerned should see to it that this is organized regularly for the teachers.

Self-Assessment Exercise(s)

1. Mention any one feature of a positive attitude towards mathematics"?
2. Mention any one observable behaviour that show negative attitude towards mathematics?

4.0 Conclusion

Developing positive attitude in the learners towards mathematics, the learning of mathematics and the teaching and learning of mathematics should be the guiding principle for all mathematics teachers. If this positive disposition towards the subject is as early as possible built in the pupils, they will surely become active seekers of mathematical knowledge

5.0 Summary

Steps that will help in developing positive attitudes toward mathematics have been identified. It was also suggested that the establishment of "mathematics club" for all secondary schools' students will provide enriching activities for further learning of mathematics practically. This too will go a long way in making the teaching and learning of mathematics interesting, enjoyable and practical.

6.0 References/Further Readings/website

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7.0 Possible answers to SAEs

1. Some features of positive attitude towards mathematics teaching and learning.
   - i Possession of confidence toward the knowledge of mathematics
   - ii Low level of math. anxiety
   - iii Aware of the usefulness of mathematics
   - iv Belief in personal ability to succeed in mathematics
   - v Show of satisfaction or pleasure in mathematics

2. Observable negative behaviour toward mathematics.
   - i. Dislike for mathematics activities
   - ii. High level of math. anxiety
   - iii. Low level of confidence in mathematical activities.
   - iv. Do not show reasonable interest in learning mathematics
   - v. Do not see the usefulness of mathematical knowledge

MODULE 3

UNIT 1 TEACHING AND LEARNING AIDS – DEFINITIONS AND TYPES

CONTENTS

1.0 Introduction

In the last unit, we discussed attitude and factors that influence the development of positive attitude towards mathematics as a subject and the teaching and learning of mathematics. In the present unit, we are going to discuss the concepts of teaching and learning materials including the various types.

2.0 Intended Learning Outcomes(ILOs)

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

- state the meaning of teaching aids
- discuss different types of teaching aids in mathematics.
- improvise some instructional materials from materials got from the environment.
- Identify at least five types of learner-centred instructional methods of teaching mathematics.

3.0 Main Content

3.1 Learning and Teaching Aids

Learning is defined as any relative permanent change in behaviour due to a result of practice or experience. On the other hand, learning or teaching aids are any type of material that can assist or speed up the process of learning with or without any assistance of a second person. Yero (2000) in Obienyem (2019) defined instructional aids as resources employed by teachers to improve the effectiveness of instruction. These aids have been categorized by a number of authors based on some features. Yero classified them into four:

Visual aids, Auditory aids, Audio visual aids and Simulation devices.

3.2 Visual aids

These include posters, bulletin boards, displays, models, chalkboard, motion pictures, projected transparencies, flip charts, flannel boards, slides etc

3.3 Auditory aids

Are such things as record players, tape recorders, language laboratories, radios etcThese types of aids relatively cheap and available. They may not require more serious training for use.

3.4 Audio visual aids

Involve both the use of sight and hearing. Facilities like, motion pictures, slides on sound and television, video, multimedia etc are involved. The simulation devices are those built to stimulate the action or functions of the real thing.

Instructional resources in mathematics can also be classified as books, concrete objects, models, mathematical games, mathematical laboratory.

3.5 Simulation Devices

A number of authors classify this as experiential learning. Here the learners engage in active learning as they learn from each other Three elements are important for effective simulation. These are, preparation, active student participation and post –simulation debrief. (www.kent.edu) Post simulation discussion with students leads to deeper learning. Experiential learning is an engaged learning process whereby students learn by doing and by reflecting on the experience. It ensures

intellectual, creative, emotional, social or physical engagement in the learning created.(www.bu.edu)

3.6 Mathematical Games

Agwagah (2000) as in Obienyem (2013) defined games as enrichment materials and activities aimed at broadening and deepening children's knowledge. Some of **t**hese enrichment materials are games, puzzles, challenging problems, alternative approaches to problems etc

They stimulate students' interests in mathematics and they encourage thinking and creativity. Through playing them, students develop positive attitude toward mathematics and they are intrinsically motivated.

3.7 Instructional Technology

In this context, we will take the definition as seen in (uncw.edu), the theory and practice of design, development, utilization, management and evaluation of the processes and resources for learning. In the classroom setting, it is the use of a variety of digital technology such as internet, web-based applications, computer devices, online curriculum and more to facilitate and enhance student learning in the classroom.(www.dcstn.org)

Self-Assessment Exercise(s)

Mention the four major classifications of instructional aids?

4.0 Conclusion

Teaching aids are many and varied and classified into types. The common ones have been mentioned, defined and classified into categories.

5.0 Summary

The classifications are first, books then concrete objects, models, computers, mathematics games, mathematical laboratory lastly Instructional Resources – prints and non- prints We are in the age of e-learning and the computer through the internet.

6.0 References/Further Readings/website

Adigun, O. T. (2012). Attitude of Mathematics teachers in Public secondary schools to the use of Mathematics instructional

resources in Oyo State. *Journal of Teacher Education,* 12(1), 175-186.

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7.0 Possible answers to SAEs

Classification of instructional aids

(i) Visual aids
(ii) auditory aids
(iii) audio-visual aids
(iv) simulation devices

UNIT 2 LEARNING AIDS: CRITERIA FOR SELECTION DEVELOPMENT AND USE

CONTENTS

1.0 Introduction

The selection and use of learning and teaching aids are important factors in effective teaching of subject matter in mathematics. A bad lesson can occur due to wrong choice of the teaching aid or wrong application of an appropriate one. In the last unit we discussed the concept of teaching and learning materials. In this unit, we shall discuss the criteria for selection, development and uses of mathematics teaching and learning aids.#

2.0 **Intended** Learning Outcomes(ILOs)

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

- State any five importance of using instructional materials in teaching and learning mathematics.
- Select the appropriate teaching and learning aid for a given lesson topic.
- demonstrate essential skills for development or improvisation of an instructional material for a given mathematical concept.
- Appreciate the importance of the use of instructional materials especial during the early stage of concept development in mathematics.

3.0 Main Content

3.1 Criteria for Selecting Teaching and Learning Aids

(a) Relationship to the Topic

During lesson presentation, the teacher may be confronted with the explanation of a concept that the pupils are finding difficult to

understand, in this case the teacher has to quickly improvise a material that can help him make the mathematical concept concrete for the pupils to be able to see meaning in what the teacher is saying. The ability to do this demands a good knowledge of the subject matter, creative and innovative skills on the part of the teacher.

The learning aid must be relevant to the topic for which it is prepared. It will help to achieve the learning outcomes of the lesson. Instructional aids when carefully identified, selected or developed is aimed at making teaching easier and learning interesting and less stressful. So when choosing the aid, you should make sure it presents the idea of the lesson well and makes it interesting.

(b) Readiness and Ability of the Pupils

Before selecting an aid for any planned lesson, the intellectual ability of the learners must be considered. It must not be too advanced for them otherwise it may not achieve the learning outcomes of the lesson. It must not also be too simple otherwise the pupils may not see the necessity of such a learning aid.

(c) Teacher's Ability to Use the Aid

Certain aids may be appropriate for the lesson but the teacher may not be able to access it or explain its application. While the teacher will experience difficulty in presenting the concepts in the understandable way for the pupils, the pupils in turn experience problem understanding the concepts being presented.

(d) Cost of the Learning Aids

The cost of the aids must be borne in mind. Some schools may not be able to afford them because of the cost, even if they are available especially if the number of aid required is large. If the material needed is very essential, the teacher can do a number of things to provide alternatives. You can use good pictures of aids, or make diagrams on cardboard papers etc.

(e) Complexity

Some learning aids are complicated to explain even when the teacher can operate them. Such cannot easily be followed and comprehended by pupils. Care must be taken to avoid such complex aids.

(f) Availability of Materials

Some aids are available to be bought from markets or by constructing them locally from acquired materials. Some may not

be available although there is money to buy them. Emphasis will be more on the use of local materials for learning aids which are available and can easily be improvised.

(g) Size of learning Aids

Some learning aids are very small, such that the important parts are not easily visible. They should be large enough so that the essential parts are visible to the pupils. Enlarged pictures or diagrams of such materials can be provided to make room for clarity

(h) Durability

Some aids can be used two or three times and need to be replaced. Such do not usually cost much and care must be taken to choose more permanent materials that can be stored and used repeatedly.

(i) Storage Facilities

Some materials used need constant maintenance and repair. Some need to be stored in drawers, a closed cupboard or room with shelves.

(j) Accuracy

There is need for accuracy of information about some of the aids. The date of production must be checked especially for commercially produced aids. The messages contained in the materials should not be outdated because of change in school programmes or curriculum.

(k) Class Size

Some learning aids need to be given to individual pupils, so each has his or her own in order to feel relaxed and participate in the lesson. When these do not go round, it is difficult to achieve the objective of the lesson. However, the teacher may decide to pair the pupils in order to overcome the problem of shortage of the aids.

3.2 Uses of Learning Aids

Learning or Teaching Aids have a number of purposes. Generally, these materials help the teacher to make the concepts concrete, real and easy to understand by the learners. We can make a list of some learning aids and some areas where they can be used.

The list is not limited to ones here.

1. Abacus: For counting, demonstration of place value of numbers.

2. Beads or counters or bottle tops for counting, solving simple addition, subtraction or multiplication problems involving whole numbers
3. Clinometers: Used for estimating angles of elevation and depression.
4. Concrete model of sphere: To calculate its surface areas, solve problems of latitude and longitude, distances along latitudes and longitudes.
5. Three dimensional shapes such as cuboids, cubes cones cylinders, pyramids, spheres etc for calculating the total surface areas, volume, angle between two planes or lines.
6. The probability box. This can contain the following playing cards, dice, coins hexagonal pencils etc for practical investigation of probability of certain events
7. Compass: For geometrical constructions
8. Protractor: for measuring and construction of angles in a plane.
9. Geo-Board: For demonstrating geometrical shapes, for estimating areas of plane shapes, illustration of parallel lines, similar and congruent shapes etc.
10. Spring balance: For measuring mass in grams, kilogrammes for showing process of solving linear equations, etc
11. Rules: For measuring distance in metres, centimetres etc. for drawing straight edges.
12. Cardboards diagrams of parallelogram, triangle, and trapezium. To calculate areas and dimensions`
13. Graphs: To represent mathematical functions in pictorial form e.g. curve sketching, pie and bar charts, histogram, point of intersection of curves to be determined.
14. Divider: To measure distances when learning geometric construction. E.g. bisecting angles, line etc.
15. Two dimensional geometric shapes such as triangles, squares, rectangles, circles, sectors, trapezia, kites, parallelograms, rhombuses and other polygons

16 Graph board or cloth: for drawing different types of graphs.

Importance of Teaching and Learning Aids

Teaching aids or instructional materials serve a number of purposes. Some of these are:

1. They help to gain and hold the attention of the learner
2. They provide visual aspects to a process or technique
3. They help to focus attention of the learner on the high lights of key points
4. They create impact on the learner
5. They help to make concrete the abstracts involved and hence facilitate understanding

6. They save time by limiting the use of lengthy explanations
7. They provide a common framework of experience to a large group of learners.
8 They help to provide for variety through which the learners can learn
9. They help to stimulate the reality
10. They provide opportunity for the learners to interact more and ask more questions Yero (2000) in Obienyem(2019)

Self-Assessment Exercise(s)

1. State any two importance of the use of instructional materials in a mathematics class
2. Mention any two factors you will consider in selecting any teaching aid for a group of learners.

4.0 Conclusion

Some criteria for selecting learning aids were stated and the uses of some learning aids were outlined. The general importance of instructional materials in teaching were also pointed out. More aids could be mentioned and their uses discussed.

5.0 Summary

In the unit, we listed many factors which will enable the teacher select appropriate learning aids for mathematics lessons. In addition, we listed some learning aids and their uses. A number of factors to be considered in selecting teaching aids were also treated.

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7.0 Possible answers to SAEs

1. Importance of using instructional materials
   (i) They gain and hold the attention of the learners
   (ii) Provision of visual aspects to a process.
   (iii) Create impart on the learners.
   (iv) Saves time that would have been used in the lengthy explanation.
   (v) Learning is practical and real.
   (vi) There is opportunity for interaction between learners and between learners and materials.

2. Factors that influence selection of materials.
   i Relationship to the topic
   ii Ability of the teacher to use the material
   iii (ii)Readiness and ability of the pupils.
   iv Cost of the material
   v Availability of material
   vi Size of the material
   vii Durability of the material
   viii Class size etc

UNIT 3 THE MATHEMATICS LABORATORY

CONTENTS

1.0 Introduction

In our previous discussions, we have seen different things about mathematics. We have discussed strategies for developing positive attitude towards the teaching and learning of mathematics, strategies for managinging individual differences in learners, instructional materials for teaching and learning Mathematics. In this unit, we will discuss the laboratory, its organization and arrangement, examples of laboratory mathematics teaching etc.

2.0 Intended Learning Outcomes(ILOs)

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

- Explain mathematics laboratory as both instructional procedure and a place that can enhance effective mathematics teaching and learning
- Explain “laboratory approach of teaching mathematics.
- Discuss any five features of a laboratory approach of teaching mathematics
- Illustrate with an example a laboratory approach of teaching a given mathematics topic for a primary school class.
- Demonstrate any five importance/benefits of laboratory method of teaching mathematics in schools.
- Explain the concept of improvisation of instructional materials and need for the teacher to be adequately equipped with essential skills for this.

3.0 Main Content

3.1 Definition

I am thinking that some of you who are not familiar with this will be wondering why laboratory for mathematics.? Yes, as a mathematical science it needs its own laboratory. Obodo (1991) in Obienyem (2013), defined mathematics laboratory as a room where things can be counted, ordered, recorded, packed, grouped, arranged, rearranged, measured, joined, partitioned, constructed, experimented in, among activities. Some authors view mathematics laboratory as a form of instructional method. Reggiani (2003) as in Obienyem (2013) observed that it is a methodology based on various structured activities targeted at the construction of the meaning of mathematical objects

The mathematical laboratory lesson is an avenue that gives the pupils/students a means of manipulating concrete objects, materials, guided by the teacher in formulating generalizations, deductions, and concepts. It allows the pupil to think for himself, interact with fellow pupils through practical experiences. It also helps the pupils to communicate with one another and the teacher.

The activities performed depend on the learning outcomes of the lesson. It makes the study of mathematics interesting, pleasurable and permanent. It helps in developing positive attitude toward the learning of mathematics. There is no doubt that if the mathematics laboratory in the schools are adequately established, equipped with essential materials, managed by experienced mathematics laboratory attendants, such that the students have free access to this all important resource centre, the mathematical riches God has deposited in these young ones will naturally begin to manifest with little supervision from a role model and a passionate professional mathematics teacher.

3.2 Features of a Laboratory Approach of Teaching Mathematics

A number of features are characteristic of laboratory method of presenting mathematical tasks and skills. Some of these can be articulated thus:

i. One major feature of this approach is provision of opportunity for practical investigation of mathematical concepts, principles and laws.
ii. It provides opportunity for individual learners to move at his own pace
iii. Learning is explorative and collaboratively done
iv. Learning materials are available and can easily be accessed.
v. Teacher –learner interaction can be both formal and informal

vi. Learning activities can be both structured and unstructured
vii. Feedback is immediate, continuous and motivating as learners see the results of their effort
viii. Instructional methods and strategies follow an integrated approach in most cases. Rules can be given, followed by demonstration, supervision of individual learner's work, formative assessment of on-going mathematics activity.
ix. Three domains of performance behaviour or learning outcomes are achievable as the learners are engaged in a number of activities that involve doing by seeing, imitation, sharing of ideas, communicating their ideas. pear assessment of quality of work as they compare their works etc.
x. It creates another perception of mathematics, the teaching of mathematics and learning of mathematics as tension usually associated with the conventional class is largely reduced if not absent.

It assists in catering for individual differences and enriches pupils with important mathematical skills. The possibilities for personal independent work make it interesting for talented and creative students to take responsibility of their learning. The group work involves encouraging and sharing of ideas and knowledge.

In the end, it brings joy to the learner, provides evidence of progress and guarantees a great transfer of learning through classroom procedure.

3.2.1 Class Arrangement and Organization

We can begin this discussion by asking this question. How can we arrange the room so that the learners can freely interact with materials, peers, and the teacher? In (wsww.jstor.org), it is observed that enough tables and chairs should be provided for the number of students in the room? It also suggested that the students should be spread out evenly. Giving room for the students to work and also see the board.

Also Jones (2017) suggested that the math lab should be prepared by removing any unnecessary books, irrelevant posters and cluster from the area. This is to ensure that the classroom has minimal distractions so that the students can concentrate.

3.2.2 Learning Materials

For the laboratory to serve effectively as a place for active, investigative and explorative teaching and learning resource centre and or as an instructional approach, many instructional materials should be provided adequately. The materials should be such that pupils can see, touch,

handle, measure, etc. so as to develop mathematical ideas. For primary school level, material needs include stones, match boxes, counters, abacus, wooden blocks, counting sticks, empty tins, empty bottles, glass jars, tape measures, papers of all kinds, cardboards, strings, ropes, cotton, threads, rubber bands, nails, razor blades, scissors etc.

Materials for measurements include: rulers, metre sticks, weights, balance scales, tape measures, micro meters, protractors, compasses, set squares, stop watches, clocks and plastic containers of various sizes.

Secondary level needs some of the above and in addition the following: centimetre cubes, geoboards, graph-and-grid-sheets, surveying equipment, mosaic tiles, student's projects folders and so on.

Most of these materials can be obtained or produced locally. As is evident from this list, we no longer need just, desk, chair, chalk-board, and chalk. Books are used in this approach of teaching but are not all important as in the traditional way of teaching and learning? They mainly serve as source of examples and questions for assignments for practice after the lesson at home.

3.3 Laboratory Lessons and Procedures

In order to ensure the success and effectiveness of a laboratory lessons, very careful planning is needed. The teacher needs to prepare very well. It is more demanding on his time, effort and skills than in a normal class but it is worth all the effort because of its rewards. He must ensure that all the materials needed for a given lesson are in place before the lesson begins. Some of the materials might have been made by the teacher himself locally and in some with the students. While in some cases, some are ready-made, bought or imported. Guide or worksheets are also to be provided. Guide sheets should include:

(i) Statement of learning outcomes
(ii) Students' necessary instructions
(iii) Exercises to evaluate the achievement of the stated learning outcomes

In a laboratory lesson, the teacher acts as a guide or a supervisor to give instructions. He makes sure there is enough space for the activities, maintains orderliness and moves around the class to assist individual students needing help and answer pupils' questions.

Where the laboratory attendant is around the students leave the equipment and other essential materials on the tables for the laboratory attendant to properly return them.

The Procedures

The procedures include the following:

There is no rigid procedure for carrying out a laboratory lesson. The first lesson can be demonstrative in nature. The teacher can explain the processes involved in investigating a certain formula. These can be written on the board and the students are then required to follow the guide. While they do this the teacher moves around to supervise and offer essential help to those experiencing difficulties. It can also take the form as outlined below.

(a) There should be guide sheets and these should be made up in such a way that pupils understand what they are to investigate and the materials needed.

(b) All equipment and materials needed for the lesson are ready and in place before the lesson starts. Guide sheets and such materials as would be needed for the particular lesson.

(c) The laboratory should be in place with adequate seats and tables for the pupils.

(d) The pupils should be involved in taking care of equipment. Students can be shared in groups to work when necessary. Independent work should also be encouraged.

3.4 Importance of Laboratory Approach to the Teaching of Mathematics

The laboratory approach to teaching mathematics assists in catering for individual differences and enriches pupils with important mathematical skills. The possibilities for personal independent work makes it interesting for talented and creative students. The group work provides opportunity for sharing of ideas and knowledge. In the end, it brings joy to the learners, provides evidence of progress and guarantees a great transfer of learning through classroom procedures.

3.5 Examples of Laboratory Lesson

Two examples of a laboratory lesson are given below

Example 1

Class: JSSI (Sec. School)

Duration: 70 minutes (Double Period)

Topic: To find an approximate value for π

Learning outcomes: By the end of the lesson the students will be able to do the following:

i use any thread to measure the circumference of any given circular plane surface.

ii determine the measurement above using the simple ruler

iii measure the diameter of the same circular plane surface as in (i) above
iv use the two readings above to show that the approximate value of pie(π) is 3.142 to three places of decimals.
v use other circular plane surfaces to estimate the value of pie as a proof that the value is not affected by the size of the shape.
vi appreciate the laboratory investigation of this constant pie.

Materials
Sheet of cardboard, rulers, compass, strings, protractor, scissors, divider, pencil, Can of Peak Milk, Bournvita Can, Milo Can and other cylindrical cans with good circular faces.

Previous Knowledge
Students can construct circles with different radii, they can measure linear dimensions such as radius, circumference, diameter of circle. (these previous learning outcomes or experiences need to be assessed to make sure that the learners can demonstrate them as readiness for the new tasks).

Procedure
Divide the students into groups of 3 each if convenient for you.
Let each group with thread measure the circular perimeter of a milk can.
Next let each group place the thread on the ruler to determine the perimeter or the circumference.
Next let them identify the diameter of the same can, measure it and put down their readings. Ask each group to divide the perimeter reading by the diameter reading.
Ask each group to write down their answer.
When all have done this ask each group leader to present their work to the hearing of all class members.
At this point you can call for discussions from the students.
Ask the students to use another circular plane surface and repeat the processes above.

Call for discussions and observations
Example 2
Class: SS1-SS3 (Sec. School)
Time: 70 minutes (double period)
Topic: Investigation of some mathematical formula and rules.
Learning outcomes
By the end of the lesson, the students will be able to do the following.
Use compass, ruler, cardboard papers, knives to construct any given geometric shapes with given dimensions.

Measure to a reasonable accuracy the dimensions of radii, lengths, perimeters, heights, angles of shapes given or constructed.
Substitute the readings into conventional formula to compare practical investigation of such formula with the theoretical works.

Materials
Cardboard papers, rulers, compass, protractor, divider, pencil, set-square, plain sheets.

Previous learning outcomes
The students can manipulate the compass, measure linear distances, effectively take readings using the ruler

Procedure
Activity one:
When the students are properly settled and ready to embark on meaningful learning the teacher should star thus;
Get your compass and ruler
Measure out 10.5cm with your compass
Construct a circle of radius 10.5cm on the cardboard paper
From the centre of the circle, mark off 120^o with your protractor.
Cut off the sector of 120^o
fold the remaining sector
What shape do you have?
Measure to the nearest whole number the radius and perpendicular height of the shape.
Write down your readings
The teacher will ensure that all the students have completed the activities above before going to the next activity. Paying attention to learners having difficulties will help to reduce learning gap and promote sense of belonging and joy.
Activity two.
Bring out a new cardboard sheet
With your ruler and pencil, measure out 44cm as length and 7.8cm as width
Fold this so that 7.8cm will be the height of the shape formed.
What is the name of the shape formed?
Measure the base radius of the shape
Write down your result
At this stage, the teacher should ensure that all the students have successfully completed the steps above. When this is done, he can now continue. Can we now move on? Yesooo
Substitute your values of radius and height into the formula $V=1/3\pi r^2h$ to determine the volume in activity one.
Also substitute your values of radius and height into the formula $V=\pi r^2h$ to determine the volume as in activity two.

Finally, give your observations with references to radius, height and volumes of the shapes.
(from activity based mathematics for primary and junior secondary schools by Obienyem and Obienyem,2017)
Lessons to be taught in mathematics laboratory approach are many and varied. They include areas of 2-dimensional geometric shapes, total surface areas of 3-dimensional shapes statistics, probability, trigonometry, numeration, conic section, etc.

3.6 Appraisal of the Method

The effectiveness of this method has been established through a number of research studies. Some of the findings show that learners are very active participants in the mathematics activities. The method fosters team approach to learning. Learners can become frustrated if activities are not properly planned and supervised by the teacher.

A number of research works have confirmed that the laboratory method of teaching mathematics is very effective as provides opportunity for the learners to be actively involved in all the activities designed for the day.
There is great potential and rewarding promises using the laboratory approach of teaching mathematics. This method is therefore highly recommended to all our mathematics teachers. It will apart from leading to better achievements for our students, also change their attitude from negative to positive. They will in addition enjoy learning mathematics at both the primary and junior secondary levels.

Self- Assessment Exercise(s)

1. Mention any two merits of the use of laboratory approach in teaching and learning mathematics
2. Mention the two ways mathematics laboratory in explained.

4.0 Conclusion

The laboratory approach of teaching mathematics is a very good method. Though it is time-consuming and involves a lot of preparations by the teacher and students, it is worth the effort because of its numerous benefits. These includes among others better achievement, positive attitude toward mathematics, fun in learning the subject. This method of teaching is hereby recommended to all teachers and learners of mathematics.

5.0 Summary

In laboratory approach, the emphasis is on discovering through individual or group activities. The students interact with the materials, class mates and with their teachers. This opportunity facilitates the achievement of learning outcomes. It encourages doing, talking and discussing mathematics. The effectiveness and success of this method have been highlighted.

The merits of the laboratory approach of teaching and learning mathematics include; better achievement in mathematics, positive attitude toward mathematics and enjoyment in learning mathematics. Some problems associated with laboratory approach include; time consuming and it involves a lot of preparation by the teacher and the students. For detail see the main content.

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7.0 Possible answers to SAEs

1. Any two merits of laboratory teaching and learning method in mathematics.
   - i Learning is explorative and collaborative
   - ii Ensures the development of positive attitude toward the learning of mathematics.
   - iii Learning activities can both be structured and unstructured.
   - iv Materials are available and can be accessed.
   - v Provides opportunity for independent learning.
   - vi Enriches the learners with important mathematical skills. Etc

2. Two ways of explaining mathematics laboratory are;
   - i It is seen as a place or room where mathematical activities can be carried out.
   - ii It is also seen a methodology based on the use of structured activities integrated with a number of strategies.

UNIT 4 LEARNER - CENTRED INSTRUCTIONAL METHODS AND STRATEGIES. TYPES

CONTENTS

1.0 Introduction

Generally, every instructional activity is organized and executed with the purpose of bringing about meaningful and observable changes in the learners based on stated learning outcomes expressed in measurable terms. In this unit we will discuss some learner centred instructional methods. In the previous unit we discussed the laboratory method of teaching and learning mathematics. We also looked at some sample lessons using the laboratory approach.

2.0 Intended Learning Outcomes(ILOs)

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

- Explain with examples the concept of learner – centred instructional method.
- Discuss any five advantages of learner –centred instructional method of teaching.
- Explain any three difficulties associated with any of these methods and strategies.

3.0 Main Content

3.1 Meaning of Learner – Centred Instructional Methods and Strategies

Let us reflect on the phrase "learner – centred" In your own understanding what does it mean? Yes, I am waiting for your reactions. Thank you.

We can see learner centred method of teaching as that which focuses on the learners and their development, rather than the transmission of content, it addresses the balance of power in teaching and learning. It moves toward learners actively constructing their own knowledge, and puts the responsibility for learning on the learners. (www.igi-global.com)

Such methods provide opportunities for every learner to experience success in any leaning activities with reduced stress. These methods take into considerations as much as is possible every aspect of the learners in selecting, the content, leaning experiences and other activities, time and duration of instruction, learning environment, types of teaching materials and even the quantity and quality required. Such methods also consider how the learners will be assessed so as to give accurate and valid picture of what the learners are and are capable of doing due to the experiences they have been exposed to or enabled to explore and acquire.

3.2 Some examples of Learner –Centred Instructional Methods and Strategies

We can begin this section by reflecting on some characteristics of learner – centred teaching methods. Study the explanation before it is possible to pick some of the features of this method of teaching from there. Do not close your mouth, talk. Thank you we have all done very well.

Any of such methods will have any of or all the following features or more.
Engaging the students
Teaches problem- solving skills
Getting the students to think about thinking
Allowing students to have control
Encourages collaboration (study.com >academy>characteristics…)

Some learner centred instructional methods include:
1. laboratory method of teaching

2. Inquiry method (guided and unguided inquiry method)
3. Discussion (small group and whole class)
4 Project method
5. Field work
6. Experimental method
7. Team work
8. Use of groups (large and small groups)
9. Demonstration (teacher led and or learner led demonstration)

With increasing complex nature of our classrooms comprised in most cases of individuals with diverse differences such as previous educational experiences, cultural background, gender, social- economic background, religious belief, family educational environment, etc no single method or strategy will conveniently serve the needs and interests of such heterogeneous group of learners.

The situation calls for adequate knowledge of and integration of all other learner-friendly methods and strategies as mentioned above

Some guidelines are however available to the teacher. These will help him in selecting the methods and strategies to be used. However, the choice of any method or strategies is determined by a number of factors. It is left for the teacher to consider all these and choose that or a combination of them that will ensure maximum learning outcome, with minimum stress for the greater majority of the learners.

3.3 Advantages of Learner – Centered Method of Teaching

We can identify some of the advantages of using these methods and strategies for teaching from the characteristics. Some of the advantages include the following among others;

1. Equips learners with skills of obtaining knowledge on their own
2. Active participation of learners in the learning process
3. Encourages maturation as learners discover something Retention of knowledge is high
4. Learners have high self confidence
5. Provides better opportunity for the development of cognitive, psychomotor and affective learning outcomes
6. Students learn faster
7. Learners are active rather than passive.
8. improves observational skills of the learners
9. learning can be explorative through practical activities.
10. learners feel satisfied when they discover new thing on their own.

You can think of many more advantages of these methods. Now let us think of some problems associated with these methods and strategies.

3.4 Disadvantages of Learner – centred Methods of Teaching

Do you think that these methods have some problems associated with their use?

Consider yourself as a teacher and also as a student, what are the likely problems you can encounter using any of these methods and strategies?

Yes, contributions. Please talk. There is no fine for mistake. Mistake provides opportunity to learn and even better. Thank you, we have all done very well. Let us now put down our points together.

1. Some of these methods may be time consuming.
2. Some may not easily be used when class is large
3. Some may be easily used when teaching and learning materials are not enough.
4. Some requires good level of experience on the part of the teacher.
5. They require very serious planning to carry every learner along. etc

Self-Assessment Exercises

Mention any five learner-centred teaching and learning methods

4.0 Conclusion

We have discussed the learner – centred teaching and learning methods and strategies, some of their advantages and disadvantages. There is no doubt that when learners are meaningfully involved and engaged with practical activities in any teaching and learning environment, they accomplish a lot. They three domains of learning outcomes manifest naturally and happily too.

5.0 Summary

A number of research studies have also revealed that these methods are still effective in the teaching and learning of mathematics in the primary and secondary school levels of our school system. These methods of teaching mathematics are based on the theory and principles of constructivism. The theory is concerned with the learners being actively involved in the teaching and learning arrangement. They seek and discover knowledge with little or no guidance as the case may be.

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7.0 Possible answers to SAEs

Some examples of learner- centred teaching methods

i Laboratory method
ii Experimental method
iii Project method
iv Use of group method
v Inquiry method
vi Team teaching
vii Demonstration
viii Use of field work or trip