Chapter One

Introduction

1.1 Background to the Study

Mathematics is a branch of science that deals with numbers and its applications. It involves measurements, calculation, computation, observations, solving of problems, deduction and proof. It is precise, methodical, orderly and a logical subject. Literally, Mathematics means "things which can be counted" and plays a crucial role in our daily experiences. We know the number of members of our family, number of students in the class, amount of money in the pocket, number of days a week, month or year as a result of applying our counting skills. Mathematics is all around us. We experience it in different forms; right from the ringing of an alarm in early hours of the day, interpreting the time on a watch, circling a date on a calendar, preparing a meal in the Kitchen, taking measurement for our clothes, spending and managing money[1]. Mathematics bring order into our lives. It encourages creativity, critical thinking, the ability to solve problems, thinking abstractly and communicating effectively. Mathematics is divided into branches, some of which are: Arithmetic; Geometry; Algebra; Trigonometry; Number theory; Mathematical Analysis; Topology; Calculus; Statistics and probability[2].

According to a research on students' Mathematics achievement in West African Senior Secondary Certificate Examination (WASSCE), it was observed that students' achievement in Mathematics have been varying irregularly. Some years, students perform so brilliantly while some other years, the reverse is the case and this is in no particular order[3]. But the truth is, some specific topics remain a hard nut to crack from year to year and this might be as a result of teaching methods employed by teachers in the teaching of these topics[4]. There are different methods teachers adopt in carrying out classroom instructions, some of which are: Lecture

method, Inductive method, Deductive method, Problem solving method, Project method, Discovery method, Analytic method and Laboratory method.

The method chosen by the teacher may be due to the following factors: Available resources; Number of students in a class; The difficulty level of topic andAge of students[5].

Set Theory is an aspect of Mathematics that deals with well-defined objects. This well-defined collection which can either be numbers, functions, objects are called sets. Set Theory is an especially important aspect of Mathematics, therefore its concept cannot be neglected. It is used in other branches such as topology, data structure, discrete structure etc. Its applications in everyday life cannot be overlooked. Humans like to categorize things and put them into sets. A typical example is the home where things are arranged in sets such as in the kitchen where things are kept in an organized pattern. A compartment in the home may be arranged for wine glasses, a different compartment for water glasses, and another compartment for mugs. Bowl plates are arranged separately from flat plates. Cutleries may be kept in an exclusive rack all in a bid to keep the kitchen organized[6]. Another example is a bedroom where clothing items are arranged in order in a wardrobe. Similar clothing materials are arranged in their unique locations for proper organization of the bedroom. For example, a man's work shirts and suits may be hung at a particular corner of the wardrobe, followed by his casual and exercise outfits, while undies (singlets, pants and boxers) may be kept in a separate corner.

This same pattern can be observed in school libraries and where books for different educational fields are being arranged on separate shelves. This allows for easy access to any book of interest to be easily located. Market places and stores are not left out because every item in the mall are arranged insets. There are different shelves for toiletries, beverages, cereals, household items and other items being displayed for sale in such stores. A visit to an organized food market reveals

different groups of people selling different items similar in purposes. A good example is having different stalls for different items based on their similarities and differences in purpose. All the examples mentioned above show that human beings unknowingly live daily based on the application of Set Theory for ease and for sorting things out without much effort.

Set Theory is one of the topics in Mathematics that is introduced to students at the elementary level of education and built upon until senior secondary level. When Set Theory is taught well in Senior Secondary School Mathematics classes, the chances of successfully tackling closely related question in the West African Examinations Council (WAEC), National Examinations Council (NECO) and Joint Admissions and Matriculations Board (JAMB) is increased. For students to have in-depth knowledge of Set Theory, certain measures must be put in place by the teacher. In a class situation, the approaches and strategies used by the teacher while imparting knowledge to the students are of utmost importance. There are several teaching methods a Mathematics teacher can adopt based on the topic to be taught and the level of the student or students to be taught. This is why a teacher is expected to carefully select an appropriate method for teaching any topic to any group of students for meaningful teaching and learning.

Set Theory deals with numbers, real objects, diagrams, visualization, and other items that can be grouped[7]. The methods adopted by a teacher should be methods that can make students comprehend easily and motivate students to be interested in learning. Such methods should encourage students' participation which gives room for self-expression. In order to adequately pass the knowledge of Set Theory down to students, there is a need for a professional teacher to be self-motivated, creative and have mastery of the topic.

Teaching and learning of Set Theory is a process that is facilitated by several factors, some of which are: teacher knowledge, enthusiasm and responsibility for learning; availability of

classroom activities that encourage learning; adopting assessment activities that encourage learning through experience and use of instructional materials. These factors are subsumed in the term teacher effectiveness which is the foundation for the effective use of interactive materials in classroom situations. In other words, they are part of the competencies, behaviours and characteristics possessed by a teacher which enable students to attain certain goals, solve problems, think critically, work collaboratively and acquire knowledge[8]. One factor that can affect the academic achievement of students is teacher effectiveness[9].

Interactive materials are aids fashioned to teach students. The use of these materials encourage active participation of students rather than passive participation as is expected from traditional methods of teaching where students just sit and try to take in the content of what is taught. Some examples of interactive materials for teaching Mathematics are: Probability – dice, games, cards, and counters. Mass, weight and volume (Mensuration) – Measuring scales and different weights. Telling the time – wall clock and stopwatch. Counting and simple arithmetic – abacus and pebbles. Fractions – edibles such as orange, pizza, cake and musical notation. Measuring angles – protractors, ruler, compass and set square.

Shapes (Geometry) – 2D and 3D shapes. Money – notes and coins. Mathematics games – Make-shift Venn diagram[10,11].

The use of constructed objects for the specific aim of teaching Mathematics cannot be over-emphasized as a crucial tool for learning Mathematics at both elementary school level and upper grade level. It has been observed that the use of specifically constructed objects for the aim of teaching and learning Mathematics create a good level of knowledge in such ways as:

it accords students the opportunity to create connections between their daily experiences and their emerging knowledge of mathematical concept; it is accountable for the development in Mathematical concepts and incites Mathematical reasoning; and it helps students create mental ideas of abstract mathematical concept[12]. Constructed objects for Mathematics teaching cover a variety of Mathematics topics. For example, there are educational constructed objects to practice addition and subtraction, probability, measurement, mensuration, Set Theory and many others such as place value cups, alligator, abacus, constructed venn diagram.

Educational constructed objects can be used to ensure a better understanding of Set Theory. The educational object to be used for this study is the constructed Venn diagram. It is made up of three large circular loops placed within a large rectangular box such that the three circular loops will interact with one another. The items to be used to explain the relationships that exist in the Venn diagram include: different types and colours of clips, sweets, and writing materials. The items are to demonstrate intersection, union, compliment of a set and universal set[13].

Academic achievement is the magnitude to which a student or school has attained educational objectives, be it short term or long term. It is the academic height that students have attained at school as shown through evaluation. It is of essence to consistently measure academic achievement because it provides vital information concerning students' proficiency of standards. Academic achievement can either be measured on a weekly, monthly, yearly or per term basis. The goal is to evaluate how students have assimilated what was taught in the classroom. It helps to ensure that the formative dimension of learning is taken care of in each subject. This show the learner areas that need improvement and areas where improvement have taken place[14].

If a teacher expects learners to understand and never forget the terminologies, principles and calculations associated with Set Theory, it may be many times more effective for the teacher to

show them what an interactive Venn diag ram looks like. With this, their visualisations will be translated into something concrete which may lead to a deeper understanding of the concept, and of course, a positive academic achievement.

Gender is a term developed by society to differentiate between the roles, behavior, mental and emotional attributes of males and females. There has been a major misconception about Mathematics and gender. Several people are of the belief that since Mathematics is about formulas and computations, it is majorly for the male gender. Several research results have it that the components of the brain of a female that focus on words and motor skills develop a year ahead than for males. This gives the female child advantages in reading and performing small motor tasks. The influence of gender on students' achievement in Mathematics has remained a controversial and topical issue amongst educationists, psychologists and researchers. This study seeks to find out if gender has a major role to play in the academic achievement of Senior Secondary School students in Set Theory[15].

Subject combination refers to the group of subjects offered by students in different departments in senior secondary school. These departments include science class, commercial class and arts class. The names of these departments shows the focus of each department for instance physics and chemistry is peculiar to the sciences, accounting and the study of commerce is domiciled in commercial class while history, literature and fine art are taught in arts class.

The combination of science, arts, and commercial subjects impacts the understanding of mathematical concepts. Language proficiency and using appropriate terms are crucial in learning Mathematics. Science subjects contribute to comprehension through quantitative reasoning and practical applications. The arts explore patterns, symmetry, and enhance problem-solving skills.

Business classes apply Mathematics to finance, economics, and statistics. Individual factors and teaching quality also influence mathematical understanding[16].

It has been observed from the Chief Examiner's Report over the years that Sets and Venn diagram questions, most times are either not correctly attempted or outrightly ignored[16,17,18,19].The low achievement in Set and Venn diagram questions might be due to the use of inappropriate teaching methods by teacher. Set Theory and Venn diagram are concepts that deal with series of definition, symbols, notations, illustrations and calculations[20].

The teaching method to be used should be one that makes the topic less abstract, easily understood and makes learning very engaging which is hands-on-approach. Therefore, there is need to carry out the study using interactive instructional materials. This study is therefore designed to investigate its effect of interactive materials' intervention on academic achievement of Senior Secondary School students in Set Theory.

1.2 Statement of the Problem

Studies have revealed that most Mathematics teachers especially in public schools are still hooked on the traditional/conventional methods of teaching Mathematics amidst the rise in the availability of instructional materials[21].Likewise, the Chief Examiners' Reports in Mathematics for some years reported Set Theory as a weak topic for students[16,17,18,19].It is either students provide wrong answers or they outrightly omit Set Theory questions. This means that students see Set Theory as a hard nut to crack. It is possible that these students performed poorly in Set Theory questions due to ineffective methods of teaching Set Theory by their teachers. Some studies have been carried out on the effect of teaching supported by interactive whiteboard on

students' Mathematical achievements. Some other studies have been carried out on the impact of using multimedia interactive programs to learn Mathematics[22,23,24]. However, to the best knowledge of the researcher, few studies have been carried out on the effect of interactive materials' on the academic achievement of students in Set Theory. Therefore, this study focuses on the effect of interactive materials' intervention on Senior Secondary School Students' Academic Achievement in Set Theory in Oyo South Senatorial district, Oyo State.

1.3 Aim and Objectives of the Study

The general aim of the study is to assess the effect of interactive materials' intervention on Senior secondary school students' academic achievement in Set Theory in Oyo South Senatorial District of Oyo State.

The specific objectives are to:

i. determine the previous Academic Achievement level of Senior Secondary School Students before the interactive materials' intervention in Set Theory in Oyo South Senatorial District, Oyo State.

ii. determine the present Academic Achievement level of Senior Secondary School Students in Set Theory after the interactive materials' intervention in Oyo South Senatorial District, Oyo State.

iii. determine the effect of interactive materials' intervention on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial district, Oyo State;

iv. investigate the effect of gender on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State;

v. determine the effect of subject combination on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State.

vi. determine the effect of interactive materials' intervention and gender on Senior Secondary School students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State; and

vii. investigate the effect of interactive materials' intervention and subjects' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State.

1.4 Research Questions

i. What is the previous Academic Achievement level of Senior Secondary School Students before the interactive material intervention in Set Theory in Oyo South Senatorial District, Oyo State?

ii. What is the present Academic Achievement level of Senior Secondary School Students in Set Theory after the experiment had been carried out in Oyo South Senatorial District, Oyo State?

1.5 Hypotheses

$H_0$1: There will be no significant main effect of interactive materials' intervention on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State

$H_0$2: There will be no significant main effect of gender on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State;

$H_0$3: There will be no significant main effect of subject combination on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State;

$H_0$4: There will be no significant interaction effect of interactive materials' intervention and gender on Senior Secondary School students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State;

$H_0$5: There will be no significant interaction effect of interactive materials' intervention and subject combination on Senior Secondary School students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State.

1.6 Significance of the Study

The findings of this research would be helpful to Mathematics teachers, parents and the school management in secondary schools as well as in lower level of education. It would help in informing teachers of the massive role interactive materials' intervention play with a view to improving teachers' output. The school management will discover the immense relevance of interactive materials' intervention as well. They will be motivated to take drastic measures in order to make available varieties of interactive materials that are necessary for the teaching of some Mathematics concepts. In addition, this study will serve as an eye opener to parents as regards the importance of infrastructural materials' intervention. It will encourage them to make available instructional materials for their children for after school studies. If the findings are not in favour of interactive materials intervention, teachers, parents and school management will come to the realisation that there are other methods of teaching that can increase student output.

This will enable them focus their time and resources on these other methods rather than on providing and utilizing interactive materials for an increased student output. Whatever the findings are, they will have a massive role to play in the teaching of Set Theory

1.7 Scope of the Study

The subject scope of the study is Set Theory in Mathematics, the population scope is Senior Secondary School Two (SSS 2) students, while the geographical scope is Oyo South Senatorial District, Oyo State.

1.8 Limitation of Study

The researcher had difficulties with students' reluctance towards answering Mathematics achievement test (MAT).

1.9 Operational Definition of Terms

Student Academic Achievement: This refers to scores of the students in the Mathematics Achievement Test(MAT). The test in this case are tests on Set Theory in Mathematics Achievement Test (MAT), whereby the high achievement group are students who scored 70 and above, medium achievement group are students who scored 50-69 while low achievement group are those who scored below 50.

Interactive Materials: These are aids fashioned to teach Set Theory for better understanding of the concept which students can see, touch and manipulate. The materials referred to in this research work is a make-shift Venn diagram and is made up of three (3) large circular loops placed within a large rectangular box such that the three circular loops will interact with one another. The items to be used to explain the relationships that exist in the venn diagram includes: different types and colour of clips, sweet and writing materials. The items are to demonstrate intersection, union, compliment of a set and universal set.

Subject Combination: This refers to students in different study area- Science, Commercial and Arts who attempted the Mathematics Achievement Test (MAT) in Oyo South Senatorial District, Oyo State.

Gender: This refers to male and female students in Senior Secondary School Two (SSS2) in Oyo South Senatorial District, Oyo State.

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Chapter Two

Literature Review

This chapter focuses on the review of literature related to the study based on the following headings:

2.1 Conceptual Review

2.1.1 Concept of Mathematics

2.1.2 Interactive Materials

2.1.3 Student Academic Achievement

2.1.4 Gender

2.1.5 Subject Combination

2.2 Theoretical Review

2.2.1 Contingency Management/Leadership Theory

2.2.2 Behaviourist Learning Theory

2.3 Review of Empirical Studies

2.3.1 Interactive Materials and Academic Achievement

2.3.2 Gender and Academic Achievement

2.3.3 Subject Combination and Academic Achievement

2.4 Conceptual Model

2.5 Summary of Gaps in Literature Reviewed

2.1 Conceptual Review

2.1.1 Concept of Mathematics

Have you ever wondered what farmers, scientists, painters, doctors, shopkeepers, accountants, cooks, carpenters etc. have in common? Apart from the fact that they are all occupations, they also share and utilize a body of knowledge whether wholly or partially. Mathematical concepts are vastly used by a variety of professionals ranging from unskilled laborers (farmers, painters, shopkeepers) to skilled labourer's (doctors, scientists, accountants, cooks) etc. Not only that, Mathematics is a recurring factor that influences the day-to-day life of living things[1].

Mathematics helps us shop wisely, read maps, tell the time, use an address, cook a delicious meal, remodel a home within budget, use the right computer or develop the next mobile app.

Insects are not left out of the utility of this recurring factor. They also make use of Mathematics in their everyday life for existence. When insects go foraging, they leave their nests in complex zig zag paths. Have you ever wondered how they manage to find their way back home? And how they manage to do so along a straight path? According to Andrew Phillippides of the center of Computational Neuroscience and Robotics at the university of Sussex the main navigation mechanism used by most insects is called path integration and involves a little geometry. The bottom-line is Mathematical concepts can be found in our everyday lives.

The Place of Mathematics in Everyday Life

All civilization comes to a standstill if Mathematics is shut out of daily life, In the world today, nobody can live without Mathematics for a single day. It is evident that Mathematics is around us all the time. When one is at the department store, balancing a cheque book or doing taxes, Mathematics is a necessary skill. Waiting in line either at the ATM for withdrawal of cash or at

the filling station to purchase petrol is an everyday reality which requires the utilization of Mathematics. All these involve the use of Mathematics. Other activities which involve its application n are captured in questions and assertions like: How many forks do we need on the table for everyone to eat? Can you count the teaspoons as I pour the oil? Ensure the eggs cook for nothing more than ten minutes. You will agree with me that Mathematics is heavily applied when cooking at home etc. Moreover, the pages of books we read have page numbers; the money we spend have number value which requires that we engage in regular arithmetic calculations (addition, subtraction, multiplication, division) when engaging in money related activities like preparing and planning for an event, shopping among others. The items we select off the shelves at stores and marts all have price tags which are numbers. Another way Mathematics is present in our lives is in the usage of numbers to calibrate watches and clocks. Also, our Ludo dice at home are characterized by having numbers ranging from one to six on each face[1].

Professions such as computer science, physics, engineering, actuarial Science, medicine and nursing require proficiency in Mathematics[2]. Almost all fields are beneficiaries of the analytical and problem-solving skills students learn in Mathematics. Even professionals as diverse as chefs or gardeners use Mathematical fundamentals when measuring and purchasing supplies. In event planning, Mathematics will help an event planner figure per head costs and inventory. Mathematics is used by seamstresses and decorators as well as anyone who works with measurements and schedules.

The Educational Values of Mathematics

Education is meant to contribute towards the attainment of:

Practical value (knowledge and skill).

Disciplinary value (intellectual habits and power).

Cultural value (desirable attitude and ideals)[3].

It can be said without any form of doubt that Mathematics has a very crucial role top for the achievement of the above values.

Any individual without a good knowledge of Mathematics will constantly be needing the help of others and will easily be cheated. This brings me to say that no individual can function without the use of fundamental processes of Mathematics in daily life.

Persons belonging to different socio-economic class of the society utilize knowledge of Mathematics in one form or another. An engineer, a businessman, an industrialist, a banker, a financier, a finance minister, a planner or a boss of any concern, even a labourer will have to calculate his wages, make purchases from the market and adjust the expenditure to his income. Counting, notation, addition, subtraction, multiplication, division, weighing, measuring, selling, buying and many more are simple and fundamental processes of Mathematics which undoubtedly has an immense practical value in life.

Mathematics possesses a real disciplinary value. It is exact, true and to the point knowledge and it therefore creates a discipline in the mind. Their genuine depictions are definite and exact. The learner has to argue the correctness or incorrectness of a statement. It develops reasoning, thinking powers and demands less from memory, if taught in the right sense. Reasoning in Mathematics possesses certain characteristics which are suitable for the training of the learner's mind. If properly emphasized, these characteristics are likely to develop the corresponding habits in the learner. The characteristics are listed below:

1) Simplicity

2) Accuracy

3) Certainty of results

4) Originality

5) Similarity to the reasoning of life

6) Verification of results

7) Power not knowledge

8) Application of knowledge

It has been rightly said that "Mathematics is the mirror of civilization. Mathematics has its cultural value and this has helped man to overcome difficulties in the way of progress.

Modern civilization owes its advancement to the progress of various occupations such as agriculture, surveying, medicine, railroad building, industry etc. These occupations build up culture and they are its backbone. But one should note that Mathematics contributes and has contributed extensively to the advancement of these occupations. Therefore, it can be said that Mathematics shapes culture. It is likely that the modern materialistic attitude in everything is the outcome of the deep influence of Mathematics on life and culture.

The Use of Mathematics Topics for Everyday Tasks

Arithmetic

When man first wanted to answer the questions:

How many

How much?

How big?

How long?

He invented arithmetic.

Arithmetic crops up a lot in daily life. For example, working out the dose of medicine to administer to a younger sibling or if a certain amount will last as pocket money for the whole month.

Algebra

Algebra was devised to simplify arithmetical computations[4].A real-world example of using algebra is pricing. Let's say one has ₦5000 and wants to buy a dress that costs ₦3000 with the intention of spending what's left on chocolates. Chocolates cost ₦250 a piece. How many chocolates can they get?

₦250X = ₦2200

X = ₦2200/₦250

X 8.8 pieces

This implies that the money left on the individual can get 8 pieces of chocolates with a remainder of 200 naira.

Fractions, Decimals and Percentages

We use a decimal system to write numbers. The word "decimal" comes from the Greek word for 10, and our system is based on the number 10. Every positive whole number can be written with the 10 symbols from this system of numbers. The symbols are 0, 1, 2, 3, 4, 5, 6,7,8,9. With the additional help of the minus sign and the decimal point, we can write any number as accurately as we want[5]. If chefs, or cooks don't get the proportion between the ingredients right when they are cooking, the result will not be palatable. Some materials used for building like cement and bricks are made of various components that need to be mixed in the right proportions. Music is also founded on proportion.

Geometry, Trigonometry, and Measurement

Mathematics is a core component of every engineering field and is also used in research. In construction, mathematical concepts such as measurement, geometry and trigonometry are used for building roofs or houses, plasterers use ratios for mixing compounds, plumbers use hydraulics for heating systems. Also, the mathematical aspect mentioned above play a crucial role in architectural design. Architecture applies these mathematical forms to plan their blueprints or initial sketch designs[6].

Probability

We use probability in daily life to make decisions when we are not certain of what the outcome will be[7]. Most times, we won't perform actual probability problems, but we will use subjective probability to make judgment calls and determine the best course of action. Some of the major ways we use probability in our day-to-day activities are highlighted below

Meteorologists cannot predict exactly what the weather will be and so they use tools and instruments to determine the likelihood that it will not rain or the likelihood that it will rain[8]. For example, if there's a 70 percent chance of rain one may settle for closed toed shoes rather than sandals or take an umbrella to work.

Probability plays a crucial role in analyzing insurance policies to determine which plans are best for one and one's family. For example, when choosing a house insurance policy, you use probability to determine how likely it is that you will need to file a claim. For example, if 20 percent of houses in one's community were razed by fire, they will likely want to consider a comprehensive insurance on their house[9].

Simultaneous Equations

Simultaneous equations are readily used to solve problems we encounter on a daily basis especially those that are more difficult to think through without writing anything down. Son ways simultaneous equations can be used in everyday life are as follows:

Rate;

Distance; and

Time

It is possible for one to calculate the best rate for their running or cycling schedule by creating a mathematical expression that can help ascertain the distance and average speed for various routes. The equations can be used to maximize time for building endurance or to maximize speed for performance. Also, the same formula can be used to determine speed, distance and time duration when travelling by car, plane or train[10].

The best deals and plans: For example, when comparing two rental companies to find out the better deal when renting a car, the best bet is to put the variables and fixed costs, such as per mile and daily rate into algebraic expressions then solve for the total cost. With this, one can ascertain the company that saves them money for different amounts of driving. Also, the same process with a system of equations can be used when on the verge of deciding on the best mobile phone plan.

The Use of Calculus in Everyday Life

Calculus is mostly used by engineers, scientists, and economists. The work of these professional has a huge impact on our daily life - from your microwaves, cell phones, TV and car to medicine, economy and national defense[11]. There are a large number of applications of calculus in our daily life. Some are highlighted below:

1. An architect uses integration in determining the amount of the necessary materials to construct curved shape constructions (e.g., dome over a sports arena) and also to measure the weight of that structure. Calculus is used to improve the architecture not only of buildings but also of important infrastructures such as bridges[11].
2. In electrical engineering. calculus (integration) is used to determine the exact length of power cable needed to connect two substations, which are miles away from each other[11].
3. Space flight engineers frequently use calculus when planning for long missions. To launch an exploratory probe, they must consider the different orbiting velocities of the earth and the planet the probe is targeted for, as well as other gravitational influences like the sun and the moon[11].
4. Biologists use differential calculus to determine the exact rate of growth in a bacterial culture when different variables such as temperature and food source are changed[11].
5. In Physics, integration is very much needed for example, to calculate the centre of gravity and mass moment of inertia of a sports utility vehicle[11].
6. Mathematics also enables Physics to calculate the velocity and trajectory of an object, predict the position of planets, and understand electromagnetism[12].
7. Statisticians use calculus to evaluate survey data to help develop business plans for different companies. Because a survey involves many different questions with a range of possible answers, calculus allows a more accurate prediction for the appropriate action[13].
8. An operations research analyst will use calculus when observing different processes at a manufacturing corporation. By considering the value of different variations, they can help a company improve operating efficiency, increase production and raise profits[13].

9. In Chemistry, it is used to determine the rate of a chemical reaction and to determine some necessary information of radioactive decay reaction[13].

Let's take a look at some other examples:

i. Doctors and lawyers use calculus to help build the discipline necessary for solving complex problems, such as diagnosing patients or planning a prosecution case[14].

ii. The field of epidemiology-the study of the spread of infectious disease - relies heavily on calculus. It can be used to determine how far and fast a disease is spreading, where it may have originated from and how best to treat it[14].

The Relation of Mathematics with other Subjects

Mathematics and Physics

Observation has it that no other science is as close to Mathematics as Physics is. For someone to take up a higher education in Physics with confidence, such an individual must have a mathematical mind, this is because mathematical calculations occur at every step-in physic.

Mathematics has absolutely necessary characteristic that shapes Physics concepts by sharpening and extending their meaning.

The units of measurement are frequently utilized in both Mathematics and Physics.

The principle of balance of the sides of an equation in Mathematics is the basis upon which the Law of lever in physics stands. Tables of specific heat, latent heat and melting points have been prepared with the help of Mathematics.

The Law of Gravitation is given in form of an equation:

$F = G. m_1m_2/r_2$ [15].

The list goes on and on.

Mathematics is found in every part of physics so much that its impact and influence can be felt tremendously.

Mathematics and Chemistry

All chemical combinations and their equations are governed by certain mathematical laws. Formation of chemical compounds is mathematically inclined. It deals largely with the addition rule in Mathematics. Water which is a compound is formed by adding two atoms of hydrogen with one atom of oxygen. Knowledge and skills in certain aspects of Mathematics like basic Mathematics, calculus etc. can be useful as a prerequisite to understanding General Chemistry[16].

Mathematics and Biology

Mathematics is an integral part of biology, as it explains or predicts so many different things. Its processes and calculations have been applied to advanced studies in heredity, growth, nutrition, maturation and many other branches. To explain the emergence of systemic functional properties of the living cell that result from the interactions of its components, the biologist needs to be equipped with the knowledge of theory of non-linear differential equations and their numerical analysis, linear algebra, theory of matrices etc[17].

Mathematics is used for basic, raw data gathering that is beneficial in tracking changes over time.

Mathematics and Agriculture

It is no doubt that Mathematics does not play a subtle role in Agriculture. Its application can be found in many ways: calculation of various fertilizer contents, measurement of land or area, production per unit area, average return or income, soil analysis, cost of labour, use of statistics in estimation, seed rate, manure rate etc[18].

The progress of a farm can be ascertained by drawing graphs of different items of production.

Mathematics and Economics

It is no news that economics modules are usually filled with Mathematics and statistics used to explain economic phenomena. Economic phenomena are described frequently with the use of mathematical methods and this is because Mathematics is the foundation upon which it rests. Mathematics is very necessary for the study of economics in that in most universities of the world, a course in advanced Mathematics is a necessary part of degree course in economics. Different issues of economics such as expenditure of public money, population trends, industrial trends etc. can be represented statistically

Literature and articles on economics can be better understood by one with good mathematical understanding. Being familiar with mathematical concepts like Variation, percentage, ratio, average variable etc. will aid in faster and better understanding of economics.

It is believed that Mathematics may have become so important in Economics to attain scientific respectability[19].

The Relationship Between Mathematics and Some Fields

Mathematics and Sports

Several people are familiar with sports rules and terminologies; however, there are not always aware of the important role that Mathematics play in sports. Concepts such as the likelihood of a particular athlete or team winning is mathematical in nature. Let's look at a few sports, basketball and football for instance.

To determine the velocity at which a basketball player must throw the ball in order for it to land perfectly in the basket we use the equation:

$F(x) = (-16/(V_0)^2\cos^2 \alpha)\ X^2 + (\tan \alpha)\ X + h_0$[21].

To find the velocity at which a player would need to throw the ball in order to make the basket, we will need to find the range.

Range = $((V_0)^2 \sin (2\alpha)/32$[22].

A football field is 100 yards long and is marked every 10 yards by a line. The 50-yard line is in the center of the field and it divides one team's side from the other.

To calculate distance across the field, the distance on both sides of the 50-yard line is calculated. For example, if the football was kicked from the cardinal's 25-yard line to the raiders 40-yard line, how long was the kick? This can be calculated using simple arithmetic[23].

Mathematics and Medicine

Professionals use Mathematics for a countless number of activities like, reading of results from CAT scans, MRIs and X-rays and to evaluate body mass index. Mathematics is also used by nurses. physicians and others in the medical industry on a regular basis in hospitals and offices when Conducting research. Physicians and nurses use Mathematics to write prescriptions for medication and determine proper dosage. At times doctors recommend doses of medicine based on patient's body weight. This means that doctors must convert weight from pounds into kilograms and make a conversion of medicine into milligrams per kilogram. Doctors will have to determine how long patients must continue taking medicines and how long the medicines will stay in the body.

In areas of research, Mathematics is not let out. Medical professionals draw and analyze graphs. They also study statistical trends to understand the level of spread of chronic illnesses and diseases in a particular society. Mathematics is also used by doctors when reading results from

X-rays and CAT scans to convert the two-dimensional images on the screens into three-dimensional body parts[19]. They ascertain abnormalities by looking at body parts from differing angles. In addition, Mathematics is used in;

Drug designing

Ascertaining solubility time [the time taken for a substance (the solute) to dissolve in a solvent.

Determining biological half-life (the time a living body requires to eliminate one half the quantity of an administered substance through its normal channels of elimination Haematrocrit (the ratio of the volume of red blood cells to the total volume of blood)[24].

Mathematics and Arts

There is a large amount of Mathematics involved in art, not to mention basic things like measuring and lines, but the intricacies of art can often be described using math. Mathematics can be recognized in arts such as music, dance, painting, architecture, sculpture and textiles. Mathematics and art have a long historical relationship. Persistent popular claims have been made for the use of the golden ratio in ancient art and architecture, without reliable evidence[25].

Mathematics and Painting

The Monalisa painting a famous piece done by Leonardo Da Vinci, is drawn according to the golden ratio. The golden ratio is 1:0.618 and has been named golden because it gives satisfaction to the senses. The golden proportion can be found throughout the human painting. A golden rectangle is simply a rectangle with dimensions that reflect the golden ratio. The Mona Lisa has many golden rectangles throughout the painting. When we draw a rectangle around her face, you will see it is golden. If we divide that rectangle with a line across her eyes, we get another golden rectangle, meaning that the proportion of her head length to her eyes is golden. There are other rectangles that can be drawn on the rest of her body, like from her neck to the top of her hands[26].

Mathematics and Music

According to Pythagoras, you can find Geometry in the humming of strings and music in the spacing of spheres. In actuality, Mathematics and music are indeed related. Counting of beat, rhythm, scales, intervals, symbols, harmonies, patterns, overtones, pitch, tone etc. are all connected to Mathematics[27].Listed below are some of the distinct ways Mathematics is related to music

1) Reading of music is related to Mathematics.

Music is divided in sections called measures and each measure has equal amounts of beats. It is similar to mathematical divisions of time. The notes and rests in music have mathematical connections.

2) The frequency of sound is related to Mathematics.

The Greek philosopher and mathematician, Pythagoras, realized that different sounds can be made with different weights and vibrations. In other words, the pitch of a vibrating string can be controlled by its length. The longer the string, the lower the pitch and vice versa.

3) Patterns are used both in music and Mathematics[24].

Mathematics involves creating of patterns of sound and Mathematics is the study of patterns and so, one can study everything in music from different mathematical perspectives, including differential calculus, number theory, trigonometry and so on.

Mathematics and Architecture

Over time, Mathematics has been seen as a very important tool for design, execution and finalization of building projects. In history, architects were mathematicians and also, some mathematicians were architects too. In architecture, shapes, spaces and their order along their geometry contributes to the process of composition and designing of any element of architecture

Some architectural pieces which have stood out over the years are:

The great wall of China; Pyramids of Egypt; The statue of Liberty and Eiffel Tower[25].

Mathematics Behind Eiffel Tower

Eiffel tower was produced by a French engineer, Gustave Eiffel. He is said to be one of the premier structural engineers in history. The tower was designed to be the masterpiece of the World's exposition in Paris, marking the centennial of the French revolution.

The spectacular tower, completed in 1889 and which remains one of the most romantic and recognizable structures in the world, has long been believed to be explainable using a mathematical equation. Considering the second edition of Advanced Engineering Mathematics text book, observations have shown that the book's cover contains photographs of various stages of the Eiffel towers construction, and the book's preface contains a non-linear integral equation a formula with a number of possible solutions for the tower s shape. An American Engineer Professor Patrick Weidman produced a mathematical model explaining the elegant shape of the Eiffel tower after series of researches into solving the problem embedded in the text book.

The tower is 1063 feet tall. This is approximately equal to the height of an 81-story building. It has 1710 steps. It weighs around 10,000 tons. Winds can cause the top of the tower to sway.

Side-to-side, by up to 7 centimeters (2.8 inches)[26].

It takes approximately 50-60 metric tons of paint to paint the tower.

Mathematics Behind the Statue of Liberty

A sculptor by the name of Frederic Auguste Bartholdi designed the statue and Gustave Eiffel (the man who designed the Eiffel tower) was responsible for the iron framework underneath the copper plaiting. The statue was built in Paris and then shipped to the U.S in 1885.

Though it wasn't stated, it is no doubt that the knowledge of Mathematics must have been utilized to a great extent. This is because, mathematical equations form the basis for such colossal and intelligently built structures.

The height from the ground to the tip of the torch is 305'6". The torch is 298 above ground.

305’6’’ – 298’ 7’6’’ tall torch.

One arm is 42’ long.

There are 25 congruent windows in the crown.

The statue and base weigh 450,000 pounds.

The eyes are 2’6” across.

The nose is 4’6’ tall.

The mouth is 3’ wide.

The tablet in its arm reads July 4, 1776 in Roman numerals.

There are 354 steps inside the statue and its pedestal.

354 steps = 22 storey building.

It would take 4,000 yards of real fabric to make a dress the same size

The length of the sandal is 25’.

The copper took 25 years to turn green.

It is obvious that numbers and measurements were hugely at play in the construction of the statue of Liberty[27].

Mathematics Behind the Great Wall of China

The building of the great wall of China started in about 700BC. The Chinese would have had used Mathematics in the construction of the great wall. They needed to know how long the wall would be in order to know how much supplies they would need. They also needed to calculate

how tall the wall would need to be in order to keep enemies out. Additionally, the Chinese would have needed to figure out how wide to make the wall so that it will be sturdy enough to support the weight of the people walking on it.

The Chinese were one of the major pioneers of Mathematics development. Chinese Mathematics influenced modern Mathematics greatly. They created a Chinese ancient calculator called Abacus, which influenced our tools that help solve Mathematics problems. They also wrote the Nine chapters on the Mathematical Art. The Chinese used Mathematics to solve problems that involve engineering like the construction of buildings as we do today.

And so, this brings me to say that, Mathematics laid the foundation for erection of the great walls. They must have used the Abacus to make calculations to ascertain the amount of supply needed. They must have used a measuring tool, maybe a calibrated rope to ascertain the length, breadth and height of the walls at different points of its erection. Mathematics must have been used in many other ways[28].

The Crucial Effects of Mathematics on the Smooth Running of The Universe

Nearly everyone enjoys the change of seasons on Earth- from dry season to rainy season, from winter to spring etc. But have we ever probed into the reason for the changes?

Mathematics is a crucial factor for the smooth running of the universe. The Earth is tilted at an angle of 23.5 degrees and that can account for the changes of seasons.

Have we ever asked ourselves what would happen if the Earth did not have a tilt.

If the Earth weren't tilted, there would be no seasons and humanity would suffer[29].

Concept of Set Theory

Set Theory can be said to be the applicable starting point of Mathematics. Because of its expressive nature, Mathematicians use Set Theory in communicating and representing ideas. It is

used in unfolding the algebra of rings, groups and fields. It is also a logical basis for calculus, topology and geometry. Set Theory is a concept that is clearly seen in our day-to-day experiences[30].

Application of sets and Set Theory in situation Real Life situation

We are always encircled by sets and its applications in our daily lives. Some vivid examples are explained below.

1. **Making a playlist of songs:** We categorize songs into different playlists by finding connections or similarities between them.

   A clear illustration is: Beauty has 72 songs in her phone music collection. She might decide to create her playlists based on any or some of the categories below:

   Name of artist, genre of Music, pace of song (slow songs, fast songs)

   time of release (70's, 80's, 90's, 2000's), purpose (Gospel music, secular music).

   Every category of songs in Beauty's music collection is a distinct set. The major aim of grouping things according to their connection or similarity is to make for easy access and a beautiful symmetry.

2. Expressing ourselves in words: When we speak or write what is in our mind, we make use of sets without even realizing it. For example: I work on every working day (given set of all days of my working life) excluding holidays, weekend (given sets of days excluded)[29].

3. A teacher may ask her students who did not attempt their homework from a whole class of boys and girls (union of sets) to stand together[31].

Importance of Set Theory in the Philosophy of Mathematics

Set Theory is closely connected to logic, which is a branch of Philosophy. It is obvious that Set Theory is a tool that helps us accurately express the connection between visualized (abstract) objects, we call sets.

1. Set Theory can be referred to as a starting point in Mathematics, and this is because sets can be used to encode other mathematical items such as numbers. Also, we can add new structures to sets to bring about new category of Mathematical items.
2. Set Theory helps philosophers understand Philosophical aspects of issues in fields of investigation like computer science and linguistics[32].

Importance of Set Theory in Business

Set Theory can help in the planning and operations of any business. Every component of business can be categorized into at least one of the following; sales, production, management, operations and accounting. Inside those sets are other sets. For example, in operations, there are sets of administrative operations, sales operations and warehouse operations. In some instances, sets intersect – administrative operations set can intersect sales operations set and warehouse operations set.

Businesses have dealings with diverse groups of people; some are one-off buyers, regular buyers (patrons), suppliers or distributors.

There are also different capital, products and employees. This suggests that, there are a lot of mutual activity between people and objects in business operations ascertaining the articles that businesses deem necessary and the persons to provide these essentials, they can be able to make the best deal thereby saving money. By categorizing the essentials as one set and the providers of

the essentials as another set, businesses can use one of the Set Theory notations (intersection) to obtain the smallest set of the suppliers or providers of the essentials for all their required inputs[33].

were merely selected randomly and did not show any promise. Also, the students in the control group of the experiment carried out by the duo had lesser scores compared to the experimental group. This effectively showed that the factor that made the difference is teacher expectation since the students in the control group were presented as "normal" students and the teachers treated them as such. The result of the experiment shows that student academic achievement is affected by what teachers expect of their students. Thus, teacher expectation is essential to the effectiveness of the teacher.

2.1.2 Interactive Materials

Mathematics is an abstract representational system used in the study of numbers, shapes and the relationships between these concepts[34]. It has been observed that students are often engulfed by the complex nature of Mathematics, its scope and techniques required to learn.

This is the reason Mathematics classes should be interactive. Students should be able to interact with learning materials that will first of all, help them develop interest in the topic and then keep them productively engaged throughout the learning period.

Set Theory is a very prevalent part of Mathematics, and so it is the foundation from which nearly all of Mathematics originates. Care must be taken by teachers to ensure learners have a deep understanding of the concept[35].

Interactive materials in teaching and learning situations are those items, real objects students can see, touch and manipulate in order to make decisions and solve problems[35].

The use of interactive materials in teaching and learning situation might lead to:

1. **Deeper Understanding**: - Mathematics teachers expect students to develop a deeper understanding of the concept taught. When a learner has deeper understanding, he or she will be able to make conceptual connections, generalizations and be a problem solver
2. **Motivation to Learn: -**Most learners stay away from Mathematics classes. And even when present in class, they are not willing to learn. Instead of getting bored, they become eager to learn because the teacher has introduced real objects or interactive materials they can connect with
3. **Increased Engagement**: - The use of interactive materials in classroom situations help to capture and hold the attention of students. It also increases student participation which helps to reinforce what is learned. This also creates an opportunity for group work leading to exchange of ideas between students and teacher[35].

Interactive Materials can either be concrete or virtual. Concrete Interactive Materials are physical objects that are used as teaching tools to engage students in the hands-on- learning of Mathematics[36]. Virtual Interactive Materials are those online resources and activities that are used as technological teaching tools to engage students in interactive learning of Mathematics[37].

Concrete Interactive Materials can be categorized into realia, constructed objects for teaching specific concepts and Mathematics games.

In education, realia are objects from real - life situations that are used by teachers in teaching and learning situations to improve students' understanding of what is taught. They are simple objects that are easy to control with the lowest risk of causing harm as students interact with them. Realia can be everyday objects found around an average classroom or household. Some

convenient and effective Interactive Materials used in the teaching and learning of Mathematics are: pebbles, cylindrical tin, coin, paper money, pizza, biscuits/cookies of different shapes and several others. Realia can be effective instructional strategy both at school and at home. Parents and family members can introduce suitable realia to children at home in order to reinforce abstract mathematical concepts[38].

Constructed Objects

These are objects or materials specifically created or put together for the teaching and learning of Mathematics. Some examples are as follows: The Amazing Addition Apparatus, Mathematics Dice, Place Value Cups, Cards and Erasers, Mr. Alligator, The Amazing Addition Apparatus, Materials required: Pool noodles, cardboard, adhesive, pebbles and a bowl.

Description: This apparatus creates excitement in early childhood students about learning the concept of addition due to its visually appealing characteristic. With the help of the first pool noodle, the student picks his/her desired number of pebbles and places it into the apparatus. With the help of the second pool noodle, the student picks more pebbles and places into the apparatus. The student adds the two numbers by counting the total number of pebbles in the collection bowl. This apparatus allows children develop addition skills while simultaneously having fun[39].

Mathematics Dice

This game can be used to strengthen addition, subtraction, multiplication, division and algebraic skills in students.

Addition and Subtraction

Younger students can create simple addition and subtraction equations using Mathematics Dice. The instructor will ask students to roll the target dice/die to get a target number. With the target

number in mind, students will roll two or three of the scoring die and add them together in a bid to see how close they come to the target number[40].

Multiplication and Division

A more complex game will be played to enhance multiplication and division skills. The instructor will ask students to roll the two-target die, they are to multiply the two numbers to come up with a specific number. The instructor will have students roll the three-scoring die and use the numbers to come up with a series of equations that will get them as close to that target number as possible. The instructor will encourage students to device more ways the numbers can be manipulated in order to get the desired result. Instructors can lead the game in a variety of ways to benefit different learning groups. Teacher can challenge students to come up with as many ways as possible to arrive at the target number or a number very close to it while awarding a point to the student that gets the closest[40].

Higher Mathematics

Mathematics Dice can be used for algebraic equations as well. The digits on the scoring die will represent root or power. For example, if the target number is 30 and the scoring die numbers are 2, 5 and 6, a student can build an equation that reads, 5^2+5. Since $5^2=25$, by adding 5, a student can reach the target number. Calculating square roots follow the same principle. For example, if the target number is 9, and the scoring numbers are 2, 3 and 6, students can add 3 and 6 to make 9 and use the 2 to create 9^2 which is 81. Making the game more or less complicated lies in the hands of the teacher and it is dependent on the age range/ class of students involved[40].

Place Value Cups

Materials: Permanent marker(s) and styrofoam cups (the number of cups depends on the place value being added).

Description: The instructor gives the student a number. The student will try to illustrate the number using the styrofoam cups and their understanding of place value. This material would be so much fun in class if students are paired in such a way that each student can challenge their partner to create the number that he/she supplies.This material is a fun way to teach and learn the concept of place value. It is also very affordable[40].

Cards and Erasers

Materials: Playing cards, virtually appealing erasers of the same size.

Description: Instructor can group students in fives. One student is the number creator while the other four are the number checkers. The number creator flips over two playing cards while the number checkers lines up the correct number of erasers to match the numbers displayed[40].

Alligator

Materials: Green construction paper, printed number cards, printed addition sign, printed subtraction sign, printed equal sign.

Description: This is a fun interactive material. The instructor will have to create a background story about Mr. Alligator. For example, Mr. Alligator is always known for eating all the time because he is always hungry. Will he turn his mouth towards the smaller number or the bigger number? This Interactive Material is used to reinforce greater than/less than skills. It can also be an effective tool to practice the concept of place value[40].

Mathematics Games

The use of games cannot be overemphasized as a crucial tool for learning Mathematics in elementary school. It has been observed over the years that game - based learning creates a good level of knowledge in such ways as:

It encourages, mathematical reasoning and strategic thinking.

It is accountable for concept development in Mathematics and incites mathematical communication.

Most Mathematics games at the elementary level are multi-sensory. That is, it incorporates sound, sight and touch into learning[41].

Mathematics games cover a variety of Mathematics topics, for example:

There are games to practice addition and subtraction.

There are games to teach learners how to find the simple interest and compound interest of different loans.

There are manipulative games to practice Set Theory[42].

Monopoly Board Game

Monopoly has more than 1200 editions and this is due to the love and acceptance it has garnered all over the world. Monopoly is a game played by a minimum of two and a maximum of eight players. Rolling two dice is the ticket to moving around the game board, trading properties and then investing into available assets. Players try to force opponents into a situation where they become bankrupt, by collecting payment for the usage of their property. Skills required for this game are: negotiation, strategy, resource management and financial management. The central point of monopoly is on making money, wisely spending and investing it, then safeguarding the profits accrued[43].

Components of a Monopoly Board Game include a board, two dice, tokens for each player, 32 houses and 12 hotels, 16 chance and community chest cards, 28 Title Deed cards for each property, money,

To begin playing, you need to first set up the board with the following steps

1. The board should be placed on a table or any convenient surface.
2. The chance and community chest cards should be placed on their spaces on the board with their faces down
3. Each player is to choose one token to represent them
4. Each player is to be given $1,500
5. A banker must be selected to manage the affairs of the bank. The banker can be a part of the game or not. If the banker is one of the players, then he must keep his funds separated from bank funds[43].

How to play the game of Monopoly

The game begins with the roll of two dice by all the players. The player that roles the highest becomes the first player and the game continuous clockwise, from that player. Once it is your turn, there are four major things you should do. They are:

1. Roll the dice and move the number of sequences specified. Whenever you pass 'GO' you are entitled to $200 from the bank.
2. You are free to purchase any property you land on from the bank provided it is not owned by any player. Your failure to purchase the property will make the banker auction the property to the one who offered the highest amount of money.

3. You may decide to build when you are the owner of all the properties in a color group. You can also decide to situate a hotel on a property. Both houses and hotels can be bought from the bank.
4. Fulfill essential operations. You will need to pay rent for the property you are occupying, as established by the title deed. It is an obligation to pay Income Tax to the bank (10% of your total assets). It is also mandatory to follow the instructions of a community chest or chance card drawn. You can then return the cards to the base of the stack of cards when you are done with carrying out necessary operations.

Going to Jail

A player can be sent to jail by:

1. Landing on a space marked 'Go to Jail'
2. Drawing a card with the mark 'Go to Jail'
3. Rolling doubles three consecutive times

Once in Jail, there are four ways to get out.

You must have to;

1. Pay the fine before rolling the dice. It is usually $50
2. Make do with a 'Get out of Jail' free card prior to rolling the dice
3. Roll doubles
4. Pay $50 fine and exit from jail after the third unsuccessful trial to roll doubles.

Once you exit from jail, move the number of squares specified by the dice Money to Pay Rent and Other Monetary Obligations. According to the rules of Monetary, if you lack enough funds to meet up with your monetary obligation during your turn, you may decide to sell any of your

property. You may not sell to the Bank. You can sell unenhanced properties like utilities and railroad to any player for any amount.

Winning the Game:

To ascertain the winner, the players may choose to play until one player has been declared insolvent, then compare the total worth of each player or players can decide to end the game at any time. If players decide to play the game till the last man standing, then the last player wins the game. If players decide to end the game at any time, then the one with the highest amount of money wins[43].

Mathematics Skills Learned by playing Monopoly

The following Mathematics skills are learned;

1. **Counting Money:**

   In the game of Monopoly, there are series of occasions to count money. Players acquire properties, make payment for taxes, pay other players for landing on their property and so on. This game teaches players to develop and accurate money counting skill[43].

2. **Making Change**

   Whenever a player makes payment to the bank, in most cases, the banker will need to give change from that transaction. By giving your young one the opportunity to be the banker in the game, they will be learning yet another Mathematics skill. With this, your young one will learn to make subtractions in order to calculate the amount of change to be handed back, when players make rent payment on their properties

3. **Basic Addition**

   Probability and problem-solving skills.

   Rolling the dice is the means through which players can make their way around the board

And so, the regular act of rolling and adding up dice helps young players harness their addition skills. Also, moving through the game, they begin to understand that moving from square to square (corner) or moving from rectangle to rectangle (side) is equal to spaces. This will bring up the analytic skill in them, they will begin to figure out how to get at least a ten when the dice is rolled to enable them reach the other side. The aforementioned is a display of probability and problem-solving skill and the regular playing of Monopoly will help develop these skills in both young and old[43]

4. **Number Sense**

Number sense is a concept probability teaches players it is applicable in the following:

- Rolling the dice and moving your piece the number of spaces signified.
- Observing the patterns in buildings and rent. For example, 1 house $120, 2 houses $240.
- Counting by ones, fives, tens, twenties, hundreds and five hundreds when dealing with money (this is linked to multiplication)
- Moving your piece, the accurate number of spaces.
- Studying numbers both on the property card and on the money.

5. **Decimals and Percentages**

When a player lands on income tax, they will be expected to pay ten percent of what they own.

Working out 10% of three to four digits without the help of a calculator is a good way to improve in mathematical problems relating to percentage and decimals. When a player does this too often, at some point they will not need to make calculations any longer because it will be very evident that 10% 100, 250, 750 are 10, 25 and 75 respectively[43].

6. Multiplication

Multiplication is another Mathematics concept that can be developed with the help of Monopoly game. When a player either owns the Water works or Electricity company to calculate four times his rolls if the player owns both, he is to calculate ten times his rolls, to work out 4 x $7 mentally, a young learner may decide to use the repetitive additive rule (7 + 7 + 7 + 7 +) which equals $28 or he might decide to do a straight multiplication 4 x $7 which will give $28. This is a very good way to improve on multiplication skills cause when a player knows that 4 x $7 gives $28 when he or another player lands on a waterworks or Electricity company that is worth $7, he will not hesitate to yell $28 and that is because he has once come done the mental or calculation when he landed on that same property[43].

2.1.3 Student Academic Achievement

The goal of the education is the improvement of the mind, the body and the soul of the individual. Of these three things, the improvement of the mind, also known as the intellect, is usually the focus of tests and examinations. However, the other two are as important for success in life as the intellect. Moreover, they serve as facilitators of the learning process. An emotionally balanced pupil is more likely to assimilate what is taught by the teacher than one who is emotionally unstable[44]. When the improvement of the mind is measured using standardized tests, the end result of the process is known as academic achievement, especially when it involves one subject. This makes it different from academic performance which is taken as the level of improvement attained by a child in all the subjects offered in a specific frame of time. Apart from standardized tests, academic achievement can also be indicated via class work[44].

Academic achievement can either be measured on a weekly, monthly, yearly or per term basis. The goal is to evaluate how well students have assimilated what was taught in the classroom. It helps to ensure that the formative dimension of learning is taken care of in each subject. This shows the learner areas that need improvement and areas where improvement has taken place.

Factors That Affect Academic Achievement

Academic achievement is influenced by various factors. Among these are intelligence quotient, conscientiousness (aka diligence), early academic achievement, parents' academic socialization, self-efficacy, expectancy, goal setting, emotional intelligence amongst others. Some of these factors can be classified as differences between individual students e.g., intelligence quotient while others are simply results of personal effort e.g., expectancy[44].

Intelligence Quotient: Intelligence quotient is a number which indicates how intelligent an individual is. It is measured through standardized tests. Its measurement is based on comparison with the scores of others who took the same test. The average score on an intelligence test is usually 100.

Intelligence quotient is an abstract concept. Its measurement is therefore not absolute.

Instead, it is an approximation. Traditionally, IQ tests, are obtained by first getting the mental age of an individual with the use of intelligence test. This mental age is then divided by the individual's chronological age. This result in a fraction or quotient which is then multiplied by 100 to get the final score, hence the name intelligence quotient. The fact that IQ tests are relative makes them different from measures like mass, weight, distance.

The intelligence quotient of an individual determines how quickly and easily they grasp new concepts and ideas. It also determines how curious they are to learn new things. For this reason, IQ is a factor which determines how well an individual learns in the classroom[44].

Conscientiousness: This is otherwise known as diligence. It is a personality trait which indicates carefulness, thoughtfulness, planning, and organization and so on. Conscientious individuals tend to pay attention to details. They also neat and systematic in their approach to any task they are given. They are usually reliable and can be expected to deliver as and when due. From the description of conscientiousness given above it can be seen that it is central to the process of learning new things[44].

2.1.4 Gender

Gender refers to the social and cultural differences that a society assigns to individuals based on their biological sex; it is a social concept rather than a biological one. Whereas sex refers to the anatomical and biological differences between females and males that are determined at conception and develop throughout childhood and adolescence, gender goes beyond biological factors and encompasses the societal expectations of behaviour and attitudes associating with gender[45].

In many societies, gender roles are established to delineate the expected behaviours, roles, and characteristics based on perceived gender. These societal expectations of behaviour and attitudes are commonly known as femininity and masculinity. Femininity typically refers to the cultural expectations placed on females, while masculinity refers to the cultural expectations placed on males. Gender roles and stereotypes are deeply ingrained in our culture and can influence various aspects of life, such as occupation choices and personal preferences[46].

Research suggests that children become aware of gender roles by the age of two or three, and by the age of four or five, they tend to adhere to culturally appropriate gender roles. Non-conformity to these roles can lead to negative consequences such as criticism, bullying, marginalization, or rejection by peers. However, it is important to note that not all individuals conform to these cultural norms, and there are those who seek employment or engage in activities that reflect personal preferences rather than societal expectations[46].

Gender stereotypes and expectations are not limited to a specific culture or society. Cross-cultural studies have shown a high degree of agreement on gender stereotypes across various cultures, suggesting that some stereotypes may be universal. However, culture also plays a role in shaping the perception of gender stereotypes. For example, males are often associated with stronger and more active characteristics compared to females, but cultural factors can influence how these stereotypes are perceived[46].

The influence of gender roles and stereotypes begins early in life. Children's exposure to gendered toys, traits, and expectations can have lasting impacts on their self-perception, choices, and behaviour as they grow up. Parents and caregivers, sometimes unintentionally, treat boys and girls differently from infancy, contributing to the reinforcement of gender norms. These early experiences shape individuals' understanding of themselves and their roles in society, perpetuating a gendered world that can unknowingly promote values associated with toxic masculinity[46].

Overall, gender roles are social constructs that define expected behaviours, roles, and characteristics based on perceived gender. These roles can vary across cultures and influence individuals from a young age. While many individuals conform to these roles, there are also those who challenge or reject them, seeking personal fulfilment and defying societal expectations[46].

The distinction between sex and gender is important in understanding gender as a social construction. While sex is determined by biology, gender is shaped by social and cultural factors. It is not solely determined by an individual's biological sex but is learned and internalized through socialization processes. Society plays a significant role in shaping individuals' beliefs, identities, and behaviours as females or males[46].

Feminist perspectives have played a crucial role in challenging traditional gender norms and advocating for gender equality. Feminism recognizes that gender is not solely determined by biology but is influenced by societal structures, power dynamics, and cultural expectations. Feminist theorists have debated the nature of the sex/gender distinction and the extent to which gender is socially constructed. They have highlighted the importance of considering social and cultural factors in understanding gender and promoting gender equity[46].

In conclusion, gender refers to the social and cultural differences assigned to individuals based on their biological sex. It encompasses the expectations, roles, and behaviours associated with being female or male in a given society. While sex is a biological concept, gender is a social construction shaped by societal norms, cultural expectations, and socialization processes.

Gender is known to influence the presence, expression, and growth of self-esteem in people. There are differences in the self-esteem levels of the various genders, according to numerous

research. Self-esteem and gender have been found to be significantly correlated in some studies, while they have not been significantly correlated in others[46]. For the purposes of the present study, gender means male and female.

153 Iranian undergraduate students enrolled in Malaysian institutions participated in a study to examine the connection between self-esteem, gender, and academic success. The study's conclusions showed that there was no meaningful connection between academic success and self-esteem. However, there was a considerable gender difference in self-esteem. This conclusion is consistent with those made public by another study, which discovered a sizable gender difference in self-esteem. A study specifically mentioned that, on average, female students had greater levels of self-esteem than male students, however a related study revealed contradicting results[47].

The results highlight the need of taking gender variations into account when evaluating the link between self-esteem and academic success. It's crucial to remember that while some studies have discovered substantial connections and disparities, other research has not found any. This shows that there may be a variety of situations and factors that influence the relationship between gender self-esteem, and academic achievement, by extension[47].

The link between gender and academic success is complex and has many different aspects. Research has examined this connection and revealed both similarities and differences between genders in terms of how they see themselves academically, their performance, and the factors that can predict achievement[48].

Gender has an influence on academic self-concept, which refers to how individuals perceive their academic abilities. Research indicates that gender differences can impact the formation

and development of academic self-concept. For instance, gender stereotypes can contribute to variations in academic self-concept, particularly in specific subjects. Male students with a strong belief in their math abilities often excel in Mathematics, while female students with positive perceptions of their verbal skills tend to perform well in languages. This impact of gender on academic self-concept is more noticeable among gifted students compared to those with average abilities. Moreover, gender-related effects on academic self-concept have been observed in areas such as social comparison, expectations of success, self-efficacy, math anxiety, and the influence of class composition on science-related self-concept[49].

Academic achievement is often assessed through standardized tests and cumulative grade point averages (CGPA). Researchers have explored the relationship between gender and academic performance in these areas, but the findings have been inconclusive. Some studies have found no significant gender differences in academic achievement, especially in Mathematics. Meta-analyses have shown minimal disparities between genders in standardized Mathematics test scores. However, other studies have reported varying results regarding gender differences in academic performance, depending on the subject and context. It's important to note that academic performance is influenced by multiple factors, such as aptitude, teaching, environment, ethnicity, parental education, age, and preparation before college. Studies have investigated how gender interacts with factors that can predict academic achievement. Researchers have developed prediction models specific to each gender to assess differences in prediction accuracy and the factors that contribute to it. It has been observed that gender interacts with various predictors of academic achievement. While the accuracy of predictions does not significantly differ between male and female students, using gender-specific models has proven to significantly enhance the accuracy of predictions. Additionally, the predictors

included in male and female models of academic achievement vary, regardless of the gender distribution in a study program[50].

To sum up, the link between gender and academic achievement encompasses factors like academic self-concept, performance, and predictors of achievement. Gender disparities can shape one's academic self-concept and have an impact on performance in specific subjects and situations. Moreover, gender interacts with predictors of achievement, and employing gender-specific models can improve prediction accuracy. It's crucial to acknowledge these complexities when exploring the connection between gender and academic achievement[50].

2.1.5 Subject Combination

The understanding of mathematical concepts can be affected by the combination of subjects, such as science subjects, arts subjects, and commercial subjects. Studies suggest that language plays a vital role in the learning process of Mathematics, and various subject combinations can influence the acquisition and comprehension of mathematical concepts[51].

Mathematics encompasses the use of natural language, symbols, models, and visual aids to convey concepts. Students employ various forms of communication, including spoken and written language, to solve problems and establish connections between different mathematical representations. However, the technical language employed in Mathematics can present difficulties for learners, particularly those acquiring math as a second language or non-native English speakers. Studies indicate that students often express their mathematical ideas through personal interpretations that may not align with formal mathematical terminology. This implies that the understanding of mathematical concepts can be influenced by language proficiency and the capacity to articulate mathematical ideas using appropriate terms[51].

When science subjects are incorporated into subject combinations, they can contribute to the comprehension of mathematical concepts. Science disciplines frequently involve quantitative reasoning and the utilization of mathematical principles. By studying science alongside Mathematics, students can foster a more profound understanding of mathematical concepts as they observe their practical relevance in real-world situations. For instance, physics heavily relies on mathematical models and equations to elucidate natural phenomena, and engaging with physics can augment students' ability to solve mathematical problems[52].

Conversely, subject combinations that include the arts can have an impact on the comprehension of mathematical concepts. Through visual arts and music, the arts provide avenues for students to delve into mathematical patterns, symmetry, and spatial reasoning. Engaging in artistic endeavors that incorporate mathematical concepts can enrich students' comprehension and admiration for Mathematics. Studies have demonstrated that integrating the arts into Mathematics education can enhance students' mathematical accomplishments and problem-solving skills [53].

Regarding commercial class, the comprehension of mathematical concepts can be impacted by their practical implementations in finance, economics, and statistics. Such classes often entail data analysis, forecasting, and mathematical problem-solving techniques. By studying business subjects alongside Mathematics, students gain real-world contexts to employ mathematical concepts and cultivate quantitative skills essential for decision-making and problem-solving in the realm of business[54].

It's worth considering that the particular influence of subject combinations on the understanding of mathematical concepts can differ based on various factors, such as individual

learning styles, existing knowledge, and teaching methods. The effectiveness of subject combinations in improving mathematical understanding can also be affected by the quality of instruction, teacher expertise, and curriculum design[54].

2.2 Theoretical Review

A theory is often seen as an "untested suspicion or guess" without the supply of evidence. To scientist, a theory is a well substantiated explanation of an aspect of the natural world that can incorporate laws, hypotheses and facts[55]. The university of California defines theory posit that; a theory is a broad, natural explanation for a wide range of phenomenon. Thus, theories are concise, coherent, systematic, predictive and broadly applicable, often integrating and generalizing many hypothesis[55].

The theoretical framework of analysis of this study are two theories employed to explain the variables. The theories selected for this work are behaviourist learning theory and contingency management/leadership theory.

2.2.1 Contingency Management/Leadership Theory

The educational sector and classroom setting specifically is subjected to vagaries occasioned by students in the class. Certain characteristics of students vis-à-vis background, level of exposure, intelligence quotient, level of emotional maturity amongst other things create unique classrooms per teacher. The characteristics peculiar to a class and the class teacher or subject teachers results in different situations or contingencies that require the use of suitable situational behaviours that are appropriate for each class situations. This underlines the relevance of the contingency theory of management or leadership in the classroom.

The contingency theory simply stipulates that managing humans should not be a function of people characteristics and the system in which those people operate. For a manager to be

effective (in this case the teacher), leadership should be viewed as an interplay between the use of management behaviours and specific situations[56]. In other words, the behaviours exhibited by a teacher should depend on the situation to be tackled. There should be no hard and fast rules of managing student behaviours and resources or material in the bid to ensure that the educational goals of an institution or school is achieved. Teachers are expected by this theory to consider various factors contingent on a situation to determine the appropriate managerial behaviour.

The contingency theory is found on the contingency theory of leadership effectiveness. This theory was developed by Fred Fielder. This theory stipulates that leadership effectiveness is a function of two components namely task motivation and circumstances[56]. These are otherwise known as task motivation and relationship motivation respectively. Leaders usually fall under either of these two components. A leader who possesses the former is more concerned with accomplishing the task(s) at hand. His relationship with staff is therefore hampered and because of his personality he is not bothered. A leader which possesses the latter is more concerned with the latter. He therefore places a premium on relationships.

According to the findings which undergird the contingency theory, consideration and the initiation of support happen to be the two most important behaviours of effective leaders[56]. A considerate leader has good rapport with his subordinates. He also shows support and concern for them. In a nutshell, he is motivated by relationships and therefore influences by having good relationships with his subordinates. His effectiveness with them is however also facilitated by the creation of structures which leaves none of them in doubt as regards what to do and when. To this end, he sets goals, assigns roles, plans, and so on.

The contingency theory results in the use of an instrument to measure whether a leader is either relationship or task oriented. This is known as the Least Preferred Worker test. A high score on this test indicates a relationship motivated leader while a low score indicates task orientation.

The theory talks about how to manage people in an organizational setting. The classroom can be taken as a formal organization in this wise. While it is not filled with adults in work mode, it is filled with students who have certain tasks before them. The theory explains the need for teacher effectiveness in deciding the use of learning methods that are appropriate for each class situation. The method exhibited by teacher should greatly depend on the level of difficulty of concept to be taught. Some concepts might need to be taught with real objects, where students just sit and listen to class instruction. While some other concepts might need to be taught with hands-on-approach, where every student is actively involved[56].

2.2.2 Behaviourist Learning Theory

Behaviourist learning theory concentrates on how students learn. It concentrates on the notion that all behaviours are acquired from the environment and that characteristics acquired by genetic transmission have insignificant influence to affect behaviour. Behaviour influences the conduct of students in learning situations. It also helps teachers see that a student's home environment and way of life can impact their behaviour and to see to it that improvement is achieved[57].

The behaviourist learning theory focuses on the motivation created when one expects to be introduced to something of interest to stir up certain behaviours.

Behaviourism believes that a student's behaviour is shaped by the teaching environment. In the same vein teachers should create a positive learning atmosphere that will motivate learners to learn.

When students are aware that classroom instruction will entail having to play their favourites game, learning with interactive learning materials or an interesting teaching technique, they become elated and this stirs up a positive attitude towards classroom instruction. In the same sense, the teacher might choose to crave the indulgence of parents to create a similar learning atmosphere at home for continuation and practice. What this is to achieve are: willingness to study and attention to details and patterns which in turn will lead to a deeper knowledge of the concept[57].

2.3 Review of Empirical Studies

Researchers agree that the use of certain types of interaction in teaching and learning of Mathematics is highly beneficial to learners but are yet to agree on the exact interactive teaching method that proves to be more effective. Researchers agree that interactive materials' intervention is effective, although the degree of effect is yet to be known.

2.3.1 Interactive Materials and Academic Achievement

A researcher, in seeking to find a means to ensure learning and knowledge retention of 12 – year – old students carried out research on the influence of digital interactive material in tackling Mathematics-oriented tasks. An experiment was carried out to this effect. It involved 633 students and 13 teachers of Mathematics which were equally divided in test groups and control groups from the results, digitalized interactive materials does not handle all tasks. In other words, this implies that digitalized interactive materials might not be best suited for all learning situations and concepts[58].

A researcher, in a quest to examine what makes Mathematics manipulative effective review literature on efficacy of teaching Mathematics with concrete manipulative. Series of studies were carried out. Some found out that learning is enhanced by manipulative whereas, others found out that learning is inhibited by manipulative. This points to the fact that manipulative in classroom instruction can be highly beneficial but only under some conditions[59].

A study was conducted to ascertain the influence of games in Mathematics teaching and learning situations. This research pointed out some importance of the use of games in teaching and learning Mathematics. They are:

- Games encourage a child to enlarge his or her skills
- Games make abstract concepts become concrete
- Games bring about motivation
- Games can be used to reinforce classroom instruction[59].

This research also made a list of some games that can be used in the teaching and learning of Mathematics. They are:

- Card game
- Some board games
- Mathematics Bee[59].

Its conclusion was that, the use of games will trigger students' interest in tackling Mathematics tasks as it brings Mathematics home to them.

A study was carried out by a group of researchers to discover if students' underachievement in Mathematics is attributed to factors like teaching approaches. This research has shown that some methods of teaching affect the achievement of students in Mathematics, through students' level of motivation and their attitude towards learning. They reviewed a literature that believes

students learn better when interacting with concrete materials. They reviewed another literature which showed that the use of manipulative has a positive impact on Mathematics learning more than any traditional teaching method[60].

Another study was carried out by a different group of researchers to examine whether Childrens' views of manipulative affect their learning or not. Some grade 2 children were divided into two groups-control group and test group. They were given some manipulatives. Children in the control group were not told whether the manipulative can be used for playing a game, doing Mathematics or both. But children interest group were instructed to view the manipulative as a Mathematics tool. The manipulative was then used in a lesson to teach equivalence in Mathematics. Children who were instructed to view the manipulative as tools for teaching and learning Mathematics achieved better understanding of the concept than the children who were not instructed to view the manipulative in this way. The summary of this finding is that, the way a student views a manipulative will determine the effect the manipulative will have on his/her learning[61].

2.3.2 Gender and Academic Achievement

The relationship between gender and the use of interactive instructional material in the classroom has been a subject of empirical research. Several studies have explored this relationship, considering factors such as access to technology, skills, attitudes, and learning outcomes.

A systematic review and meta-analysis on gender differences in information and communication technology (ICT) use found a small but positive effect size in favour of boys. The study highlighted the importance of collaboration to address concerns, enhance IT skills, and formulate effective ICT policies[62]. Another research on the factors influencing online learning effectiveness

during the COVID-19 pandemic indicated that educational level and personality traits have a significant impact on learning outcomes, while gender showed no significant effect [63].

In a field experiment conducted in a secondary school context, the impact of individual vs. group learning and text vs. video content on mobile devices was investigated. It was found that female students engaged in group learning with video material exhibited distinct patterns, spending more time in the application and showing higher peer-influenced learning scores compared to male students. This study emphasized the importance of gender-sensitive approaches and the potential of mobile technologies to enhance learning outcomes [64]. Similarly, another field experiment in a secondary school context demonstrated that female students engaged in group learning with video material spent more time in the application and showed higher peer-influenced learning scores than male students. This study also emphasized the importance of gender-sensitive approaches, mobile technologies, and collaborative learning in education[65].

These studies collectively highlight the need for gender-sensitive approaches in the use of interactive instructional material in the classroom. They emphasize the importance of considering gender differences in access, engagement, and learning outcomes when designing and implementing instructional strategies. Collaborative learning and the use of mobile technologies show promise in addressing gender disparities and enhancing learning outcomes. Further research is needed to explore the specific mechanisms through which gender influences the use of interactive instructional material and to develop effective interventions that promote gender equity in educational settings.

The relationship between gender and the use of interactive instructional material in the classroom can have implications for academic achievement. Several studies have explored this relationship and its impact on educational outcomes.

Gender disparities in academic achievement have been observed globally. In Trinidad and Tobago, for example, females consistently outperform males in subjects such as reading, English language, and technical subjects. Various factors contribute to male underachievement, including societal influences, maturational differences, learning styles, and school-related issues. It is crucial to create inclusive environments that address the unique needs of both genders [66].

When it comes to the use of interactive instructional material, studies have shown that leveraging technology can impact learning outcomes. A field experiment conducted in a secondary school setting examined the impact of mobile technology on learning. The study found that female students engaging in group learning modes, supported by video materials, exhibited distinct engagement patterns and higher peer-influenced learning scores compared to male students. This suggests that the use of interactive instructional material can potentially contribute to improved academic achievement, particularly for female students [67].

Furthermore, personality traits have been found to play a significant role in academic success. Conscientiousness, in particular, has been linked to better academic achievement. Females tend to outperform males in academic achievement across different educational stages, even after considering socio-economic factors. The mediating role of personality traits, such as conscientiousness, has been observed in the relationship between gender and academic achievement. Understanding these gender differences and the influence of personality traits can provide insights into the acceptance and effectiveness of various instructional technologies [67].

In addressing the achievement gap and promoting equitable learning experiences, it is essential to consider the intersectionality of various factors, including race/ethnicity, socio-economic status, and gender. Socio-economic, racial/ethnic, and gender inequalities in academic outcomes have been examined using an intersectionality approach. The study highlights the negative

impact of intersecting racial/ethnic and gender discrimination on academic success. It emphasizes the need to address social stratification and eliminate achievement gaps by considering multiple social positions and their interactions[67].

In summary, the relationship between gender and the use of interactive instructional material in the classroom can influence academic achievement. Leveraging technology and considering gender-sensitive approaches in instructional design can potentially enhance learning outcomes, particularly for female students. Additionally, understanding the interplay between gender, personality traits, socio-economic factors, and other social positions is crucial in addressing achievement gaps and promoting equitable educational experiences for all students. Further research and the development of inclusive strategies are necessary to ensure that the use of interactive instructional material supports academic achievement for students of all genders.

2.3.3 Subject Combination and Academic Achievement

Art Subjects

Engagement in arts education and the use of teaching aids have been topics of extensive research to determine their impact on academic achievement and competencies. This empirical review aims to summarize the findings from various studies on the relationship between arts subjects, teaching aids, and academic achievement. The review considers evidence from a range of sources and evaluates the methodological characteristics of the included studies.

Studies have explored the effects of arts education on academic achievement and competencies. Research suggests positive outcomes such as improved academic achievement, attainment, social behavior, and health benefits[68]. However, conclusive evidence is lacking in many areas due to small sample sizes and a limited number of studies. The impact of arts education on academic

outcomes varies across different art forms, with music and multi-art contexts showing more pronounced effects, particularly among pre-school children [68].

A systematic literature review focused on the learning outcomes of student teachers in teacher education courses that emphasize arts-based teaching and learning. The review identified patterns such as emotional turns, the ability and desire to act, and changed attitudes among student teachers. These patterns contribute to their learning outcomes and highlight the epistemological possibilities created by arts-based teaching and learning in teacher education [69].

The importance of social and emotional factors in education alongside academic achievement is increasingly recognized. Studies have explored the complexities of social and emotional factors and their relationship with academic achievement. These studies highlight topics such as academic buoyancy, psychological capital resources, achievement goals, learning climate support, and the impact of social network sites on university adjustment. They emphasize the need for integrating social and emotional learning strategies into education at all levels [70].

High-quality music and arts education have been associated with extramusical benefits, such as enhanced social-emotional skills and habits of mind. However, achieving "far transfer" of skills developed through music education remains challenging. Studies suggest that participation in music education programmes can promote growth mindset and have a positive impact on overall mindset and musical growth mindset among at-risk children. Visual arts integration in education fosters creativity, imagination, problem-solving, reflection, evaluation, and learning[71].

A study investigated the impact of creative dramatics interventions on fourth-grade students' vocabulary achievement in a language arts classroom. The findings support the notion that the arts, specifically creative dramatics, can enhance academic achievement, particularly in the area of vocabulary development[71].

The empirical evidence reviewed suggests that engagement in arts education and the use of teaching aids can have positive effects on academic achievement and competencies. However, further research is needed to establish conclusive evidence, especially through experimental research designs. Music and multi-art contexts appear to have more pronounced effects on academic outcomes, particularly among pre-school children. Arts-based teaching and learning in teacher education courses can contribute to student teachers' learning outcomes. Integrating social and emotional learning strategies into education is crucial alongside academic achievement. Additionally, high-quality music and arts education can provide extramusical benefits and foster creativity, imagination, and problem-solving skills. The arts, including creative dramatics, show potential in enhancing vocabulary development and academic achievement in specific subject areas. Overall, arts subjects and teaching aids have the potential to positively impact academic achievement, but further research is necessary to fully understand their causal impacts and optimal implementation strategies[72].

Commercial Subjects

The relationship between commercial subjects and teaching aids can have an impact on academic achievement in commercial subjects. Several factors and studies contribute to our understanding of this relationship.

One study focuses on the phasing-out of commercial entrepreneurship subjects in rural Limpopo secondary schools in South Africa due to poor learner performance. The findings reveal that poor

teacher performance, inadequate pedagogical content knowledge, and a shortage of teachers contribute to the phasing out of commercial streams. A hostile working environment caused by work overload and lack of school resources and infrastructure was also identified [73]. The study recommends qualified teachers teaching commercial subjects, subject specialization, addressing teacher shortages, improving teaching and learning resources, and addressing the backlog of subject advisors.

Another study explores the influence of business studies teachers' competency on students' academic achievement. The research emphasizes the importance of teachers' knowledge, skills, and professionalism in aligning the subject of Business Studies with the current economic wave. The study found that the three components of McBer's Iceberg Competency Model (knowledge, skill, and professionalism) had a positive but modest-to-weak impact on student achievement in business studies [74].

The quality of teacher-student relationships is another important factor in academic achievement. Positive teacher-student relationships are associated with successful classroom management, effective teaching, higher student achievement, improved cognitive skills, and a sense of school belonging. Students' experiences with teachers greatly influence their learning and development. Building positive relationships, demonstrating teaching skills, and effectively managing disruptive behavior are key aspects that contribute to positive teacher-student relationships. Students perceive good teachers as friendly, kind, fair, committed, caring, trustworthy, and respectful. On the other hand, they view bad teachers as disrespectful, inconsistent, untrustworthy, and unfair . It is important to understand students' perspectives on teacher-student relationships to improve educational practices [75].

Furthermore, the commitment of teachers is positively associated with student academic achievement. Teacher commitment indicators such as commitment to students, profession, teaching, and society play a significant role in fostering academic success. Professional commitment also has a moderating influence on the relationship between teacher commitment and student performance [75].

Overall, the relationship between commercial subjects and teaching aids can affect academic achievement in commercial subjects. Factors such as teacher performance, pedagogical content knowledge, teacher specialization, teacher-student relationships, and teacher commitment all play crucial roles in determining the impact on academic achievement. Addressing these factors and ensuring the availability of qualified teachers, appropriate resources, and supportive learning environments are important for enhancing academic success in commercial subjects.

Science Subjects

The relationship between science subjects and teaching aids and its impact on academic achievement has been a topic of interest in educational research. This empirical review aims to summarize and analyze relevant studies that investigate this relationship. The review considers the findings from multiple sources to provide a comprehensive understanding of how science subjects and teaching aids affect academic achievement.

Research has explored the relationship between students' attitude toward science and their academic achievement. Studies have shown both moderate and strong positive correlations between attitude toward science and academic achievement, indicating the significance of attitude in science learning outcomes [76]. Attitude toward science is a multifaceted construct encompassing dimensions such as interest, self-efficacy, societal relevance, and mixed attitudes.

Academic achievement is influenced not only by cognitive factors but also by social and emotional factors. Studies have shown that social and emotional measures, such as academic buoyancy, psychological capital resources, learning climate support, and self-determined motivation, are associated with higher academic engagement and achievement [76]. These findings highlight the importance of considering social and emotional factors alongside science subjects and teaching aids to enhance academic achievement.

The use of effective teaching practices has been found to positively impact academic achievement in science. A study conducted in Australia examined the mediating role of student engagement in the relationship between effective teaching practices and academic outcomes. The findings revealed that effective learning time directly impacts students' performance and also indirectly influences it through improved positive behavior, attendance, and homework behavior[76]. Therefore, employing effective teaching practices, along with science subjects and teaching aids, can contribute to improved academic achievement.

Research has investigated the relationships between student-centered teaching approaches, problem-based learning, and academic achievement in science education. The findings suggest that student-centered teaching approaches and problem-based learning have a positive correlation with academic achievement in science. These teaching approaches promote active student engagement, critical thinking, and problem-solving skills, which enhance academic achievement.

Practical work in science education has been found to have a positive impact on students' academic attainment. Engaging students in practical lessons enhances laboratory skills, scientific

knowledge, understanding of science concepts, and promotes positive attitudes and motivation for learning science [76]. Providing ample opportunities for practical work and ensuring schools have the necessary equipment can contribute to improved academic achievement in science.

The empirical evidence reviewed suggests that the relationship between science subjects, teaching aids, and academic achievement is complex and multifaceted. Students' attitude toward science, along with social and emotional factors, plays a significant role in academic achievement in science. Effective teaching practices, including student-centered approaches and problem-based learning, have a positive impact on academic achievement. Additionally, incorporating practical work in science education can enhance students' academic attainment. These findings emphasize the importance of considering various factors, such as attitude, teaching practices, and practical work, to promote academic achievement in science.

It is worth noting that the reviewed studies provide valuable insights into the relationship between science subjects, teaching aids, and academic achievement. However, further research is necessary to explore specific instructional strategies, the role of technology, and other contextual factors that may influence this relationship.

2.4 Conceptual Model

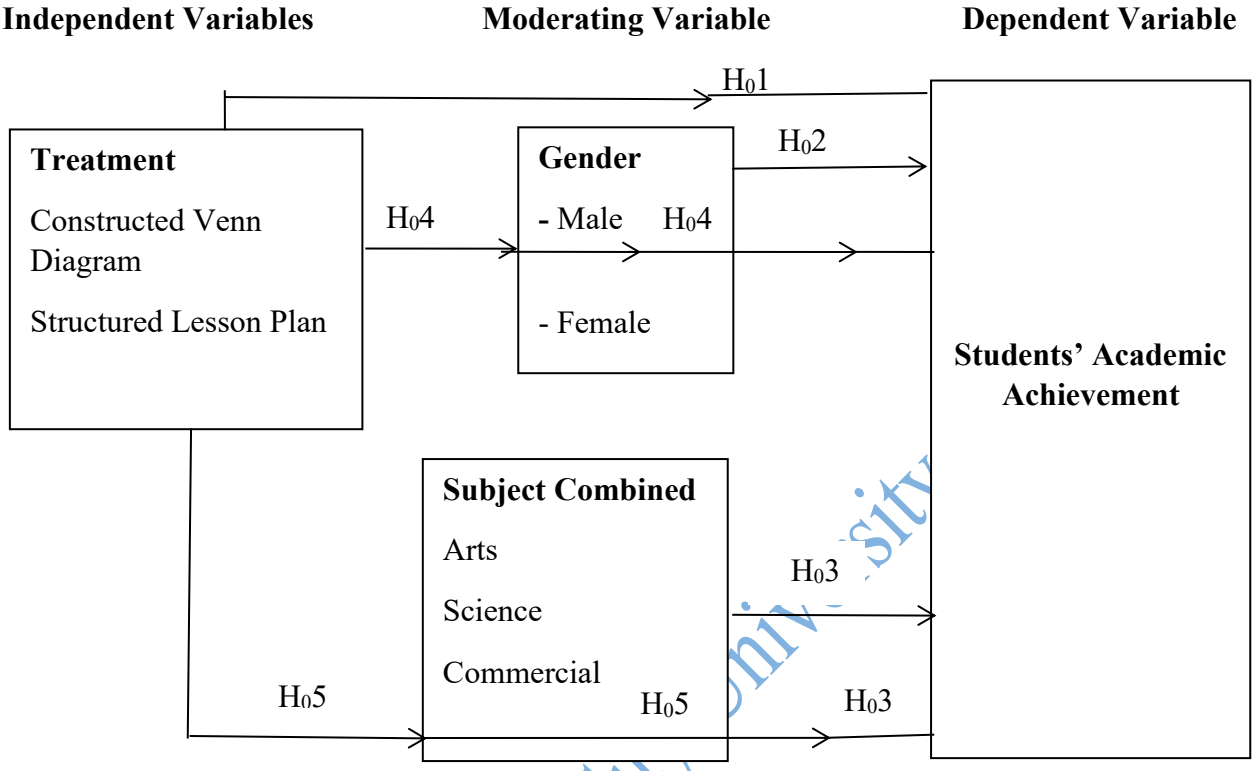

Fig. 2.1: Conceptual Model showing the Relationship between Variables

Source: Researcher's Field work 2023

The figure above shows the relationship between the following: Independent Variable and the dependent variable, Moderating variable 1 and the dependent variable, Independent variable 2 and the dependent variable, independent variable, moderating variable 1 and the dependent variable, independent variable, moderating variable 2 and the dependent variable.

The figure above shows the relationship between the dependent variable which is, Students' Academic Achievement and the independent variable which is interactive materials intervention. It also shows the relationship the moderating variables which are, subject combination and gender have with both the dependent variable and independent variable. The interactive materials

used are: constructed venn diagram, structured lesson plan and Mathematics achievement test. Students' academic achievement is on three (3) levels: high, medium and low.

Learning process is at the centre of the diagram because it is affected by the introduction of interactive instructional materials (constructed venn diagram, structured lesson plan and Mathematics achievement test). Moreover, it is also affected by two selected characteristics of learners that is, gender and subject combination. These two characteristics are the moderating variables. Furthermore, the effect of both the independent variables and the moderating variables is measured using academic achievement, which is the dependent variable.

2.5 Summary of Gaps in Literature Reviewed

Most research on interactive materials have pointed out to the fact that the use of interactive materials played a crucial role in learning Mathematics hence determine students' success in the subject. Research also supported that the view students had on interactive materials used for classroom instruction determined the effect on their learning process.

Literature confirms that interactive materials are majorly utilized in the elementary schools and junior secondary schools. It also confirms a higher academic achievement in Mathematics due to the introduction of interactive materials in elementary schools.

However, there has not been a finding as to the effect of interactive materials use in senior secondary school Mathematics classes. There has not been a relationship between interactive materials intervention and the effect it has on students' achievement in set. Theory

This study sought to create mere awareness and understanding on a common misconception on interactive materials. Most teachers are of the view that interactive materials are to be used only for lower classes, making senior secondary classes an exception.

Set Theory is a topic that entails series of symbols and relationship, and so not every student would grasp its concept without engaging in hands-on-approach technique of learning. This calls for a mere concerted effort in order to change this belief of teachers. It is also necessary for the school management to make adequate provision of Mathematics tools and interactive materials that will be well suited for teaching and learning Mathematics on the secondary school level.

The school management should make available, Constructed Venn diagrams for class instruction in Set Theory in order to achieve a better understanding of the concept, which in turn will lead to a greater achievement in Mathematics.

Endnotes

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Chapter Three

Methodology

This chapter deals with the methods and procedures that were adopted in the collection of data to carry out the research on effect of interactive materials, intervention on academic achievement of Senior Secondary School students in Set Theory in Oyo State under the following sub-headings: Research Design, Population of the Study, Sample and sampling Technique(s), Research Instrument, validation of Instrument, Reliability of instrument, Administration of Instrument, and method of Data Analysis.

3.1 Research Design

This study adopted 2x2x3 quasi- experimental design consisting of experimental group and control group. The factorial matrix goes thus; treatment is on two levels (i.e treatment group and control group), gender is on two levels (Male and Female), Students' Academic Achievement level is on three levels (i.e high, medium and low) and Students Subject Combinations is on three levels (i.e, Arts, Commercial and Science). Interactive Materials serve as the independent variable, subject combination and gender are the moderator variables while Mathematics achievement is the dependent variable.

Table 3.1 Research Design Layout

Group	Pre-test	Treatment	Post-test
E_1	O_1	X_1	O_2
E_2	O_3	X_2	O_4

Source: Field Work (2023).

Keys:

O_1, O_3 = Pre-test

O_2, O_4 =Post-test

X_1: Treatment (Interactive Materials' Intervention)

X_2: Treatment (Conventional method)

E_1: Treatment group

E_2: Control group

2 by 2 factorial design.

Where the groups are on two levels (Experimental and Control groups) and Mathematics Achievement Test (MAT) are on two levels (Pretest and Posttest)

3.2 Population of the Study

The population for this study consists of twenty-six thousand, seven hundred and ten (26,710) senior secondary school two (SSS 2) students in public secondary schools in Oyo South Senatorial District, Oyo state.

3.3 Sample and Sampling Techniques

The study adopted intact class procedure. Purposive Sampling technique was used to select the schools for the study. This is due to the aspect of subject combinations, in the study. Other

conditions used for the selection include: presentation of candidates for the Senior Secondary School Certificate Examination for at least ten consecutive years and each of the schools must have at least two Mathematics teachers of which one of the teachers teach Mathematics at the Senior Secondary School Two class.

Table 3.2 Schematic Representation of the 2 x 2 x 2x 3 Factorial Matrix

Treatment	**Subject Combination (Number of students)**		
	Arts	**Commercial**	**Science**
Interactive Materials' Intervention	19	19	9
Conventional Method	11	11	16

Source: Field Work (2023)

3.4 Description of Research Instruments

Three research instruments were used for the study;

(i) Mathematics Achievement Test (MAT)

(ii) Structured Lesson Plan for teaching Set Theory

(iii) Constructed Venn diagram.

The Mathematics Achievement Test (MAT) consists of forty multiple choice questions on Set Theory with 4 options A to D and was based on three cognitive levels – "knowledge",

"comprehension" and "application" . The questions were carefully selected from the West African Senior School Certificate Examination (WASSCE) past examination questions 2006 to 2020. The table of specification for the Mathematics Achievement Test (MAT) is shown below.

Table 3.3 Table of Specification

Level of objective	Definitions	Set Notation	Venn Diagram (2 sets)	Venn Diagram (3 sets)	Total
Knowledge	3	5	5	2	15 (37.5%
Comprehension	1	6	4	7	18 (45%)
Application			5	2	7 (17.5%)
	4(10%)	11(27.5%)	14(35%)	11(27.5%)	40(100%)

Source: Field Work (2023).

The Structured Lesson Plan is on Set Theory and was taught in Senior Secondary School Two (SSS2) Students, by the researcher and the research assistant. The teaching duration was eight (8) weeks. It summarizes the activities of both the teachers and students in the classroom.

The Constructed Venn Diagram is made up of a large wooden rectangle which as three circular metal loops arranged within. The circular loops are arranged to overlap each other to make room for intersection and union.

3.5 Validity of the Research Instruments

The validity of the instrument was carried out for face, content and construct validity. The research instruments were scrutinized by the supervisor and two other lecturers in the department of Science Education, Lead City University, who equally vetted the structuring, adequacy and

content of the items in the Mathematics Achievement Test (MAT). All corrections were affected before administration of the final draft.

3.6 Reliability of the Research Instruments

The reliability of the instruments was carried out on two (2) intact classes of Senior Secondary School Two (SSS2) from two public secondary schools which did not partake in the main study. The samples were administered for pre-test and post-test in order to compare the effect of treatment on them before the main study. The reliability of the Mathematics Achievement Test (MAT) was derived using Kuder Richardson formula (Kr20). The reliability of MAT was 0.75.

3.7 Administration of Research Instrument(s)

The research instruments were administered by the researcher to the selected respondents in each of the two (2) randomly selected schools in Oyo South senatorial District. The Mathematics Achievement Test (MAT) was administered on students in two intact classes that represent the sampled facilities. This was done in a bid to ensure that the instruments were attended to by the actual respondents. A research assistant was trained for this purpose and the research lasted for a period of eight (8) weeks. The first (1^{st}) week was used to conduct the pretest in the two (2) schools. The second (2^{nd}) week to seventh (7^{th}) week were used to teach students Set Theory. The eight (8^{th}) week was used to conduct the posttest in the two (2) schools.

3.8 Methods of Data Analysis

Quantitative data was obtained from closed ended items in the students' Mathematics Achievement Test. They were coded and entered in the computer using Statistical Package for Social Sciences (SPSS) program. Specifically, the data were analyzed using simple descriptive statistics: frequency, percentages and means and presented with the aid of tables. ANCOVA was used to test the hypotheses generated for the study at 0.05 level of significance.

Chapter Four

Results and Discussion of Findings

This chapter presents results of the analyses and discussion of findings. The results and discussion of findings are presented based on demographic characteristics of the participants, research question and hypotheses as follow:

4.1 Presentation of Data

The below are the socio-demographic characteristics of the participants.

Table 4.1: Distribution of the Participants by Gender

Gender	Frequency	Percent
Male	40	47.1
Female	45	52.9
Total	85	100.0

Source: Field Survey, 2023

Table 4.1 reveals that 40 (47.1%) of the participants were males, while 45 (52.9%) were females. This means that, most of the participants were females.

Table 4.2: Distribution of the Participants by Subject Combination

Subject Combination	Frequency	Percent
Art	30	35.3
Commercial	28	32.9
Science	27	31.8
Total	85	100.0

Source: Field Survey, 2023

Table 4.2 reveals that 30 (35.3%) participants were in Art class, 28 (32.9%) were in Commercial, while 27 (31.8%) participants were in Science class. This means that most of the participants were in Art class.

Table 4.3: Distribution of the Participants by Groups

Treatment Groups	Frequency	Percent
Experimental Group	47	55.0
Control Group	38	45.0
Total	85	100.0

Source: Field Survey, 2023

Table 4.3 reveals that 47 (55.0%) participants were in experimental group, while 38 (45.0%) were in control group. This implied that most of the participants were in experimental group.

4.2 Hypotheses Testing and Discussion of Results

Research Questions

The following research questions were answered:

Research Question One: What is the previous Academic Achievement level of Senior Secondary School Students before the interactive materials' intervention in Set Theory in Oyo South Senatorial District, Oyo State?

Table 4.4: Summary of Result on Previous Academic Achievement level of Senior Secondary School Students in Set Theory

Achievement	Frequency	Percent
Low	85	100.0

Source: Field Survey, 2023

Table 4.4 reveals that all the Senior Secondary School Students (85=100.0%) in Oyo South Senatorial District had low academic achievement in Set Theory. This implied that all the Senior Secondary School Students in Oyo South Senatorial District had low academic achievement in Set Theory before the intervention.

Research Question Two: What is the present Academic Achievement level of Senior Secondary School Students after the interactive materials' intervention in Set Theory in Oyo South Senatorial District, Oyo State?

Table 4.5: Summary of Result on Present Academic Achievement level of Senior Secondary School Students in Set Theory

Achievement	Frequency	Percent
Low	56	65.9
Medium	21	24.7
High	8	9.4
Total	85	100.0

Source: Field Survey, 2023

Table 4.5 reveals that 56 (65.9%) participants had low academic achievement in Set Theory, 21 (24.7%) had medium achievement, while 8 (9.4%) participants had high academic achievement in Set Theory. This implied that a considerable number of Senior Secondary School Students in Oyo South Senatorial District had low and medium academic achievement in Set Theory respectively.

Hypotheses

The following hypotheses were tested in this study.

$H_0$1: There will be no significant main effect of treatment on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State.

Table 4.6.1: Summary of Analysis of Covariance of Main Effect of Interactive Materials' Intervention on Senior Secondary School Students' Academic Achievement in Set Theory

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	9852.296	2	4926.148	26.328	.000	.391
Intercept	13957.440	1	13957.440	74.595	.000	.476
Pretest	382.912	1	382.912	2.046	.156	.024
Treatment	9414.889	1	9414.889	50.317	.000	.380
Error	15342.998	82	187.110			

Total	177031.250	85
Corrected Total	25195.294	84

R Squared = .391 (Adjusted R Squared = .376)
Source: Field Survey, 2023

Table 4.6.1 shows that that there was a significant main effect of interactive materials' intervention on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District($F_{(1,82)}$=50.317, p<0.05, η^2=0.380. The null hypothesis was therefore rejected. This implied that the effect of interactive materials' intervention was effective on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District. The eta square value of 0.380 shows the contributing effect size of 38.0%.

Table 4.6.2: Estimated Marginal Means of Intervention on Senior Secondary School Students' Academic Achievement in Set Theory

Treatment Groups	Mean ($\bar{x}$)	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Interactive Materials' Intervention (Experimental)	51.729	1.995	47.760	55.698
Control	30.559	2.219	26.144	34.974

Source: Field Survey, 2023

Table 4.6.2 shows the estimated marginal means of intervention (treatment) on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District. It was revealed that after controlling for the effect treatment on Senior Secondary School Students' academic achievement, the participants exposed to Interactive Materials' Intervention had a higher mean score (mean=51.729), while the control group had a mean score of 30.559. This implied that Interactive Materials' Intervention was potent as an intervention on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District.

$H_0$2: There will be no significant main effect of gender on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State.

Table 4.7.1: Summary of Analysis of Covariance of Main Effect of Gender on Senior Secondary School Students' Academic Achievement in Set Theory

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1288.106	2	644.053	2.209	.116	.051
Intercept	14835.946	1	14835.946	50.886	.000	.383
Pretest	354.757	1	354.757	1.217	.273	.015
Gender	850.700	1	850.700	2.918	.091	.034
Error	23907.188	82	291.551			
Total	177031.250	85				
Corrected Total	25195.294	84				

R Squared = .051 (Adjusted R Squared = .028)
Source: Field Survey, 2023

Table 4.6.1 shows that there was no significant main effect of gender on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District($F_{(1,82)}$=2.918, p>0.05, η^2=0.034. The null hypothesis was therefore accepted. This implied that gender had no significant effect on the Senior Secondary School Students' academic achievement in Set Theory. The eta square value of 0.034 shows the contributing effect size of 3.4%.

Table 4.7.2: Estimated Marginal Means of Gender on Senior Secondary School Students' Academic Achievement in Set Theory

Gender	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Male	38.901	2.703	33.523	44.279
Female	45.255	2.548	40.185	50.324

Source: Field Survey, 2023

Table 4.7.2 shows that female participants had a higher posttest mean score (45.255) than their male (38.901) counterparts. This implied that the interactive materials' intervention had a better effect on female Senior Secondary School Students' Academic Achievement in Set Theory in Oyo South Senatorial District than their male counterparts.

$H_0$3: There will be no significant main effect of subject combination on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State.

Table 4.8.1: Summary of Analysis of Covariance of Main Effect of Subject Combination on Senior Secondary School Students' Academic Achievement in Set Theory

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1901.086	3	633.695	2.204	.094	.075
Intercept	14993.072	1	14993.072	52.135	.000	.392
Pretest	192.860	1	192.860	.671	.415	.008
Subject Combination	1463.679	2	731.840	2.545	.085	.059
Error	23294.208	81	287.583			
Total	177031.250	85				
Corrected Total	25195.294	84				

R Squared = .075 (Adjusted R Squared = .041)
Source: Field Survey, 2023

Table 4.6.1 shows that there was no significant main effect subject combination on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District($F_{(2,81)}$=2.545, p>0.05, η^2=0.059. The null hypothesis was therefore accepted. This implied that subject combination had no significant effect on the Senior Secondary School Students' academic achievement in Set Theory. The eta square value of 0.059 shows the contributing effect size of 5.9%.

Table 4.8.2: Estimated Marginal Means of Subject Combination on Senior Secondary School Students' Academic Achievement in Set Theory

			95% Confidence Interval	
Subject Combination	Mean	Std. Error	Lower Bound	Upper Bound
Art	39.629	3.167	33.328	45.930
Commercial	48.259	3.242	41.808	54.710
Science	38.978	3.272	32.468	45.487

Source: Field Survey, 2023

Table 4.8.2 shows that participants with Commercial subject combination had the highest posttest mean score (48.259) and this might be because of the knowledge of accounting and economics they have followed by participants with Art subject combination (39.629), while the participants with Science subject combination had the least posttest mean score (38.978).This implied that subject combination had a better effect on participants with Commercial subject combination among Senior Secondary School Students' Academic Achievement in Set Theory in Oyo South Senatorial District than their counterparts with Art and Science subject combinations respectively.

$H_0$4: There will be no significant Interactive effect of interactive materials' intervention and gender on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State.

Table 4.9.1: Analysis of Covariance of Interaction Effect of Intervention and Gender on Senior Secondary School Students' Academic Achievement in Set Theory

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial -Eta Squared
Corrected Model	10469.628	4	2617.407	14.220	.000	.416
Intercept	14450.518	1	14450.518	78.505	.000	.495
Pretest	204.481	1	204.481	1.111	.295	.014
Treatment	8583.743	1	8583.743	46.633	.000	.368
Gender	74.937	1	74.937	.407	.525	.005
Treatment *Gender	507.662	1	507.662	2.758	.101	.033
Error	14725.666	80	184.071			

Total	177031.250	85
Corrected Total	25195.294	84

R Squared = .416 (Adjusted R Squared = .386)
Source: Field Survey, 2023

Table 4.9.1 shows that that there was no significant interaction effect of intervention and gender on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State($F_{(1,80)}$= 2.758, p>0.05, η^2=0.033. The null hypothesis was therefore accepted. This implied that intervention and gender had no significant interaction effective on Senior Secondary School Students' academic achievement in Set Theory. The eta square value of 0.033 shows the contributing effect size of 3.3%.

Table 4.9.2: Estimated Marginal Means of Intervention and Gender on Senior Secondary School Students' Academic Achievement in Set Theory

Treatment Groups	Gender			95% Confidence Interval	
		Mean	Std. Error	Lower Bound	Upper Bound
Experimental	Male	47.398	3.227	40.977	53.819
	Female	54.428	2.537	49.379	59.476
Control	Male	31.887	2.896	26.122	37.651
	Female	28.714	3.402	21.944	35.484

Source: Field Survey, 2023

Table 4.9.2 shows that male participants in the experimental group had a higher mean score (47.398) than their female (54.428) counterparts. This implied that the interaction of intervention and gender had a better effect on female Senior Secondary School Students' academic achievement in Set Theory among those who were exposed to interactive materials' intervention than their male counterparts. In the control group, the male participants had a higher mean score (31.887) than their female (28.714) counterparts. This implied that the interaction of intervention and gender had a better effect on male Senior Secondary School Students' academic achievement in Set Theory among those in the control group than their female counterparts.

The overall comparison shows that female participants in experimental group had the highest mean score, followed by male participants in the same group, male participants in control group was rated 3rd based on the mean score, while female participants in control group was the least. It implied that the interaction of intervention and gender had a better effect on female Senior Secondary School Students' academic achievement in Set Theory among those who were exposed to interactive materials' intervention than their male counterparts; than male counterparts in the same group as well as male and female in the control group respectively.

$H_0$5: There will be no significant main effect of interactive materials' intervention and subject combination on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State.

Table 4.10.1: Analysis of Covariance of Interaction Effect of Intervention and Subject Combination on Senior Secondary School Students' Academic Achievement in Set Theory

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	11172.961	6	1862.160	10.358	.000	.443
Intercept	14257.362	1	14257.362	79.307	.000	.504
Pretest	148.647	1	148.647	.827	.366	.010
Treatment	9172.397	1	9172.397	51.022	.000	.395
Subject Combination	1149.992	2	574.996	3.198	.046	.076
Treatment * Subject Combination	110.617	2	55.309	.308	.736	.008
Error	14022.334	78	179.774			
Total	177031.250	85				
Corrected Total	25195.294	84				

R Squared = .443 (Adjusted R Squared = .401)
Source: Field Survey, 2023

Table 4.10.1 shows that that there was no significant interaction effect of intervention and subject combination on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State($F_{(2,78)}$=0.308, p>0.05, η^2=0.008. The null hypothesis

was therefore accepted. This implied that intervention and subject combination had no significant interaction effective on Senior Secondary School Students' academic achievement in Set Theory. The eta square value of 0.008 shows the contributing effect size of 0.8%.

Table 4.10.2: Estimated Marginal Means of Intervention and Subject Combination on Senior Secondary School Students' Academic Achievement in Set Theory

				95% Confidence Interval	
Treatment Group	Subject combination	Mean	Std. Error	Lower Bound	Upper Bound
Experimental	Art	47.064	3.122	40.849	53.279
	Commercial	55.748	3.348	49.083	62.412
	Science	53.614	4.049	45.553	61.674
Control	Art	26.640	4.080	18.517	34.764
	Commercial	36.785	4.048	28.726	44.845
	Science	28.946	3.385	22.208	35.685

Source: Field Survey, 2023

Table 4.10.2 shows that participants with Commercial subject combination in the experimental group had the highest mean score (55.748), followed by participants with Science subject combination with a mean score of 53.614; and Art subject combination with a mean score of 47.064. This implied that the interaction of intervention and subject combination had a better effect on Senior Secondary School Students' academic achievement in Set Theory among those the participants with Commercial subject combination who were exposed to interactive materials' intervention than; than their counterparts with Science and Art subject combination respectively.

In the control group, the participants with Commercial subject combination in the control group had the highest mean score (36.785), followed by participants with Science subject combination with a mean score of 28.946; and Art subject combination with a mean score of 26.640. This implied that the interaction of intervention and subject combination had a better effect on Senior Secondary School Students' academic achievement in Set Theory among the participants with Commercial subject combination in control group; than their counterparts with Science and Art subject combination respectively.

The overall comparison shows that participants with Commercial subject combination in the experimental group had the highest mean score, followed by participants with Science subject combination, while those with Art subject combination in experimental group was rated 3rd. In addition to this, the participants with Commercial subject combination in the control group were rated fourth, followed by participants with Science subject combination; while the participants with Art subject combination in the control group were the least. This implied that the interaction of intervention and subject combination had a better effect on Senior Secondary School Students' academic achievement in Set Theory among those the participants with Commercial subject combination who were exposed to interactive materials' intervention than; than their counterparts with Science and Art subject combination in the same group and control group respectively.

4.3 Discussion of Findings

This study examined the effect of interactive materials' intervention on Senior Secondary Students' Academic Achievement in Set Theory in Oyo State and the variable used as the independent construct is the constructed Venn diagram while for the dependent construct is academic achievement. The study aimed to contribute immensely towards designing an

appropriate teaching intervention that is different from the conventional methods used in various Senior Secondary Schools in order to teach Set Theory effectively and to increase their success rate. Two research question were postulated and the outcomes state that both the previous and present academic achievement level of Senior Secondary School Students in Set Theory is low. A research work is in line with the outcome. The research work states that high school students have been having poor performance in Mathematics for a number of years and this may be due to some factors which are: teacher-student relationship, students self efficacy and students' perception of Mathematics[1].Another research work is also in line with the outcome. The research work states that poor achievement in Mathematics is an issue of great concern for Fiji in South Pacific and this is due to the following factors: ineffective Mathematics curriculum and teachers' incompetence[2].

Five hypotheses were postulated and the results derived shows that there is strong and linear relationship between the variables used to measure the two constructs in terms of gender and subject combination, which invariably mean interactive materials' intervention have significant impact on Academic Achievement of Senior Secondary School Students. This result is supported by a research work which studied development and validation of interactive learning material in grade 8 Mathematics, where all findings from the research work support that interactive materials intervention facilitate Mathematics learning. Both the teachers and learners benefit from interactive materials' intervention in Mathematics classrooms. Interactive materials make Mathematics teaching and learning effective, making the class interactive and interesting, motivating the learners, facilitating Mathematical skills[3]. The result is supported by another research work with the title impact of instructional materials on students' academic performance in Physics in Sokoto – Nigeria, where all the findings from the work support that instructional

materials play an important role in improving students' academic performance. Students taught with instructional materials were found to be of improved performance compared to those taught without instructional materials[4]. However, the first hypothesis had to be rejected based on the result from the analysis because there is significant effect of interactive materials intervention on academic achievement of Senior Secondary School Students in Set Theory in Oyo South Senatorial District, Oyo State.

The outcome of the second hypothesis states that there is no significant effect of gender on Senior Secondary School Students' academic achievement in Set Theory. From the research work, it was observed that the performance of female students slightly surpassed their initial performance after the introduction of the interactive material. A research work is in variance with the outcome. The research work states that female pupils taught with instructional aids performed significantly better than their male counterparts who were not taught with instructional aids[5]. However, the second hypothesis had to be acceptedbecause there is no significant effect of gender on Senior Secondary School Students academic achievement in Set Theory in Oyo South Senatorial District, Oyo State.

The outcome of the third hypothesis states that there is a significant effect of subject combination on interactive materials' intervention on Senior Secondary School Students' academic achievement in Set Theory. A research work is in line with the outcome. The research work states that through visual arts and music, the arts provide avenues for students to delve into Mathematical patterns, symmetry and spatial reasoning. Engaging in artistic endeavours that incorporate Mathematical concepts can enrich students' comprehension and admiration for Mathematics[6]. Regarding commercial class, the comprehension of mathematical concepts can be imparted by their practical implementation of finance, economics and statistics. By studying

business subjects alongside Mathematics, students gain real world contexts to employ Mathematical concepts[7]. For science class by studying science alongside Mathematics, students can foster more profound understanding of Mathematical concepts as they observe their practical relevance in real world situations[8]. This implies that subject combination has an effect on interactive materials intervention on Senior Secondary School Students academic achievement in Set Theory in Oyo South Senatorial District, Oyo State.

The outcome of the fourth hypothesis states that there is no significant effect of gender on Senior Secondary School Students' academic achievement in Set Theory. From the research work, it was observed that the performance of female students slightly surpassed their initial performance after the introduction of the interactive material. A research work is in variance with the outcome. The research work states that female pupils taught with instructional aids performed significantly better than their male counterparts who were not taught with instructional aids[5]. However, the second hypothesis had to be acceptedbecause there is no significant effect of gender on Senior Secondary School Students academic achievement in Set Theory in Oyo South Senatorial District, Oyo State.

The outcome of the fifth hypothesis states that there is a significant effect of subject combination on interactive materials' intervention on Senior Secondary School Students' academic achievement in Set Theory. A research work is in line with the outcome. The research work states that through visual arts and music, the arts provide avenues for students to delve into Mathematical patterns, symmetry and spatial reasoning. Engaging in artistic endeavours that incorporate Mathematical concepts can enrich students' comprehension and admiration for Mathematics[6]. Regarding commercial class, the comprehension of mathematical concepts can be imparted by their practical implementation of finance, economics and statistics. By studying

business subjects alongside Mathematics, students gain real world contexts to employ Mathematical concepts[7]. For science class by studying science alongside Mathematics, students can foster more profound understanding of Mathematical concepts as they observe their practical relevance in real world situations[8]. This implies that subject combination has an effect on interactive materials intervention on Senior Secondary School Students academic achievement in Set Theory in Oyo South Senatorial District, Oyo State.

Endnotes

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Chapter Five

Conclusion

This chapter deals with the Summary of Findings, Conclusion, Recommendations based on the finding of the study, contribution to knowledge and suggestion for further research.

5.1 Summary of Findings

The results of the findings showed the previous academic achievement scores of Senior Secondary School Students in Set Theory in Oyo South Senatorial District, Oyo State. 100% of students had low academic achievement in Set Theory in their pre-test scores for both control group and experimental group. This implied that all the Senior Secondary School Students in Oyo South Senatorial District had low academic achievement in their previous academic achievement.

The findings also showed the present academic achievement scores of Senior Secondary School Students in Set Theory in Oyo South Senatorial District, Oyo State. 100% of students had low academic achievement in post-test scores for the control group, although, there was a slight improvement in test scores. For the experimental group, 65.9% of students had low achievement scores, 24.7% of students had medium achievement scores and 9.4% of students had high achievement scores. This implied that a considerable number of Senior Secondary School Students in Oyo South Senatorial District had medium and low academic achievement in Set Theory.

There is a significant main effect of interactive materials' intervention on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District. ($F_{(1.82)} = 50.317$, $p < 0.05$, $n^2 = 0.380$).

There is no significant main effect of gender on the academic achievement of Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State.($F_{(1.82)}$= 2.918, p > 0.05, n^2=0.034).

There is no significant main effect of subject combination on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State. ($F=_{(2.81)}$)=2.545, p > 0.05, n^2=0.059).

There is no significant interactive effect of interactive Materials' intervention and gender on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State. ($F_{(1.80)}$=2.758, p > 0.05, n^2= 0.033).

There is no significant interactive effect of interactive materials' intervention and Subject combination on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State. ($F_{(2.78)}$= 0.308, p > 0.05, n^2= 0.08).

5.2 Conclusion

The study reached the following conclusion based on the collected data, discussion, interactive review and finding.

This study was carried out as one of such efforts to improve students' performance in Set Theory in Senior Secondary Schools. To achieve this, the study determined the Effect of Interactive Materials' Intervention on Senior Secondary School Students' academic achievement in Set Theory in Oyo South Senatorial District, Oyo State. However, the interactive Materials' intervention method was found more effective in students' academic achievement for treating Set Theory.

5.3 Recommendations

Based on the findings, discussion and conclusion drawn from this research, the following recommendations were made:

i. Teachers and school administrators should work together to address the challenges posed by the use of conventional methods in the teaching of Set Theory.

ii. School management should make interactive Materials available for teaching Set Theory and Mathematics as a whole.

iii. Government should hold a regular workshop/seminar for teachers which should be aimed at training them on how to be innovative in the classroom. That is, they should be trained on how to create interactive materials suitable for every topic.

iv. Male and female gender should be encouraged and assisted for better achievement in Set Theory.

v. The different subject combinations should be encouraged and assisted for better achievement in Set Theory.

vi. Teachers should be mindful of the interactive effect between interactive materials' intervention and gender on academic achievement. This suggests that teachers may need to tailor their teaching methods to suit the diverse learning needs of male and female students. It's important to foster an inclusive learning environment that accommodates various learning styles.

vii. Teachers should be mindful of the interactive effect between interactive materials' intervention and subject combination. This suggests that teachers may need to tailor their teaching methods to suit the intellectual level of Arts, Science and Commercial students.

5.4 Contribution to Knowledge

1. Conceptual Contribution

Conceptually, this study has enhanced the conceptual definitions of the following terms, such as the "effect of interactive materials' intervention," "students' academic achievement" and Set Theory.

2. Experimental Contribution

This research significantly contributes to the growing body of evidence supporting the effectiveness of Interactive Materials' Intervention in Set Theory.

3. Implications for Education and Policy makers

Education and Policy makers are encouraged to consider the integration of Interactive Materials' Intervention into the teaching of Set Theory as a means to foster improved learning outcomes.

5.5 Suggested Area for Further Research

It is essential to acknowledge the limitations of the study. The research was conducted in Senior Secondary Schools in Oyo South Senatorial District, Oyo State and the findings may not be directly generalized to other regions or educational settings. Additionally, other unexamined

factors , such as student motivation, teacher expertise and classroom dynamics could have influenced the results.

Future researchers in the field should aim to address some of these limitations:

1. Multicenter Study: Conducting a broader, multicenter study could provide a more comprehensive understanding of the effects of interactive materials' intervention across diverse educational levels, such as primary schools and junior secondary schools. This approach would allow for further research in varied contexts.
2. Long-term Effects: Exploring the long-term effects of the interactive materials' intervention approach on students' Set Theory proficiency and retention could also be a valuable avenue for further investigation. This would provide insights into the lasting impact of this teaching approach on students' learning outcomes.
3. This study could also be conducted in other states in Nigeria with at least three Senior Secondary Schools.
4. More investigations need to be carried out on interactive materials' intervention using other moderating variables like attitude and school location.
5. This study can be extended to other concepts in Mathematics not examined.

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Appendix I

CRITERIA FOR CHOOSING SAMPLE FOR EXPERIMENTAL RESEARCH

1. It must be from a public secondary school.
2. It must be a Senior Secondary Class.
3. Set Theory must be in the curriculum of the class to be chosen
4. Students must have been taught Set Theory.
5. It must be an intact class

Appendix II

Table of Specifications for Mathematics Achievement Test (MAT)

Number of Objectives

Level of objective	Definitions	Set Notation	Venn Diagram (2 sets)	Venn Diagram (3 sets)	Total
Knowledge	3	5	5	2	15 (37.5%
Comprehension	1	6	4	7	18 (45%)
Application			5	2	7 (17.5%)
	4(10%)	11(27.5%)	14(35%)	11(27.5%)	40(100%)

Appendix III

OYO STATE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

S/N	Local Government	No. Of Schools	SSS2 Enrolment
1	Ibadan North	42	5,283
2.	Ibadan North- East	34	2,611
3.	Ibadan North- West	13	1,771
4.	Ibadan South- East	40	5,797
5.	Ibadan south- West	36	5,182
6.	Ibarapa Central	11	1,129
7.	Ibarapa North	8	952
8.	Ibarapa East	11	571
9	Ido	26	2,414
	Total	221	26,710

Appendix IV

Lesson Note on Set Theory

Subject: Mathematics

Class: Senior Secondary School Two (SSS2)

Duration: 1 hour 20 minutes (3 periods)

Date: December 9, 2022 – March 8, 2023

Topic: Set Theory

Specific Objectives:- at the end of lesson, students should be able to ;

1. Carry out all set Operations
2. Draw Venn diagram
3. Interpret Venn diagrams and solve problems on Venn diagrams.

Instructional material (control group): Comprehensive Mathematics for Senior Secondary Schools 1, 2, & 3, by D. B. Adu

Instructional material (Experimental group): A Constructed Venn diagram, coloured clips, other items.

Previous knowledge; The Students are required to already have an idea of what a set is all about.

Content:

SET THEORY

Definitions and Notations

A set is a well-defined collection of objects or things. For example, a set of whole numbers from 4 to 20. A set is usually represented by the symbol { } and capital letters are used to name set. For example, Let P = {Prime numbers from 1 to 30} read as P is the set of Prime numbers from 1 to 30.

Elements of a Set

The elements of a set are the items or things that belong to the set. They are also called members of a set. The symbol Ɛ is used to represent membership of a set while $\notin$ is used to represent non - membership of a set.

For example, Let Q = { 1, 2, 3, 4, 5, 6, 7, 8}

P = { 9, 11, 12, 13, 14}

Since 2 is contained in set Q then 2 Ɛ Q read as 2 is an element of set Q.

Also, 4 is not contained in set P, then 4 $\notin$ P read 4 is not an element of set P.

Number of elements in a set

The number of elements in a set is also called the cardinal number of the set. It is written as n (A).

Hence, given A = {5, 4, 6, 8}

B = { a, b, c, d, e, f, g, h}

then n(A) = 4 ie number of elements in A is 4.

n (B) = 8 i.e number of elements in B is 8.

Subsets

A subset is a set within another set. Consider the two sets below:

Let X = {3, 5, 6, 7, 8, 9, 10}

Y = {5,7,8}

Y is said to be a subset of X. This is so because elements of set Y are contained in set X. The symbol for subset is $\subset$. Therefore Y as a subset X is written as Y $\subset$ X. In the above example, Y is called the proper subset of X since Y does not contain every element of X.

The number of subsets which a particular set has is called its power set. This can easily be determined.

Consider, if P = {2}

Subsets are {2} and {}

Also if Q = {3, 1},

Subsets are {3} {1} {3, 1) and {}

And if R = { 4, 6, 7}

Subsets are {4}, {6}, {7}, {4, 6}, {4, 7}, {6, 7} {4, 6 7} and { }

Algebraic Set Notation

A set is written in such a way that the elements are listed out. This is not always the case, sometimes some algebraic approach needs to be used, such notation in algebraic forms are given below:

P = {X : X is a prime number less than 25}

The interpretation is: P is a subset of X such that X is a prime number less than 25

P = {2, 3, 5, 7, 11, 13, 17, 19, 23}

D = { X : X € z 5 ≤ x ≤14}

The above statement is read as, D is a set of X such that x is an integer and lies between 5 and 14 both inclusive, i.e X greater or equal to 5, X less than or equal to 14

Hence D = {5, 6, 7, 8, 9, 10, 11, 12, 13, 14}

Types of set

1. **Empty Set:** An empty set is a set withoutany element or member. It is called a null set. The notation for empty set is either ∅ or {}.Note that {0} is not an empty set because it contains element zero.

2. **Finite set:** A set is said to be finite if the elements can be counted. This is, the counting of the elements has a definite end.

   For example; G = {number of grains in a bag of beans}

   This is countable except that the time to complete it may be long, other examples are:

   {Local Governments in Nigeria}

   {Students in Nigerian Universities}

3. **Infinite set:** A set is infinite if the elements are uncountable.

   For example:

   {Multiples of 9}

   {Positive integers}

4. **Disjoint Set**. Two sets are disjoint if they have no elements in common.

   For example: If F = {a, m, t, h}

   G = {k, l, d, r }.

   then F and G are disjoint

5. **Equal Sets:** Sets are said to be equal if they contain the same members. The Order of the arrangement of the members does not matter.

   For example; If A = {1, 3, 4, 7}

   B = {8, 7, 1, 4}

   Hence A = B

Relationship between sets

- **Intersectionof Sets**

The intersection of sets P and D (written as P ∩ D) is a set that contains all elements common to sets P and D.

Examples:

If P = { 1, 2, 3, 4, 5, 6} and

Q = {9, 6, 4, 8, 10, 12} then P ∩ Q = {4, 6}

Given that A = {a, b, c, d, e, f, g, h}

B = {a, e, i, o, u, d, q, r}

Therefore A ∩ B = {a, e, d}

- **Union of Sets**

The set of all elements in set P or Q or both, is the union of sets and written as P U Q. When listing the union of two or more sets, it will only require combining the elements of two or more sets in one common set without repeating any element, i.e no element is written twice.

Examples:

1. Let A = {1, 3, 5, 7, 9, 11, 13}

   And B = {1, 2, 3, 4, 6, 9, 10}

   then A U B = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13}

2. Given that X = {a, b, c, d, e}

   Y = {a, e, i, o, u}

Therefore X ∩ Y = {a, e}

The Universal Set

The universal set denoted by U or E is the background set which contains the elements being discussed under each smaller set (i.e subsets) within it.

Rectangles used to represent universal set and other set discussed under it are usually represented by circles.

For example:

U = {1,2,3,4,5,6,7,8,9,10}

P = {1, 3, 5, 9, 8}

Q = {1, 2, 4, 6, 8}

R = { 3, 5, 6, 9}

The complement of a set

Complement of a set P written as P^1 or P^C is the set of all elements which are present in the universal set but are not in set P itself.

U = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10}

P^1 = {2, 4, 6, 9, 10}

Q^1 = {3, 5, 7, 9, 10}

R^1 = {1, 2, 4, 7, 8, 10}

Difference of sets

Given any two sets A and B, the difference between A and B denoted by "A - B" is the set of elements in A but not in B. Similarly, the difference between B and A denoted by B - A is the set of elements in B but not in A.

For example,

If A = {a, b, c, d, e, f}

B = {b, d, e, g, h}

then

A - B = {a, c}

B - A = {g, h}

Set Notation

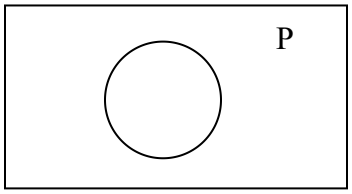
$a \in X$	a is an element of X
$P \notin Q$	P is not an element of Q
n(x)	number of element in X
$\cup$ or ε	the universal set
$\varnothing$ or $\{\ \}$	the null or empty set
A^1	the complement of A
$B \subset A$	B is a subset A
$A \supset B$	A is a super set of B
$\cup$	union
$\cap$	intersection

Venn Diagrams

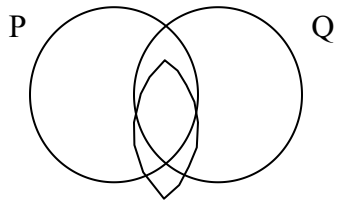
The venn diagram is a geometric interpretation of sets using diagrams which show different relationships between sets. The diagram was invented by one English mathematician by name John Venn (1834-1923). In venn diagram, the rectangle is the universal set while the oval shaped sets inside it represent the subsets. If the ovals overlap, it shows intersection. If the ovals do not overlap, it shows that there is no intersection between them. The following diagrams show some relationship which the venn diagram can be used to explain.

Relationship between two sets.

P is a subset of the universal set



The shaded portion is the complement of set P written as P^{l}

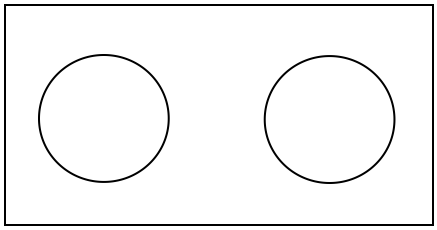


Shaded portion stands for P intersection Q written as P ∩ Q.

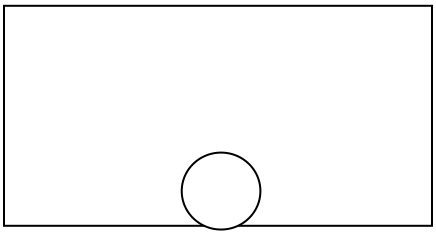
Shaded portion shows elements in set P but not in set Q. i.e. P - Q or P ∩ Q

Shaded portion shows elements in Q but not in P. i.e. Q - P or P^{1} ∩ Q .

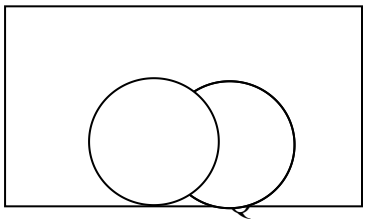
P U Q, i.e. P union Q region is shaded.



P and Q are disjoint sets, i.e no intersection between them. Therefore P ∩ Q = Φ



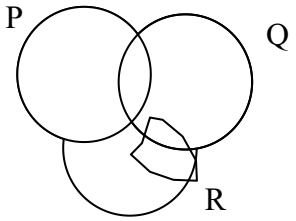
The relationship shows that P is a subset of Q written as P ⊂ Q.



The shaded portion is the element common to the set of the elements neither in P nor Q. It is written as $P^I \cap Q^I$ or $P \cup Q)^I$

Relationship between three sets

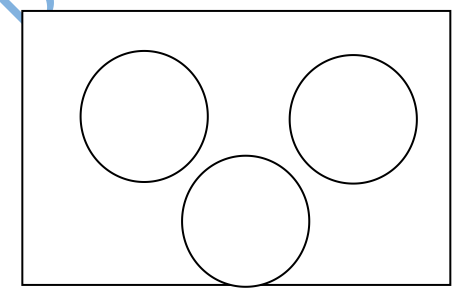
Shaded portion is the intersection of the three sets, P, Q, R written as P ∩ Q ∩ R.



Shaded portion shows the elements in Q and R, but not in P written as Q ∩ R ∩ P^I

Shaded portion shows the elements in P only, but not in Q and not in R written as P ∩ Q^I ∩ R^I

Shaded region shows the union of the three sets written as P U Q U R



P, Q, R are disjoint sets. i.e no intersection between them.

Examples

Use the Venn diagram to illustrate the information below

U = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10}

P = {2,4, 5, 7}

Q = {1, 2, 5, 6, 8}

R = {1, 2, 4, 6, 9}

Solution

2. In a class containing 32 students, a student can either do Government or History or both. If 16 students do Government, 18 do History and 3 do none of the subjects, find how many do both.

Solution

Let the students who do both be x

U = 32

Government n(G) = 16

History n(H) = 18

Neither $n(GUH)^1$ = 3

$\varepsilon = 32$

But $16 - x + 18 - x + x + 3 = 32$

$\therefore \quad 37 - x = 32$

$\therefore \quad x = 5$

5 students do both Geography and History.

3. Out of the 400 students in the final year in a senior secondary school, 300 are offering Biology and 190 are offering Chemistry.

(i) How many students are offering both Biology and Chemistry. If only 70 students are offering neither Biology nor Chemistry?

(ii) How many students are offering at least one of Biology or Chemistry?

Solution

(i) Let y represent students offering both Biology and Chemistry.

n(B) 300

P(C) =190

U = 400

Fig. 8.19

But $300 - y + 190 - y + y + 70 = 400$

$560 - y = 400$

$- y = 400 - 560$

$- y = - 160$

$y = 160$

(ii) At least one of Biology or Chemistry is

$B \cap C^I + C \cap B^I + B \cap C$

$300 - 160 + 190 - 160 + 160$

$= 140 + 30 + 160$

$= 330$ students.

4. In a class of 40 students, 25 speak Hausa, 16 speak Igbo, 21 speak Yoruba and each of the students speaks at least one of these three languages. If 8 speak Hausa and Igbo, 11 speak Hausa and Yoruba and 6 speak Igbo and Yoruba.

Draw a venn diagram to illustrate the information using x to represent the number of students who speak all the three languages

(b) Calculate the value of x.

Solution

n(HUIUY) = U = 40

n(H) = 25

n(I) = 16

n(Y) = 21

n(H∩I) = 8

n(H∩Y) = 11

n(Y∩I) = 6

Putting this in Venn diagram becomes

U= 40

Note: $6 + x = 25 - (8 - x + x + 11 – x)$

$2 + x = 16 - (8 – x + x + 6-x)$

$4+x = 21 (11-x + x + 6 – x)$

(b) $(6 + x) + (2 + x) + (4 + x) + (8 – x) + (11 - x) + (6 –x) + x = 40$

$37 + x = 40$

$x = 40 - 37$

$x = 3$

Control Group

Teacher's activities: Teacher will do the following:

1. Carry out classroom instruction using her lesson note alone.
2. Give definitions, explanations and solve some examples.
3. Give room for students to ask questions on areas not clear to them.
4. Call out students, one after the other to solve problems on the board.
5. Write note on the board for students.

Students' activities: Students will do the following:

1. Pay rapt attention to classroom instruction.
2. Ask teacher questions on areas not clear to them.
3. Go to the board when called out by teacher to solve some problems on the board.
4. Write note from the board into their notebooks.

Experimental Group

Teacher's activities: Teacher will do the following:

1. Carry out classroom instruction using a make-shift venn diagram.
2. Display the make-shift venn diagram in front of the class
3. Explain the term "set" and set notations with the help of the make-shift venn diagram.
4. Write some problems on the board.
5. Represent the problems on the make-shift venn diagram
6. Solve problems on the board while referring to the interactive material for every detail
7. Write examples on the board
8. Call students randomly to represent the example on the make-shift Venn diagram.

9. Solve examples on the board

10. Write note on the board for students

Students' activities: Students will do the following:

1. Move to the front of the class to have a view of the make - shift venn diagram .

2. Listen to class instruction with rapt attention.

3. Carefully observe how teacher interacts with the interactive material

4. Represent written examples on the make-shift Venn diagram, when picked by teacher

5. Write note from the board into their notebooks.

MATHEMATICS ACHIEVEMENT TEST (MAT)

Dear respondents,

This achievement test of 40 questions is for Senior Secondary School Two (SSS2) science, Arts and Commercial students. It is meant to test your knowledge of Set Theory. Please adhere to the instructions and attempt all questions,

Thank you.

Instruction: Each question has options A to D. Tick the most appropriate option for each question.

Section A: Demographic Characteristics of the Students

1. Age as at last birthday ----------
2. Gender Male ( ) Female ( )
3. Present class ----------
4. Do you have Mathematics teacher(s) in your school? Yes ( ) No ( )
5. How many are they? ----------
6. Do they teach Mathematics very well? Yes ( ) No ( )
7. Do you perform well in Mathematics tests? Yes ( ) No ( )
8. Have you been taught Set Theory? Yes ( ) No ( )
9. In which class was it taught ----------
10. Can you recognize the Venn diagram if you see one? Yes ( ) No ( )

Section B

1. Given A = {2,4.6.8}

   B = {a, b, c, d, e, f, g, h}

   The number of elements in set A and set B can be written a.

   a. n (A) = 4, n (B) = 6

   b. n (A) - 8, n (B) = h

   c. n (A) =20, n (B) = ah

   d. n (A) 4, n (B) = 8

2, Two sets are disjoint if they:

   a. Have some elements in common

   b. Have two elements in common

   c. Have no element in common.

   d. Are the same.

3. If A {1, 3, 4, 7}

   B {3, 7, 1, 4.}

   Hence, it can be said that:

   a. $A + B = \varnothing$

   b. $A \neq B$

c. A = B

d. A – B = 4

4. List the elements of set A, if set A={factors of 24}

a. A= {0, 1, 4, 6, 9, 12 and 24}

b. A= {1, 2, 3, 4, 5, 6, 8, 12 and 24}

c. A = {1, 2, 3, 4, 6, 8, 12 and 24}

d. A = {0, 2, 4, 6, 8, 12 and 24}

5. List the members of P, if P= {X: X E N, X < 10

a. P = {1, 2, 3, 4, 5, 6, 7,8, 9}

b. P = {-1,-2,-3, -4,-5, -6, -7,-8,-9,-10}

c. P ={ -1, -2,-3, -4,-5,-6, -7, -8,-9}

d. P = {1,2 ,3, 4, 5, 6, 7, 8, 9, 10}

6. If F = {a, m, t, h}

G = {k, l, d, r}

Which statement is true?

a. F=G

b. F and G are disjoint

c. F and G have two elements in common

d. F and G are equal sets.

7. Given that P - {1,2, 3, 4, 5, 6} and Q = {2, 4, 6, 8, 10, 12}

   Which of the statements is correct?

   a. P ∩ Q = {2, 4, 6}

   b. P ∩ Q = {1, 2, 6}

   c. P ∩ Q = {4, 6}

   d. P ∩ Q = {1, 4, 6}

8. If M = {X:3 ≤ X <8} and N= {X:8<X ≤12}

   Which of the following is true?

   I. 8 EM ∩ N II. 8 E M U N III. M ∩ N = ϴ

   a. II only.

   b. I and II only

   c. II and II only

   d. I, II and II

9. If A= {u, v, w, X, Y, Z}

   B ={a, b, c, d, e, x}

   Which statement is correct?

   a. A ≠ B

   b. A =B

   c. A and B are disjoint

   d. A ∩ B = ϴ

Instruction: Study the diagrams below. Use fig 1 to fig 15 to answer questions 10 – 25

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

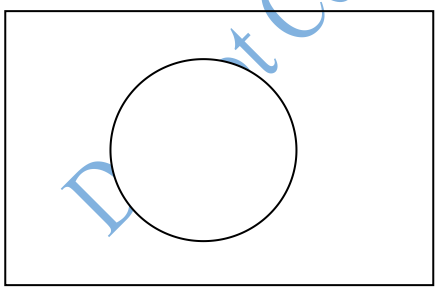


Fig. 7

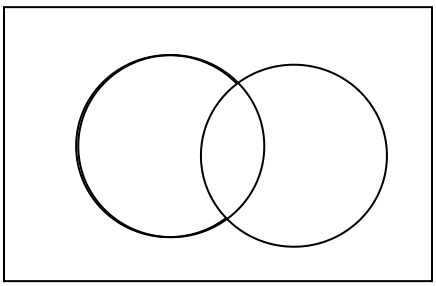


Fig. 8

Fig. 9

Fig. 10

Fig. 11

Fig. 12

Fig. 13

Fig. 14

Fig. 15

10. In figure 1, P and Q are said to be

    a. Joint sets
    b. Disjoint sets
    c. Divided sets
    d. Universal sets

11. In Fig 2, P and Q are described as

    a. P is a subset of Q
    b. P is a superset of Q
    c. P ∩ Q
    d. P is equal to Q

12. In Fig. 3, the shaded portion is best described as

    a. $P \cap Q^1$
    b. $P^1 \cap Q$
    c. $P \cap Q$ or $(P \cup Q)^1$
    d. $P^1 \cup^1$ or $P \cap Q^1$

13. In Fig 4, the shaded portion can be written as:

    a. P - Q or $P \cap Q^1$

b. P^1 - Q

c. Q -P or Q ∩ P^1

d. $Q^1 – P^1$

14. In Fig 4, the non- shaded portion can be written as

a. P-Q or P n Q^1

b. P^1 - Q

c. Q - P or Q ∩ P

d. $Q^1 – P$

15. Which statement best describes Fig 5?

a. P - Q or P ∩ Q^1

b. Q - P or Q ∩ P^1

c. P ∩ Q

d. P U Q

16. Which of the statements is true of Fig. 6?

a. P is the universal set

b. E is the subset of P

c. P is the subset of E

d. None

17. In Fig. 7, the shaded portion is the complement of set P. It can be written as:

    a. P^1 or P^c

    b. 1^p or C^p

    c. P^i or P^c

    d. CP or CP^i

18. In Fig. 8, the shaded portion is described as

    a. P U Q

    b. P ∩ Q

    c. P^i U Q

    d. P^i ∩ Q

19. Which of the statement is true of fig. 9?

    a. P, Q and R are disjoint sets

    b. P, Q and R have some elements in common

    c. P, Q and R have no elements in common

    d. None

20. The relationship in Fig. 9 can best be described as:

    a. P U Q ∩ R

    b. P U Q U R

    c. P ∩ Q U R

    d. P ∩ Q ∩ R

21. The shaded portion in Fig. 10 shows:

    a. The elements in Q and R, but not in P

    b. The elements in P and Q, but not in R.

    c. The elements in Q and R and P.

    d. None.

22. The shaded portion in Fig. 10 can best be described as:

    a. $Q \cap R \cap P$

    b. $Q \cap R^i \cap P$

    c. $Q^i \cap R \cap P$

    d. $Q^i \cap R^i \cap P^i$

23. The shaded portion in Fig. 11 can be represented as:

    a. $P \cap R \cap Q'$

    b. $P \cap R \cap Q$

    c. $P' \cap R \cap O$

    d. $P \cup R \cap Q$

24. From fig. 12, which statement is true?

    a. The shaded portion shows the union of two sets P and Q

    b. The shaded portion show the intersection of two sets P and Q

    c. The shaded portion is the element common to set P alone

    d. None

25. Fig. 13, 14 and Fig, 15, the shaded portions have characteristics in common which is?

a. They show the elements in one set only

b. They show the union of two sets

c. They show the intersection of two sets.

d. None.

26.

Using the venn diagram, find n(X ∩ Y')

a. 2

b. 3

c. 4

d. 6

27. Consider the following statements

X: Locally manufactured tyres are attractive.

Y: Many locally manufactured tyres do not last long.

(a) b. c.

d.

28. _____

Determine M ∩ N from the Venn Diagram

a. (f, g)

b. (c)

c. (c, f, g)

d. (e, f, g)

_____

29

Determine X ∩ Y ∩ Z from the

Venn diagram.

a. 6

b. 2

c. 1

d. 10

30. _____

Using the Venn diagram, find n(P ∩ O)

a. 2

b. 3

c. 4

d. 6

31. In a class containing 32 students, a student can either do Government or History or both. If 16 students do Government, 18 do History and 3 do none of the subjects, find how many do both.

a. 2

b. 4

c. 5

d. 6

32. U {1, 2, 3, 4, 5, 6, 7, 8, 9, 10}

P = {2, 4, 5, 7}

Q = {1, 2, 5, 6, 8}

R {1, 2, 4, 6, 9}

Which is the correct representation of the above information?

a.

b.

c.

d.

Let

A = {a, b, c, d}

B = {a, c, g}

C = {c, g, m, n, p}

U = {a, b, c, d, g, m, n, p}

Instruction: Use the above information to answer questions 33-35

33. Find {(A U B) Ո C}

a. {a, g}

b. {c, g}

c. {g, m}

d. {a, d}

34. Find (A ∩ B) U C

a. {a, b, c, d, g, m, n, P}

b. {b, c, d, g, m, n, P}

c. {a, b, c, d, m, n, P}

d. None

35. Find A ∩ B ∩ C

a. {a}

b. {b}

c. {c}

a. {d}

36. On the reception or induction of new students in a certain university, 800 students turned up at the opening ceremony, 600 students turned up at the novelty match and there is a total of 1234 students altogether in the school. How many students attended both functions?

a. 66

b. 166

c. 266

d. 206

37. Suppose the school bursar said that 600 students entered for Mathematics, 300 entered for Physics while 173 students entered for both Mathematics and Physics in 2002 SSCE, how many students enrolled in the two courses altogether?

a. 27

b. 127

c. 427

d. 727

38. In a school inter-house competition, 80% of the students turned up at the athletic competition, 60% turned up at the football match. What percentage of students attended both functions?

a. 10%

b. 20%

c. 30%

d. 40%

All the 62 students in SSS3 of a named school take either Mathematics (M) or Physics (P) or Chemistry c. 40 take Mathematics, 42 take Physics, 38 take Chemistry, 20 take Mathematics and Physics, 28 take Physics and Chemistry, while 25 take Mathematics and Chemistry.

39. How many take Mathematics, Physics and Chemistry (All 3 subjects)

    a. 73

    b. 51

    c. 15

    d. 37

40. How many take Mathematics but neither Physics nor Chemistry?

    a. 5

    b. 10

    c. 15

    d. 20

Bio-data

A. Personal Data

1.	Full name:	George Omenihu ODUALI
	Email:	mabbyclick@gmail.com
	Phone number:	09020027219
2.	Date and Place of Birth:	31st October, 1986, Port- Harcourt
3.	Nationality:	Nigerian
4.	Name & Address of Next of Kin:	Mrs. Elizabeth Nnenda Oduali 3, Wagbara Lane, Owhipa St. Choba, River State

B. Educational Background with Dates

Lead City University, Ibadan M.Ed Mathematics Education (In view)	2019 till date
Lead City University, Ibadan B.Sc (Ed.) Mathematics	2018
Adeniran Ogunsanya College of Education, Ijannikin Lagos State NCE Mathematics/ Physics	2015
Erijoy Secondary Academy, Port- Harcourt	2003
Rivers State College of Education Demonstration Secondary School, Ndele	2000
CITA International Nursery/ Primary School, Rumuogba, Port- Harcourt Senior Secondary School Certificate	1997

C. Working Experiences with Dates

Lead Academy Nur. / Pry School, Felele Ibadan	September, 2020- January 2022
Lead City University, Ibadan	December, 2022

D. Awards and Fellowships (if any)

E. Membership of Academic/Professional Bodies

Member, Teachers Registration Council of Nigeria	October, 2018
Institute of Personality Development & Customer Relationship Mgt.	April 2018

F. Publications

1. **Thesis/Dissertations: Oduali G.O.** Perceived Influence of Study Habit and Teacher-Efficacy on Senior School Students' Academic Achievement in Mathematcs in Ibadan, Nigeria.

2. Effects of Interactive Materials' Intervention on Senior Secondary School Students' Academic Achievement in Set Theory in Oyo South Senatorial District, Oyo State

G. Major Conferences Attended with Dates

i)Participated in the 6th Faculty of Education International Conference, themed: Re-engineering Teacher Preparation To Catch-Up With Industry 4.0 in Lead City University, Ibadan, on the 25th to 27th of July 2023

ii) Attended Fortune Royal Multiconcepts Workshop for Teaching Staff in Lead City University on the 27th and 28th of July.

iii) Participated in Lead City University postgraduate conference, themed "Innovative Research and Quality Education for Sustainable Development". October 16th - 19th, 2023

H. References

Prof. Philias Tunde Yara
Head of Department, Science Education Department
Faculty of Arts & Education
Lead City University, Ibadan
08034715891

Dr. Akuche Ukamaka E.
Senior Lecturer
Faculty of Arts & Education
Lead City University, Ibadan
08055425576

Dr. Sam-Kayode Christianah O.
Lecturer I
Faculty of Arts & Education
Lead City University, Ibadan
08052109811

_____ _____

Signature **Date**

The University Compliance Certification

This is to certify that this thesis by Omenihu George ODUALI in the Department of Science Education, Lead City University, Ibadan, is in Full compliance with the approved University Format and Style.

_____ _____

Signature **Date**