

Chapter One

Introduction

1.1 Background to the Study

Mathematics is one of the subjects studied at all academic levels and in all scientific disciplines. The knowledge of other sciences, even those that are intimately connected to humans in terms of technology and science is built on the foundation of Mathematics. Based on how it is used, Mathematics is always changing in a way that is closely related to how the age is changing. As a result, it can be said with certainty that Mathematics is always present in our lives¹. The advancement of scientific, technological, economic and social knowledge depends heavily on Mathematics. Mathematics is seen as a significant enabler of the sciences, digital technologies, and innovation, which are regarded as the primary jobs and economic drivers of the future².

Many of the sciences, including physics, chemistry, biology, engineering, and information technology, as well as non-science disciplines like accounting, economics, geography, and even physical education, music, and art, are based on Mathematics. Mathematics serves as a link between all knowledge and is one of the most important subjects in the school curriculum. Any nation's scientific, technological, and economic development is supported by Mathematics, which serves as both its foundation and a tool. Educationists hold the widespread belief that no one can advance in any field without a fundamental understanding of Mathematics. Without the foundation of Mathematics, science and technology cannot flourish and achieve economic independence. Base on this, Mathematics is one of the most important core subjects taught in secondary schools in Nigeria³.

Evidently, education is the fundamental means by which any society can grow economically and advance technologically. Secondary education serves as a bridge between primary and tertiary education. It is the type of education that students receive prior to the tertiary level and after primary school. Students go through six years in Secondary School, which is 3 years of JSS (Junior Secondary School), and 3 years of SSS (Senior Secondary School); during the 3 years of Junior Secondary School training, students are to take subjects, for example, Mathematics, English, French, Social Studies, cultural and creative arts, basic science and technology, pre-vocational studies, business education, Home Economics, Computer Studies or Fine Arts. The Senior Secondary curriculum consists of four core subjects followed by four or five elective subjects. The core subjects are: English; Mathematics; Economics; Civics Education; one or more science class electives from Biology, Chemistry, or Physics; one or more electives from English Literature, History, Geography, Agricultural Science, or a career-related field, such as Book-Keeping, Commerce, Food and Nutrition, Technical Drawing amongst other 17 subjects⁴.

Mathematics at senior school level is of two structures: General Mathematics and Further Mathematics. General Mathematics is a compulsory subject that all students in senior secondary school offer and an essential requirement for admission processing into university and other higher institutions in Nigeria. On the other hand, Further Mathematics is optional to students and is offered by science students in senior secondary school. Further Mathematics is not mandatory and normally disregarded by students attributable to challenges they experience in its learning. The term "Further Mathematics" refers to advanced Mathematics, which is more challenging than General Mathematics

but offers greater potential for tertiary education and career advancement. Its relevance is determined by a critical review of its significance to current and future goals in science and technology-related fields. The teacher may only encourage students to offer Further Mathematics if they do not do so. In addition to being advised to do so by their parents or teachers, students of science extraction need compelling reasons to continue their education in Mathematics⁵.

Further Mathematics is a subject that overcomes any barrier between Elementary Mathematics and Higher Mathematics because it serves as the foundation for the development of all science courses in all of their ramifications. The significance of Further Mathematics to the advancement of science and technology cannot be overstated. In the realm of science and technology, it is evident that Further Mathematics holds the key to unlocking the nation's technological advancement. The term "Further Mathematics" refers to an advanced level of Mathematics that goes beyond "Ordinary Arithmetic," "Geometry," "Algebra," and "Trigonometry". Topical contents of Further Mathematics include Calculus, Coordinate Geometry, Matrices, Sets and Logic, Mechanics, Theory of Numbers, Probability and Statistics⁶.

Specifically, Calculus is seen to be the foundation of many modern conceptions and theories. The development of calculus in the seventeenth century was a significant turning point in several disciplines, including Mathematics. Some consider its influence as a theoretical basis to be one of humanity's most powerful interventions. As a result, many countries of the world start teaching calculus ideas to students in high school. Calculus is a crucial prerequisite for the majority of scientific, technical, medical, and even business programs at university level. Students are expected to finish various levels

of calculus courses in order to understand calculus ideas. Students may be required to finish one, two, or even four levels of calculus, depending on their academic program and its mathematical requirements⁷.

Learning the essential ideas of Calculus is a significant piece of secondary school and university educational plans. It is hard to imagine a scientific culture in the modern era without integrals and derivatives. These ideas comprise a firmly interconnected bunch of central thoughts and a fundamental device for grasping the world. Issues in learning and solving calculus have been in the overall focal point of exploration in arithmetic training for a long time⁸. Calculus concepts are viewed as the establishment for some hypotheses in our day to day existence. However, students in calculus classes worldwide experience high rates of failure and negative attitudes⁷.

Calculus is the foundation of analysis as a mathematical discipline. Limits, continuity, and the differentiation and integration of functions of one or more variables are all topics covered in calculus, which is the study of change. One of the themes in the senior secondary Mathematics curriculum is "introductory calculus," which refers to "basic calculus." With sufficient evidence, it has been determined that, worldwide, the majority of secondary school students consistently perform poorly in Mathematics, particularly introductory calculus⁹.

The level of proficiency in a particular academic domain, such as reading Mathematics, science, and social studies, among other subjects, is what defines academic achievement. Parents, teachers, and educational planners all have a significant role to play in maximizing academic achievement¹⁰. The performance of students on either teacher-created tests or standardized achievement tests administered by examining bodies

such as the West African Examination Council (WAEC), National Examination Council (NECO), National Business and Technical Examination Board (NABTEB) is the primary focus of Mathematics achievement¹¹.

In Oyo state, students' achievement in Further Mathematics has been fluctuating over time. The following are the percentage of students who achieved a credit pass or above in Further Mathematics, via trend analysis studies covering a decade of senior secondary school students' achievement pattern in May/June West African Examination Council (WAEC) SSCE results: 2013 (40.0%), 2014 (49.6%), 2015 (54.3%), 2016 (57.4%), 2017 (58.7%), 2018 (60.0%), 2019 (52.0%), 2020 (52.4%), 2021 (74.8%) and 2022 (72.1%). The fluctuating performance in Further Mathematics was attributed to a number of factors, including gender inequalities, poor Mathematics teacher quality, low motivation, inappropriate peer groups, low retention, negative student attitudes or interest in Further Mathematics, and ineffective teaching strategies^{12,13}.

During a typical session of Further Mathematics class, the teacher solves problems on the chalkboard and assigns class-work to the students to solve. These exercises are marked, and corrections can be carried over to the lesson the following day. There is no prompt discussion of the problem at hand or student feedback from the teachers of Further Mathematics¹⁴. This answer-oriented, rule-based, and computation-dominated view of Further Mathematics is a poor representation of what it really entails. The abstract nature and challenging course content of Further Mathematics makes many learners view it as a difficult subject and as such some of students offer it as a school subject. There is a widespread misconception that it is an exclusive subject for students with exceptional intelligence; for them, the classroom and the textbook are where Further

Mathematics begins and ends. There are urgent steps that need to be taken to improve optimal performance because these may be factors that contribute to the fluctuating performance in Further Mathematics¹³.

The awareness of various teaching strategies and their applications determines the manner in which tasks are presented to assist students in developing skills in learning. A teaching strategy is a method that the teacher of Further Mathematics employs to assist students in becoming independent, systematic learners by selecting appropriate methods and effectively utilizing them to complete tasks or reach goals. Further Mathematics can be taught using a variety of methods, such as; lecture, guided discovery, games, simulations, laboratory approach, problem solving, investigations, modeling, demonstration, memorization, inductive and deductive method. It is one thing for these methods to already exist, but it is quite another for the Further Mathematics teacher to know which one to use and changing from instructing students by 'telling' them what to do to instructing students by getting them to use valuable mathematical problem-solving strategies while working creatively and cooperatively¹⁵.

As far as this study is concerned, Inductive Teaching Strategy (ITS) and Deductive Teaching Strategy (DTS) are the two teaching strategies considered to be used to establish senior secondary school students' academic achievement in Further Mathematics, and calculus in particular. These two strategies are based on the two different forms of reasoning that people utilize while conducting proving processes, deductive reasoning and inductive reasoning, respectively. Deductive reasoning is distinctive because it is a method of drawing inferences from pre-existing knowledge (premise) based on formal logic principles. These conclusions must result from the

information presented and do not require experimental validation. In contrast, inductive reasoning uses particular premises or observations to draw a conclusion or general rule¹⁶.

In many ways, the deductive and inductive approaches to education are very different from each other. Teacher's role is the primary distinction between these two approaches. In a deductive classroom, the teacher introduces and explains concepts to students during lessons. Students are then expected to complete exercises or tasks to put these concepts into practice. However, the teacher employs the "noticing" method in an inductive classroom. That is, students are allowed the opportunity to get the rule from the examples given to them. It is hypothesized that for students to retain a concept, structure, or rule in their short- or long-term memory, they must notice it. In addition, research suggests that the direction in which information flows is the primary distinction between these two approaches. In inductive teaching, information flows from specific to general, whereas in deductive teaching, it flows from general to specific¹⁷.

The term "gender" is the scope of physical, biological, mental and behavioral characteristics relating to and differentiating between the feminine and masculine (female and male) population. The social and cultural differences between boys and girls are the primary reason why examining achievement in relation to gender is important¹⁰. Traditionally, some tasks and responsibilities are thought to be reserved for men only. Examples include agriculture, arts and crafts, and engineering. Catering, typing, nursing, and other careers, is adjust for ladies. The majority of the time, parents assigned the male child domestic tasks like washing the car, cutting the grass, fixing bulbs, and climbing ladders to fix or remove things. On the other hand, the female child is given domestic duties like washing dishes, cooking, and cleaning up the house¹⁸. By and large, it is

accepted that any assignment that is requesting or complex in nature ought to be taken care of by the young men while less requesting or generally simple undertaking ought to be dispensed to the young ladies¹⁹. Female are seen as the weaker sex because of this arbitrary way of thinking and/or belief held by the majority of society. Base on this, the typical Nigerian girl goes to school with these preconceived notions^{10,20}.

Gender differences in scientific and mathematical pursuits emerge in early childhood. Around early puberty gendered designs emerge, simultaneous with the improvement of gender identity and adult gender roles. Around this time, educational and professional interests start to form, which leads to different levels of participation in and enthusiasm for learning Mathematics and science in and outside of school. After that, gender differences in participation in Mathematics and science education emerge during advanced course selection in secondary education. This is consistent with gender differences in science education, which typically emerge in secondary education when students are given the option to choose a specialization. Adolescents discover their strengths and interests and choose their areas of focus accordingly, such as major and minor subjects²¹. The question of gender differences is now a matter of grave concern especially among academics and educational policymakers¹⁰.

Despite the fact that Further Mathematics is a subject that both male and female students find challenging, the study of Further Mathematics education has the potential to change the type of mathematical learning that students are exposed to regardless of their gender status. Since teaching strategy and gender element are seen as recurring element of investigation in the field of Mathematics education⁶. The fluctuating performance in Further Mathematics over the years which is partly due to instructional strategies, call for

further studies which this study “Effect of Inductive and Deductive Teaching Strategies on Senior Secondary School Students’ Academic Achievement in Further Mathematics in Oyo State” center around to achieve.

1.2 Statement of the Problem

The trend analysis investigations disclosed the following fluctuations in the percentages of the May/June West African Examination Council (WAEC) SSCE results: The percentage of Oyo State students who receive a credit pass or above in Further Mathematics has not been consistent over the past ten years, as evidenced by reports from 2013 (40.0%), 2014 (49.6%), 2015 (54.3%), 2016 (57.4%), 2017 (58.7%), 2018 (60.0%), 2019 (52.0%), 2020 (52.4%), 2021 (74.8%), and 2022 (72.1%). Part of factors attributed to this fluctuating performance in Further Mathematics; especially in Calculus was ineffective teaching strategies. Since the method of instruction in Further Mathematics is the traditional method of teaching and the gender element is a recurring element of investigation in the field of Mathematics Education. Hence, there is a need for further studies. A number of studies have been conducted in a number of areas to improve students' academic achievement in Further Mathematics. However, to the best of the researcher's knowledge not much has been done in the area of effectiveness of Inductive Teaching Strategy (ITS) and Deductive Teaching Strategy (DTS) on Senior Secondary School Students' Academic Achievement in Further Mathematics in Oyo State. Therefore, this study intends to fill the research gaps and provide a solution with the established problems.

1.3 Aim and Objectives of the Study

The aim of this study is to investigate Effect of Inductive and Deductive Teaching Strategies on Senior Secondary School Students' Academic Achievement in Further Mathematics in Oyo State.

The objectives were to:

- i. investigate the main effect of inductive teaching strategy on senior secondary school students' academic achievement in Further Mathematics.
- ii. determine the main effect of deductive teaching strategy on senior secondary school students' academic achievement in Further Mathematics.
- iii. assess the main effect of gender on senior secondary school students' academic achievement in Further Mathematics.
- iv. examine the interaction effect of inductive teaching strategy and gender on senior secondary school students' academic achievement in Further Mathematics.
- v. examine the interaction effect of deductive teaching strategy and gender on senior secondary school students' academic achievement in Further Mathematics.
- vi. examine the interaction effect of inductive teaching strategy and deductive teaching strategy on senior secondary school students' academic achievement in Further Mathematics.
- vii. analyze the interaction effect of inductive teaching strategy, deductive teaching strategy and gender on senior secondary school students' academic achievement in Further Mathematics.

1.4 Hypotheses

The following null hypotheses were tested at the 0.05 level of significance based on the stated objectives:

H₀₁: There will be no significant main effect of inductive teaching strategy on senior secondary school students' academic achievement in Further Mathematics.

H₀₂: There will be no significant main effect of deductive teaching strategy on senior secondary school students' academic achievement in Further Mathematics.

H₀₃: There will be no significant main effect of gender on senior secondary school students' academic achievement in Further Mathematics.

H₀₄: There will be no significant interaction effect of inductive teaching strategy and gender on senior secondary school students' academic achievement in Further Mathematics.

H₀₅: There will be no significant interaction effect of deductive teaching strategy and gender on senior secondary school students' academic achievement in Further Mathematics.

H₀₆: There will be no significant interaction effect of inductive and deductive teaching strategies on senior secondary school students' academic achievement in Further Mathematics.

H₀₇: There will be no significant interaction effect of inductive teaching strategy, deductive teaching strategy and gender on senior secondary school students' academic achievement in Further Mathematics.

1.5 Significance of the study

Students, teachers, principals, educational administrators, curriculum planners, researchers, and the general public stand to gain greatly from the findings and conclusions of this study.

This study is important, especially for senior secondary schools in Oyo State and other states in Nigeria, where teachers and students face significant difficulties in teaching and learning calculus concepts in Further Mathematics.

The knowledge derived from this study would be of immense value to all the stakeholders; particularly, Further Mathematics teachers and other teachers that teach calculus as related topic to make use of effective teaching method in carrying out their lessons in senior secondary school level in order to improve students' academic achievement in particular and other students' academic achievement in general.

Furthermore, the publicity of this study in a reputable journal will serve as reference material to the teachers, educational policymakers, curriculum planners and researchers to source for teaching strategies (Inductive Teaching Strategy (ITS) and Deductive Teaching Strategy (DTS)) and citing the idea in their findings.

This study's findings will shed light on the impact that gender has on Senior Secondary School Students' Academic Achievement in Calculus Concepts. However, the weaknesses and strengths of the respondents and the limit of conceptual and geographical scope of this study will help other researchers to have research gap to fill as loop hole in future related research.

1.6 Scope of the Study

The study investigates Effect of Inductive and Deductive Teaching Strategies on Senior Secondary School Students' Academic Achievement in Further Mathematics in Oyo State. Hence, the contextual scope of the study was limited to effect of Inductive Teaching Strategy (ITS) and Deductive Teaching Strategy (DTS)) on Senior Secondary School Two (SSS II) Students' Academic Achievement in Further Mathematics. However, the geographical scope of the study was limited to Schools of Science, Oyo State, Nigeria.

1.7 Limitation of the Study

The following were the constraints encountered in the course of carrying out this research work:

Unavailability of Data: Problems were encountered in gathering data to update trend analysis of students' academic achievement in Further Mathematics in Oyo State. Latest percentage reports regarding academic achievement of Further Mathematics' students in Oyo state were inaccessible and not available online.

Political Factor: Problems were encountered in accepting the researcher to carry out the fieldwork in the selected schools of science for this study due to political reasons. The selected schools of science felt reluctant to accept the researcher to carry out the field work because they were afraid of using the research work for political purpose and asked the researcher to go through Ministry of Education Science and Technology for thorough screening and approval.

Time Constraint: Problems were encountered in fixing periods for the treatments in the selected schools of science for this study due to the tight scheduled of curriculum activities of the schools. The principals and the research assistants felt inconvenient with the tasks of assisting the researcher to carry out the treatments because of the schools' time frame for school periods that would be affected.

1.8 Operational Definition of Terms

The following are the key concepts used in this study and their operational meaning:

Academic Achievement: This is result of the test administered on the students during the course of this study as measured by DICAT.

Teaching Strategies: These are methods that involve sequence of instructions employed for teaching and learning process in the school system. In this study, it includes: Inductive Teaching Strategy (ITS) and Deductive Teaching Strategy (DTS)

Inductive Teaching Strategy (ITS): This is a teaching method used in this study to convey instructions from example to general rule in teaching and learning process.

Deductive Teaching Strategy (DTS): This is a teaching method adopted by this study to convey instructions from general rule to example in teaching and learning process.

Calculus Concepts: These are contents to be taught in this course of study which consist of topics that deal with change in variable with respect to other variables. It includes: Differential and Integral Calculus.

Gender: These are senior secondary school male and female students that participated in the study.

Endnotes

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Chapter Two

Literature Review

This chapter reviews relevant literature in every aspect. It was organized under the following subheadings:

2.1 Conceptual Review

2.1.1 Academic Achievement

2.1.2 Teaching Strategies

2.1.2.1 Inductive Teaching Strategy

2.1.2.2 Deductive Teaching Strategy

2.1.3 Gender

2.1.4 Further Mathematics

2.1.5 Calculus

2.2 Theoretical Framework

2.2.1 Social Cognitive Theory

2.2.2 Sociocultural Theory

2.2.3 Constructivist Theory

2.3 Review of Empirical Studies

2.3.1 Gender and Academic Achievement in Further Mathematics

2.3.2 Teaching Strategies and Academic Achievement in Further Mathematics

2.3.3 Teacher Skills and Academic Achievement in Further Mathematics

2.3.4 Students' Attitude and Academic Achievement in Further Mathematics

2.4 Conceptual Model

2.5 Summary of Literature Reviewed

2.1 Conceptual Review

2.1.1 Academic Achievement

Academic achievement is a term used to describe the degree of success and accomplishments that people achieve in their educational endeavors. It is a measurement of how well someone has performed in their academic endeavors, which can include various forms of learning, assessments, and accomplishments within an educational system¹. Academic achievement can be evaluated through grades, test scores, research projects, presentations, and other indicators of knowledge and skill acquisition. It is influenced by a variety of elements, including a student's work, the learning environment, access to resources, support systems, and personal circumstances. Although academic achievement is an important part of education, it is not the only determinant of a student's abilities, potential, or success. Students can differ in their abilities, talents, and skills in ways that go beyond the conventional academic achievement criteria^{1,2}.

Grades and assessments are essential parts of education that offer an organized approach to gauge the student's academic achievement and comprehension of the subject matter³. Within a system of education, they act as tools for communication, tracking progress, and providing feedback. A student's knowledge, abilities, and comprehension of the subject are evaluated using assessments and a student's level of success in a specific course, subject, or task is indicated by the symbols or numbers that make up their grades. They function as a quantitative indicator of a student's academic achievement². There are two types of grading scales that are frequently used: letter grades (A, B, C, etc.) and numerical scales (out of 100 or a certain range). It's crucial to understand that while grades and assessments are useful tools, they are not the only indicators of a student's

skills, potential, or all-around learning experience⁴. A well-rounded education is influenced by a variety of other elements, including participation, critical thinking abilities, and extracurricular activities⁵.

There are two different forms of assessments used in education to gauge students' comprehension of ideas, abilities, and subject matter: "teacher-made tests" and "standardized tests." Each kind has unique traits and is used for a certain purpose⁶. The term "teacher-made tests," also referred to as "classroom assessments" or "teacher-designed assessments," refer to examinations developed by individual teachers to assess their students' learning and progress within a particular classroom environment. These exams are made specifically for the subject matter and curriculum of a given course^{6,7}. Standardized tests are evaluations made to measure a student's talents, knowledge, and skills in a consistent and standard way. All test takers receive the same instructions, questions, and time constraints because these tests are given under standardized conditions. Standardized tests are designed to offer a fair and impartial method of evaluating students' academic readiness, performance, and potential⁸.

Teacher-made evaluations are personal to the classroom and are based on the teaching methods and curricula of the instructor, whereas standardized tests are uniform and are used for wider comparisons and a variety of educational judgments. In assessing student learning and guiding educational practices, both kinds of assessments are crucial^{6,9}. Standardized tests are important tool for gathering information, but they are just one component of a comprehensive evaluation of students' capabilities and potential. A more thorough assessment of a student's readiness for higher education and beyond is

possible with the help of additional variables like classroom performance, extracurricular activities, and personal traits⁸.

One of the most important standardized testing organizations in Nigeria is the West African Examination Council. The National Business and Technical Examination Board (NABTEB), the Joint Admissions and Matriculation Board (JAMB), and the National Teacher's Institute (NTI) are the others¹⁰. In order to administer exams that would be most appropriate for West Africa's needs and as necessary in the benefit of the public for the four British West African Countries of Nigeria, Ghana, Sierra-Leone, and Gambia, the West African Examinations Council was established as an inter-territorial authority in 1952. Its two responsibilities are to conduct such exams and award certificates and degrees based on the results of the exams performed, as well as to review and consider annually the exams to be held in West Africa¹¹. In May 1953, Nigeria's WAEC held its inaugural test, the Public Service Executive Competitive Examination. September of the same year saw the opening of the Lagos office. The West African School Certificate Examination (WASSCE) and Teacher College Grade II (TCII) were both originally administered by the council in December 1955 in collaboration with the University of Cambridge Local Examination syndicate. Liberia first joined the council in March 1970 as an associate member before becoming a full member in 1974^{10,11}.

The National Office of each of the member countries, however, administers the exams within its own territory despite the council's inter-territorial structure¹². The WAEC administers numerous tests in Nigeria. For instance, the council administered thirty various tests in 1986. The May/June School-based and November/December Private Candidates-based Ordinary Level School Certificate Examinations are currently

the two main exams offered by the council. The WAEC monopoly on the administration and certification of ordinary level examinations was broken once the Federal Government of Nigeria established the National Examinations Council (NECO) in April 1999¹³. In the interim, there were other testing organizations before the WAEC was implemented in Nigeria, including Cambridge University, which administered the Cambridge School Certificate Examination, and London University, which administered the General Certificate Examination, more commonly referred to as the London GCE. Then, both the regular and advanced level certificate examinations were conducted only by these British-based testing organizations in Nigeria^{11,14}.

A student's academic achievement is demonstrated by their participation in coursework, research projects, and presentations that call for in-depth comprehension and critical thinking¹⁵. Research and projects are essential parts of education because they give students the chance to delve deeply into a subject, use critical thinking abilities, and advance their knowledge in a variety of areas. These exercises offer chances for experiential learning, independent investigation, and innovative problem-solving¹⁶. Research projects allow students to develop skills in critical thinking, data analysis, information synthesis, and communication. Research entails the methodical exploration and analysis of a particular subject or issue in order to produce new knowledge or insights. Projects require students to produce concrete results that show their comprehension and application of principles. It gives students the chance to put their theoretical knowledge into practice, work with colleagues, manage their time wisely, and present their findings or results to others^{15,16}.

By encouraging abilities like critical thinking, problem-solving, creativity, communication, and teamwork, both research and projects contribute to a well-rounded educational experience. They enable students to take charge of their education and have a greater understanding of the things they study. Additionally, research and project outcomes sometimes include presentations, exhibitions, or reports that highlight students' accomplishments and boost their self-assurance¹⁵.

External evaluations are not the only way to gauge academic achievement. Academic achievement can also be attributed to having a sincere desire to learn as well as intellectual curiosity and personal development¹⁷. Self-motivated learning sometimes referred to as self-directed learning or autonomous learning is a proactive method of education in which students take charge of their own educational experience and propel their own intellectual development¹⁸. In self-motivated learning, students take charge, establish goals, and actively participate in picking up information and skills without relying exclusively on formal instruction. This strategy supports the acquisition of important skills outside of the classroom and promotes lifelong learning. Learning that is driven by one's own interests can occur in a variety of settings, including formal schooling, career advancement, and personal pursuits. By encouraging a proactive, lifelong learning mindset, it enhances conventional training. Self-motivated learners have never before seen opportunity to independently explore a wide range of topics and advance their knowledge and skills as technology and internet resources become more widely available^{19,20,21}.

Educational milestones are major accomplishments or developmental stages that students reach as they advance through their academic career. These landmarks identify

important junctures of change, development, and achievement within the educational system. From early childhood education to higher education and beyond, there are many different levels at which educational milestones might take place. Educational accomplishments act as progress markers, giving people a sense of accomplishment and directing their subsequent actions. Additionally, they influence curriculum design, educational regulations, and student success awards²².

In the context of education, the terms "recognition" and "honors" relate to the honors, awards, and distinctions that people get for their accomplishments, contributions, and academic success. These acknowledgements may come from organizations, communities, educational institutions, or even the general public. Honors and recognition not only provide recipients a sense of accomplishment, but they also inspire them to keep up their high standards. Additionally, they can improve a student's academic and professional resume, help with college and job applications, and open doors to more opportunities in the future. Recognition can also help people feel proud of themselves and like members of the educational community²³.

Degrees, diplomas, certificates, and other academic credentials are physical evidence of academic achievement and signify the successful completion of academic prerequisites. Degrees and graduation are important milestones in a person's educational career. These achievements denote a level of mastery and accomplishment in a particular field of study and recognize the successful completion of academic programs. Degrees and graduation can lead to a variety of opportunities in the academic and professional worlds²⁴. Graduating is the term used to describe completing a particular degree of education, such as high school or a college or university programs. To commemorate this

accomplishment, graduation ceremonies are frequently held, although they might differ in formality and tradition. Receiving a diploma or certificate after graduating frequently signifies moving on to the next educational stage. A transforming experience, earning a degree helps people develop their perspectives, knowledge, and skills in addition to giving them academic credentials. Graduation and earning degrees have great importance for a variety of reasons, including personal development, job advancement, and societal contribution^{25,26}.

2.1.2 Teaching Strategies

Teaching strategies refer to the techniques and procedures that teachers employ to help their students learn effectively. These techniques aim to engage students, improve their comprehension of the material, and foster critical thinking, problem-solving abilities, and general cognitive growth²⁷. Different teaching methods accommodate diverse learning preferences, learning styles, and educational objectives. The subject content, the students' requirements and learning styles, the educational setting, and the targeted learning results are all taken into account by effective teaching techniques. A dynamic and interesting learning environment is frequently created by skilled educators by combining several different tactics. To create a dynamic and adaptive learning environment that meets the needs and preferences of diverse learners, effective teaching strategies frequently incorporate components from a variety of concepts. The topic, the lesson's objectives, the students' learning preferences, and the resources available are all important considerations when choosing a technique²⁸.

The teaching strategy known as "Lecture and Discussion" combines a traditional lecture style with interactive conversations to promote learning. In this method, once the teacher has lectured the class about a subject, there are opportunities for the students to participate in discussions, ask questions, and voice their opinions. With this strategy; the teacher gives a well-organized presentation on the topic. In order to do this, it may be necessary to clarify relevant terms, theories, and details²⁹. The lecture gives students a foundational understanding of the subject and aids in their comprehension of its essential components. The teacher encourages students to participate in discussions at certain times after the lecture or during it. Students are free to share their ideas, voice their opinions, and ask questions regarding the content being covered. These discussions give students the chance to engage with the material more deeply, address any questions, and consider various viewpoints. The "Lecture and Discussion" method is adaptable and can be used with a variety of educational contexts and topics. Even though it's a tried-and-true strategy, adding interactive components makes it current and useful in today's classrooms^{29,30}.

A teaching strategy called active learning transfers the burden of learning from the teacher to the learners. It places a strong emphasis on involving students in activities that call for them to take part, exercise critical thinking, work through challenges, and interact with the course material and one another. Promoting a greater comprehension, memory retention, and application of knowledge is the aim of active learning. A dynamic strategy called active learning can improve students' learning and make the classroom atmosphere more engaged and interesting³¹.

Problem-Based Learning is an interactive, student-centered teaching strategy that promotes using real-world issues to solve knowledge. Problem-Based Learning involves students working cooperatively in small groups to solve challenging, open-ended issues that are frequently taken from real-world scenarios. Encouragement of critical thinking, problem-solving abilities, teamwork, and the application of information to real-world situations are the main objectives. In a dynamic and student-centered approach to education, problem-based learning encourages critical thinking, teamwork, and the use of information in real-world situations. It works especially well in fields where the ability to solve difficult problems is crucial^{32,33}.

An innovative teaching strategy that reverses the traditional method of instruction is flipped classroom³⁴. When teaching is done in a "flipped" classroom, lectures and readings are often given outside of class time using internet videos or materials. The remainder of the class period is then devoted to interactive exercises, debates, and knowledge application, enabling the students to become more invested in the material and receive individualized instruction from the teacher³⁵. Various educational levels and subjects can be applied to the flipped classroom concept. By putting an emphasis on interactive experiences during crucial class time, it improves student engagement, encourages active learning, and fosters a deeper knowledge of the topic³⁶.

In order to accomplish common learning objectives, collaborative learning is an instructional technique that places a strong emphasis on teamwork, interaction, and active engagement among students³⁷. In collaborative learning settings, students work in groups to resolve issues, finish tasks, exchange ideas, and share knowledge. This method encourages cooperation, critical thinking, communication, and the capacity to work well

in teams—skills that are beneficial in both academic and practical contexts. A flexible method that may be applied to different subjects and educational levels is collaborative learning. It promotes critical thinking, social connection, and active engagement while preparing students for teamwork outside of the classroom³⁸.

A common learning objective is accomplished by students working together in small groups as part of the cooperative learning instructional technique. Cooperative learning places a stronger emphasis on group members' teamwork, communication, and shared responsibility than competitive or individualistic methods. This strategy aims to improve both academic comprehension and social abilities. Collaboration, critical thinking, and social skills are fostered through cooperative learning, which is beneficial in both academic and practical contexts. Teachers foster a welcoming and inclusive learning atmosphere by involving students in active learning activities and encouraging teamwork^{37,39}.

Peer teaching, sometimes referred to as peer instruction or peer mentorship, is a teaching strategy in which students assume the role of instructors to guide their peers in learning and mastering particular skills or concepts⁴⁰. Peer teaching involves students collaborating with one another to create an engaging and collaborative learning environment in the classroom by exchanging knowledge, debating concepts, and offering support. When done correctly, peer teaching can be a potent and useful learning approach. It improves student comprehension and retention of the information while also fostering a supportive and cooperative learning community inside the classroom⁴¹.

Experiential learning is an educational approach that places a focus on learning through hands-on activities, practical applications, and reflective practices by including

them in worthwhile and pertinent activities, such as simulations, field excursions, internships, experiments, and project-based learning, it encourages students to actively interact with the subject matter. Experiential learning is intended to encourage knowledge application in real-world situations, deepen understanding, and improve retention. By giving students the chance to learn by doing, connecting theory to practice, and developing crucial life skills, experiential learning enhances the educational experience. It works especially well in subjects that require problem-solving, critical thinking, and practical application^{42,43,44}.

The teaching strategy known as inquiry-based learning focuses on student-driven investigation, critical thinking, and problem-solving. In inquiry-based learning, students actively participate in their education by formulating inquiries, researching subjects, and looking for answers via study, experimentation, and analysis. The intention is to encourage curiosity, a thorough comprehension of ideas, and the growth of abilities other than memorization⁴⁵. Students that participate in inquiry-based learning have the freedom to freely research, evaluate, and synthesize information. It excels in developing students' capacity for lifelong learning and getting them ready to address problems with a critical and inquisitive perspective⁴⁶.

The Socratic Method is a teaching and philosophical inquiry method that promotes critical thinking and the investigation of concepts through a sequence of well-crafted questions. This approach, which bears the name Socrates, involves a teacher (or facilitator) and students (or participants) having a cooperative discussion. The objective is to encourage deeper knowledge and expose a topic's underlying assumptions and ramifications rather than to give clear answers⁴⁷. The Socratic Method is credited to the

Greek philosopher Socrates as its creator by engaging in discourse with his pupils in this way, he was able to question their assumptions and inspire them to approach knowledge, ethics, and abstract notions with a critical eye. Plato, a student of Socrates, preserved some of their conversations, which have affected philosophical thought ever since⁴⁸.

The Socratic Method has developed over time and is currently utilized in a variety of academic settings and subjects in addition to philosophy. It motivates students to learn more about a subject, look into underlying presuppositions, and develop more complex understandings. For instance, the Socratic Method is frequently used in law schools to instruct students on how to evaluate legal theories and apply them to particular situations⁴⁹. The development of critical thinking abilities, the capacity to communicate and defend ideas, and the encouragement of active engagement in the learning process are all advantages of the Socratic Method⁵⁰. However, it can be difficult for both participants and facilitators. Participants may find the approach unsettling due to its emphasis on challenging preconceptions, and facilitators must be adept at formulating good questions and facilitating dialogues⁵¹. In essence, the Socratic Method is a potent instrument for intellectual exploration that encourages people to think critically, to reflect on their ideas, and to question them in order to gain deeper comprehension of difficult subjects⁵².

There are two competing methods for delivering information and promoting learning: inductive and deductive teaching strategies by organizing how information is delivered, how students interact with the content, and how they draw conclusions or develop insights, these techniques direct the teaching and learning process. Both the inductive and deductive techniques have advantages and uses in various educational

settings⁵³. The decision to use inductive or deductive teaching strategy is influenced by a number of variables, including the subject matter, the learning objectives, the students' existing knowledge, and the teaching situation⁵⁴. In order to promote exploration, critical thinking, and a deeper comprehension of concepts, inductive education is frequently used. Contrarily, deductive teaching offers a clear framework for presenting new concepts and ideas, and it is especially successful when laying a basis for knowledge before digging into particular examples. An overview of the research on inductive and deductive training approaches shows that each is distinctive⁵⁵. In many instances, combining the two approaches can result in a well-rounded educational experience by letting students independently find patterns and concepts while simultaneously receiving clear direction and explanations from the teacher⁵⁶.

2.1.2.1 Inductive Teaching Strategy

Inductive teaching is a strategy that involves giving students specific examples, observations, or facts and helping them to recognize patterns, principles, or generalizations based on those instances. In order to develop a deeper understanding of an idea or subject, this method encourages students to actively engage in critical thinking, observation, and pattern recognition⁵⁵. It promotes students' ability to draw inferences from evidence, making it a discovery-based learning strategy. In order to promote discovery-based learning and inspire students to create their own ideas, inductive teaching is frequently utilized. Teaching concepts that entail practical applications, scientific discoveries, or complex patterns is more beneficial when using inductive

strategies. It promotes students exploration and knowledge construction through their observations and analyses, resulting in a more fulfilling educational experience⁵⁷.

Inductive Teaching Strategy can be implemented as thus; the concept or subject you intend to teach can be illustrated by a specific set of examples, observations, or data. The various aspects of the subject should be illustrated by these instances. Give the students the examples at the start of the lesson. Encourage them to carefully examine and evaluate the provided examples. Ask open-ended questions to get students thinking about the examples' trends, commonalities, and patterns. Students should be able to develop connections and observations as a result of these questions. Encourage students to contribute their thoughts and insights during group or pair discussions. Students are encouraged to gain insight from one another's perspectives through this collaborative method⁵⁸.

Encourage students to point out any patterns, connections, or principles that they discover when analyzing the samples. Assist them in expressing these conclusions in their own terms. Encourage students to construct broad concepts or conclusions that can be applied beyond the offered specific instances based on the patterns and observations they have made. Encourage students to connect the derived generalizations to what they already know and to consider how they relate to the overall context of the subject. Introduce relevant theories or concepts that contribute to or clarify the generalizations the students have made. Students can now link their observations to previously known information using this stage. Give them tasks or challenges that let them use the generalizations they've learned to solve new difficulties^{55,58}.

This helps to clarify their thinking and make them more aware of the practical implications. Encourage students to consider the inductive learning process. Talk about the ideas that came from their observations and how they helped them understand the subject. The benefit of Inductive Teaching is as follows; it promotes observational and critical thinking abilities, encourages participation and ownership in learning, enhances concept retention and understanding, It improves pattern awareness and problem-solving skills and enables students to independently find connections and principles⁵⁸.

In summary, the rule of acceptance is a key component of the inductive strategy. The purpose of enlistment is to establish a generally recognized fact by stating that if it holds true in one particular situation and is further supported by a sufficient number of other examples, it is then applicable to all similar claims. As a result under this approach, a problem is addressed right away using the student's prior knowledge, thinking, and facts. At this point, the understudy doesn't consider any equation, standard, or method for handling the situation at hand. Once the students have been exposed to a sufficient number of related models, realities, or products, they try to come up with a conclusion for each of those. The inductive teaching strategy is heavily rooted in science education that makes use of it. The instructor assigns the students a specific examination or problem, such as an investigation that needs to be understood or a certifiable problem that needs to be solved. The students should use their background knowledge to further their research, test, and investigation before coming to their own conclusions or arrangements^{59,61}.

Propositions that the content will be important later in the educational program or careers are the only motivation for students to learn, if they receive any at all. Inductive teaching simply involves introducing students to many facts and models, from which they

must figure out or construct a general equation. In this sense, it is a method for creating a recipe with the help of a sufficient number of reliable models. Consequently, an inductive strategy for demonstrating leads from known to unknown, specific to general, or guide to readily available standard and cement to extract. When several credible cases have been identified, the student might try his or her hand at speculating⁵⁹.

2.1.2.2 Deductive Teaching Strategy

Deductive teaching is a strategy where basic ideas, rules, or principles are first presented, and then students are led through concrete examples and applications to help them understand those ideas. This strategy begins with a broad viewpoint and then narrows it down to focus on particular issues, assisting students in comprehending how the fundamental ideas are put to use in real-world situations⁵⁹. To introduce students to new ideas and concepts in an organized manner, deductive education is frequently utilized. When explaining difficult theories, mathematical concepts, logical reasoning, and subject matter that necessitates a solid understanding foundation before moving on to specific examples, deductive teaching is particularly effective. It offers a well-organized framework for developing student understanding from the broad to the specific^{53,54}.

The guide to implementing the deductive teaching strategy is as thus; present the broad idea, guiding principle, or guideline you want to convey at the start of the class. Explain the primary concept in detail and its importance. Clearly define and explain any key terms or terminology related to the concept. Ensure students have a strong foundation to build upon. Give the broad rule or principle that the concept is built upon. Give instances when this principle has been used in different circumstances. Give

specific illustrations of how the rule is used in actual circumstances. Make sure that the examples are varied and relevant to the concept⁶⁰.

Engage students in practice activities under supervision where they use the concept to resolve issues or evaluate scenarios. Describe the steps and thought process to them. Give students other cases or illustrations to deal with on their own. Students can practice using the principle independently in this phase. Give examples of how the rule can be altered or used in special circumstances. Explain the reasons behind these exceptions and how they affect how the concept is used. Help students compare and contrast different examples to better grasp how the principle operates in various situations. Encourage your students to consider how the general idea was used in the particular situations. Encourage them to provide a brief summary of what they have learned^{59,60}.

Describe how the particular examples relate to the larger idea or topic. Encourage pupils to make connections between the general principle and its real-world applications. The merit of Inductive teaching is as follows: it gives new ideas a clear structure to be introduced, assists students in understanding the fundamental ideas before going on to specific examples, helps students understand how general principles are used in practice, provides context and application to the real world, which improves understanding, helps students become capable of applying their information and solving problems⁶⁰.

In summary, deductive method for educating depends on an allowance, which progresses from general to specific as well as from active to cement. In this method of instruction, the teacher first explains the norm, authority, or law to the students before explicitly modeling the norm, authority, or law for them. The criteria are set first, and then understudies are encouraged to use these rules to resolve further problems. In junior

auxiliary, upper optional or higher classes, this method is used to demonstrate fundamental science. The deductive approach keeps going from general (rules, regulations, administrators, or recipe) to explicit (models), from difficult to understand to clear model, from complex to elementary⁵⁹.

A deductive approach to teaching entails moving away from the problem, searching for a preliminary theory, organizing a speculative idea, and determining whether the case has been persuasively acknowledged. The process of thinking from at least one assertion to get a consistently certain conclusion is known as deductive reasoning, logical derivation, or "top-down" reasoning. The deductive approach to education is considerably different from the inductive approach. A deductive approach is more instructor-focused since it requires the teacher to introduce the students to a new concept, explain it, and then ask them to apply it^{59,61}.

2.1.3 Gender

The idea of gender relates to the cultural expectations, roles, behaviors, activities, and norms that come with being male, female, or non-binary. Gender must be distinguished from biological sex, which is determined by physical and physiological traits including chromosomes and reproductive organs⁶². The concept of gender is social and cultural, and it differs throughout countries and historical eras. Many societies have historically only recognized the two genders of male and female. As an example, male are typically supposed to be strong, forceful, and providers, whereas female are frequently expected to be loving, caring, and primarily responsible for household duties.

It's crucial to remember that these expectations and roles are social constructions rather than aspects of being male or female⁶³.

Gender is not binary and exists along a spectrum, and this has come to be understood more and more in recent years. Due to this, identities that do not fit under the conventional binary framework, such as non-binary, have come to be recognized. Non-binary people may reject the idea of gender altogether or identify as having a gender that is neither primarily male nor exclusively female⁶⁴. Gender identification refers to a person's firmly held perception of their own gender, which may or may not coincide with the gender that was given to them at birth. In the case of transgender people, their gender identity differs from the sex they were given at birth. Some transgender people go through the transitioning process to match their gender identity with their outward behavior, presentation, and occasionally legal documents. This could entail both social and psychological adjustments as well as medical measures like hormone therapy or surgery. The idea of gender should be approached with respect and openness, with the understanding that everyone has the freedom to determine and express their own gender identities^{62,65}.

The gender concept is one that is frequently employed by academics, legislators, government employees, financial institutions, the commercial sector, civil society organizations, instructors, and regular citizens. For teachers to develop a gender responsive academic environment, gender responsive pedagogy is particularly crucial. Many times, both teachers and students are unaware of the unique demands that boys and girls have based on their gender. Intentionally or unintentionally, discrimination against girls occurs in the classroom. For instance, the majorities of instructional materials

utilized in the classroom are gender biased and feature gender stereotypes⁶⁶. The main tool for promoting gender equality and fostering equitable growth is education. The idea of gender in education is an important topic of concentration since it deals with how educational institutions and systems handle issues like gender identity, gender roles, and gender equality. All students must have access to inclusive and secure learning settings, regardless of their gender identity or expression⁶⁷.

The goal of gender equality in education is to guarantee that all students, regardless of gender, have equal access to educational opportunities and resources. This includes tackling the attainment and retention gaps between the sexes. It also entails combating biases and stereotypes that may restrict students' possibilities and options based on their gender. An inclusive curriculum recognizes and includes the opinions, experiences, and contributions of people with different gender identities and backgrounds. As a result, students will have a deeper knowledge of the complexity of gender and how to challenge traditional gender customs. All students, including those who identify as transgender, non-binary, or gender non-conforming, should have access to safe and welcoming environments in educational institutions. This entails putting procedures into place to stop harassment, bullying, and discrimination based on gender expression or identity^{64,67}.

It is important to educate and train teachers and staff members on gender diversity and inclusion. By doing so, they are better able to comprehend the needs and experiences of students who identify as different genders and are more prepared to handle any problems that may occur. Regardless of gender, gender-responsive teaching takes into account the various learning needs, interests, and experiences of all students. It strives to

provide instructional strategies and resources that are considerate of these variations and guarantee an equitable learning environment. Institutions can better understand trends and discrepancies by gathering data on gender-related issues in education. The creation of policies and actions targeted at advancing gender equality and inclusion can be guided by this data. An environment that is more encouraging and understanding for all students can be created by involving parents, guardians, and the community in talks concerning gender ideas in education. Promoting a gender-inclusive educational system is crucial for creating a culture that appreciates diversity, upholds individual rights, and equips students to succeed in a world that is both varied and undergoing rapid change^{67,68,69}.

In a number of disciplines, including education, sociology, psychology, and gender studies, the connection between gender and academic achievement has drawn attention. In the past, gender inequalities in education were more prominent, and expectations for academic achievement were frequently influenced by traditional gender roles. Female were occasionally discouraged from choosing particular majors or occupations, which resulted in attainment gaps. Gender differences in academic achievement can occur, based on research, but they are frequently complicated and influenced by a variety of elements, including financial situation, cultural background, and individual abilities. In some circumstances, male may perform better than female in particular areas (such as Mathematics and science) but female may perform better in other areas (such as language and the humanities)⁷⁰.

The term "stereotype threat" describes the phenomena where people who are made aware of unfavorable stereotypes about their social group may perform less well as a result of worry and a fear of supporting those stereotypes. In many situations, this may

have an effect on both male and female. Addressing gender differences in academic achievement, policies and initiatives have been developed in the field of education. The traditional gender roles in education have been challenged, and efforts have been made to support diversity and offer equal opportunity to people of all genders. The self-perception and motivation of students might be influenced by gender identity. Female might, for instance, be more driven in subjects where they feel accomplished or where they have female role models. Students' aspirations and academic preferences are significantly influenced by societal norms and expectations. For instance, male could face pressure from society to be successful in particular occupations, but female might encounter expectations relating to nurturing responsibilities^{62,63,71}.

The interaction of gender with other characteristics such as race, ethnicity, socioeconomic background, and sexual orientation can result in particular difficulties and experiences that have a diverse effect on academic achievement for various groups. Gender-related patterns of academic achievement have changed over time. More female are going to college and working in fields that have traditionally been dominated by male⁷². It's crucial to remember that there are numerous and complex factors that play a role in the relationship between gender and academic achievement. Learning more about how gender dynamics affect educational systems, student experiences, and learning results, researchers are still investigating this issue. Ensuring that all students, regardless of gender, have the chance to achieve academically, it is also imperative to provide inclusive and equal educational environments⁷³.

2.1.4 Further Mathematics

Further Mathematics is an advanced level of mathematical study that goes beyond the standard curriculum covered in regular Mathematics courses. It is primarily designed for students who are highly motivated and mathematically gifted and who wish to investigate more advanced and specialized areas⁷⁴. Further Mathematics is a regular course at the university level and is also offered as an elective in high schools. It's significant to remember that depending on the educational institution and the curriculum it offers, the precise subjects and level of study might differ greatly. The appropriate course of action for students with interests in Further Mathematics should be discussed with their teachers or academic advisors. Students who intend to pursue jobs in subjects that demand a solid mathematical foundation, such as economics, physics, engineering, computer science, and Mathematics, will benefit most from taking courses in Further Mathematics. It offers a strong basis for in-depth study and studies in various subjects⁷⁵.

In 1985, Nigeria's Senior Secondary School curriculum included Further Mathematics. It is a subject taught in schools at the senior secondary one, two, and three levels. Pure Mathematics, mechanics, and statistics make up the three core areas that make up the curriculum, which was organized thematically. These three core areas in Further Mathematics provide students with a well-rounded education in advanced mathematical concepts and their applications. Students that study pure Mathematics, mechanics, and statistics have the skills necessary to solve challenging issues in a variety of academic and professional fields, such as engineering, physics, computer science, economics, and more. Further Mathematics' extensive nature enables students to gain a

deeper understanding of the complexity and beauty of Mathematics while preparing them for more advanced coursework and study^{76,77}.

The study of abstract ideas and the investigation of mathematical structures are the main objectives of the branch of Mathematics known as pure Mathematics, which does not always place a strong emphasis on how these ideas and structures might be used in the real world. It is frequently contrasted with applied Mathematics, which uses mathematical methods to address issues in a variety of disciplines, including physics, engineering, economics, and more. The study of pure Mathematics is motivated by the desire to comprehend mathematical relationships, patterns, and principles for both aesthetic and intellectual reasons. Pure Mathematics advances our understanding of the mathematical universe, and its discoveries frequently have unexpected applications in other disciplines. It may not always have direct practical ramifications, but it enriches society intellectually and culturally⁷⁸.

In pure Mathematics, emphasis is placed on the construction of rigorous proofs and a profound comprehension of mathematical principles. Pure Mathematics focuses on abstract mathematical concepts and structures. The pure Mathematics component of Further Mathematics may cover the following topics: Further algebraic techniques and concepts beyond what's covered in standard math courses; Complex numbers and their applications; Matrices and linear transformations, including eigen-values and eigen-vectors; Further calculus, such as advanced techniques of integration, differentiation, and applications of calculus; Proof by mathematical induction and other proof techniques; Hyperbolic functions and their properties; Additional topics in algebra, number theory, and discrete Mathematics⁷⁹.

Typically, when discussing Further Mathematics, the term "mechanics" refers to a subfield of Mathematics that studies the behavior of physical objects and systems in motion. It is a fundamental element of physics and engineering and is essential for comprehending and resolving issues with forces, motion, and dynamics in the real world. In the context of Further Mathematics instruction, mechanics frequently addresses topics like: Kinematics: Describing the motion of objects in terms of position, velocity, and acceleration; Newton's laws of motion and their applications; Forces, energy, and momentum; Circular motion and simple harmonic motion; The mechanics of particles and rigid bodies; Applications to real-world problems in physics and engineering. Mechanics is a mathematically demanding field, and advanced Mathematics courses in mechanics sometimes include employing calculus and vector Mathematics to solve challenging issues. It serves as a foundational course for people who want to major in or pursue professions in physics, engineering, or similar subjects since it gives students the necessary tools for understanding and predicting the behavior of physical systems^{74,76,80}.

Statistics is a subfield of Mathematics that deals with the gathering, analysis, interpretation, presentation, and organization of data in the context of Further Mathematics. It offers methods and tools for analyzing data, coming to conclusions, and making wise choices. Statistics often covers a variety of topics in Further Mathematics instruction, including: Probability distributions, including discrete and continuous distributions; Statistical hypothesis testing and confidence intervals; Correlation and regression analysis; Further concepts in probability theory and random variables; Multivariate data analysis and distribution fitting; Applications of statistics in various fields, including social sciences, economics, and sciences. In Further Mathematics,

statistics frequently makes extensive use of mathematical notation, ideas, and methods, such as calculus and probability theory. It is a broad field with applications in many fields, including business, social sciences, healthcare, and science. In today's data-rich environment, having a solid understanding of statistics is essential for doing research, analyzing data, and making data-driven decisions^{75,80}.

In 2007, the Further Mathematics curriculum was revised and operation research and coordinate geometry were included due to the necessity to apply mathematical knowledge to real-world situations and difficulties. The goals for adding Further Mathematics to the curriculum are to prepare students for future studies in Mathematics and its applications, help students develop connectional and manipulative skills in Further Mathematics; reflect continuity with the curriculum used in universities and polytechnics and help students become future mathematicians, engineers, and scientists⁷⁶.

2.1.5 Calculus

Calculus is regarded as the foundation of numerous contemporary theories or concepts. In point of fact, the discovery of calculus in the seventeenth century marked a significant shift in numerous fields, including, of course, Mathematics. One of the most significant human interventions is its power as a theoretical foundation⁸¹. Isaac Newton and Gottfried Wilhelm Leibniz independently developed infinitesimal calculus at the end of the 17th century. These advancements were given a more solid conceptual foundation through subsequent work, which included codifying the concept of limits. Today, calculus has far and wide purposes in science, engineering, and social science⁸².

The four main categories of scientific and mathematical issues of the period that inspired Newton and Leibniz's work were as follows: Identify the tangent line at a specific location to a general curve; calculate a general region's area, a general curve's length, and a general solid's volume; determine the maximum or minimum value of a quantity, such as the highest and lowest separations of a planet from the Sun or the greatest range a projectile may travel by adjusting its angle of fire; determine the body's velocity and acceleration at every given instant using a formula for the distance a body travels in a given length of time. On the other hand, find the distance that a body travels in a certain amount of time, given a formula that defines the acceleration of velocity at that moment. Finding a tangent line to a curve and calculating the area of a region have a basic link. The "discovery of calculus" is credited to Newton and Leibniz for realizing this relationship^{81,82}.

Calculus is a branch of Mathematics that focuses on the study of rates of change and the accumulation of quantities. It is a fundamental branch of Mathematics with numerous applications in the disciplines of science, engineering, economics, and countless others⁸³. Calculus is an effective mathematical tool that enables us to represent and analyze change and accumulation-related real-world occurrences. It serves as the basis for more complex mathematical and scientific studies and has played a significant role in forming our understanding of the physical universe and providing solutions to real-world issues in a variety of domains⁸⁴.

Similar to the study of shape in geometry and the generalizations of arithmetic operations in algebra, calculus is the mathematical study of continuous change. It has two significant branches, differential calculus and integral calculus; the first one is concerned

with instantaneous rates of change as well as the slopes of curves, whereas the second one is concerned with the accumulation of quantities as well as the areas under or between curves⁸⁵. The fundamental theorem of calculus connects these two branches, which employ the fundamental concepts of convergence of infinite sequences and series to a well-defined limit. Limits are at the heart of calculus. They describe how a function behaves as it gets closer to a certain value or point. When defining derivatives and integrals, the term "lim" refers to the limit of a function at a given point⁸⁶.

Calculus' basic theorem is a theorem that connects the concepts of differentiating a function (calculating its slopes or rate of change at each moment) and integrating a function (calculating the area under its graph or the cumulative impact of little contributions). According to this rule, if you find the anti-derivative (indefinite integral) of a function and then evaluate it at two points, the difference is equal to the definite integral of the function across the interval between those places. Aside from a fixed number that relies on where one begins to compute area, the two procedures are inverses of each other^{86,87}.

The derivative of a function calculates the rate at which the output (the dependent variable) of the function changes in response to a change in the input (the independent variable). It only represents the slope of the tangent line to the function's curve at a specific point⁸⁶. The power rule, product rule, quotient rule, chain rule, and other rules can all be used to find derivatives of functions. These guidelines offer a methodical technique to distinguish between varieties of functions. Applications for derivatives can be found in many fields, such as physics (e.g., determining acceleration from velocity), economics (e.g., determining marginal cost and revenue), and biology (e.g., modeling

population growth). The idea of differentiation is expanded to include functions with many variables in multivariable calculus. The rate of change of a function with respect to one variable is measured using partial derivatives while the values of the other variables remain constant^{88,89}.

Integrals are used to compute the accumulation of quantities over a period of time. On a graph, the net area under a curve connecting two points is represented by the definite integral. The process of finding the indefinite integral is known as integration and it represents a family of functions. There are various methods for solving integrals, including substitution, integration by parts, and trigonometric integrals. These methods aid in locating an anti-derivative of a function. Integrals can be used to calculate areas, volumes of solids, work done by a force, and the accumulation of quantities over time, among other things. Integration is extended to include functions of many variables by multiple integrals. Volume, area, and other quantities can be calculated in multidimensional spaces using double and triple integrals^{90,91}.

2.2 Theoretical Framework

This section examines the theoretical framework for the relationship between teaching strategies, gender, and academic achievement.

2.2.1 Social Cognitive Theory

Albert Bandura is the originator of Social Cognitive Theory, which is a broad theoretical framework that focuses on how people learn new skills, adapt to new situations, and increase their feeling of self-efficacy through their interactions with

others⁹². This theory places a strong emphasis on the role that social interactions, observational learning, and cognitive processes play in determining how people behave and develop. The idea that people can learn by observing others is at the heart of this theory. For the acquisition of knowledge and behaviors, people do not only rely on their own direct experiences. Instead, by seeing and imitating others, particularly those who serve as role models or whom they believe to be competent, they can learn new abilities, behaviors, and attitudes. Bandura identified four fundamental processes for observant learning, which are as follows: People need to focus on the model's actions and their effects; Observers need to be able to recall the behavior they saw; Witnesses must be able to mimic the behavior both physically and mentally; The choice to engage in the observed behavior is influenced by the perceived benefits or drawbacks of doing so⁹³.

In Social Cognitive Theory, the combination of personal factors (such as beliefs, attitudes, and self-efficacy) with environmental factors (such as social norms and cultural context) and behavior itself determines how people behave. In a dynamic process, these three elements constantly reinforce and affect one another. A key idea in social cognitive theory is self-efficacy. It describes a person's confidence in their capacity to carry out a specific task or accomplish a specific objective. High levels of self-efficacy are linked to increased drive, perseverance, and success, whereas low levels can result in self-doubt and less effort. Evidently, self-efficacy is a key psychological idea that affects a person's behavior, decisions, and general well-being. It is directly related to one's perceptions of their own skills and can be fostered and developed to support personal development and success in a variety of spheres of life⁹⁴.

People's expectations of the results or repercussions of their activities have an impact on their behavior as well. People are more willing to engage in a behavior if they believe their efforts will produce positive results. This model explains how individual, environmental, and behavioral factors interact throughout time. It implies that modifications to any one of these elements may have an impact on the others⁹⁵. In psychology and human behavior, the term "self-regulation" refers to a person's capacity to control their thoughts, feelings, behaviors, and impulses in order to accomplish personal objectives, change course when necessary, and retain self-control. It entails deliberately and consciously observing and directing one's responses and actions. Self-regulation is a crucial skill for social relationships, personal growth, and general wellbeing⁹⁶.

The Social Cognitive Theory recognizes the significance of self-regulation, in which people set objectives, assess their progress, and modify their behavior as necessary. Gaining self-regulation abilities can improve a variety of elements of life, such as personal relationships, academic and professional success, and mental health. It is a skill that can be developed and strengthened over time with practice, self-awareness, and the application of methods and approaches designed to strengthen self-control and goal achievement⁹⁷. Self-efficacy and self-regulation work hand in hand because people with high levels of self-efficacy are more likely to stick with their attempts to accomplish their objectives. Education, psychology, health promotion, and organizational behavior are just a few of the areas where the Social Cognitive Theory has been extensively used. Our knowledge of how people learn, acquires skills, and adjusts to their social and cultural

settings have improved as a result. It also has applications for programmes that try to boost self-efficacy and encourage positive behaviors⁹⁶.

Within the framework of Albert Bandura's Social Cognitive Theory, learning is emphasized through modeling, imitation, and observation. Self-efficacy is also emphasized, as is the dynamic interplay between environmental influences, behavior, and personal characteristics (reciprocal determinism). Using an inductive teaching approach, students are guided to find general principles or rules by starting with specific examples or issues. Social cognitive theory and inductive instruction combined can improve students' comprehension and interest in Further Mathematics. Social cognitive theory gives students access to relevant and understandable models or instances of addressing mathematical problems. The procedures and approaches you wish the students to learn have to be modeled by these examples. Inductive Instruction starts with particular case studies or mathematical problems that demonstrate the ideas or methods you want the students to comprehend. Students can witness real-world implementations of complex mathematical concepts through this method^{53,92}.

Students pick up skills through observation of their teacher's or their peers' activities and problem-solving techniques. They absorb these procedures and results, which shapes their understanding and subsequent behavior. Inductive Teaching provides a variety of case studies or examples, and urges students to closely examine and evaluate these situations. Encourage students to speak about what they have seen and comprehend the fundamental ideas of mathematics by facilitating discussions. Social cognitive theory assists students in appreciating the connection between effective outcomes and observed problem-solving procedures. Give comments to clarify misconceptions and reinforce

proper understanding. Inductive Teaching guides students through the process of finding similarities and patterns in the given instances. To encourage critical thinking and self-discovery, use questioning strategies^{54,93}.

Social cognitive theory increase students' feelings of self-efficacy by giving them chances to put observed problem-solving techniques into practice, get feedback, and succeed. Inductive Teaching establishes a safe space where learners can explore cases and draw conclusions with confidence. To help students become more competent and confident in their ability to solve challenging mathematics issues, give them constructive criticism and encouraging words. To strengthen the transfer of knowledge and abilities, Social cognitive theory encourages students to apply what they have learned from models to new mathematical problems. Inductive Instruction helps students apply the general principles to new situations or issues after they have recognized them. This phase serves to reinforce their comprehension and shows how the mathematical ideas are used in real-world situations^{55,94}.

Social cognitive theory includes peer modeling and cooperative learning exercises so that students can observe and interact with one another to learn from one another. Inductive Teaching encourages students to share their observations and insights through group projects and conversations. Peer interactions help students learn more because they expose them to different viewpoints and interpretations. In order to improve students' comprehension and problem-solving abilities in Further Mathematics, educators might establish a productive learning environment by incorporating Albert Bandura's Social Cognitive Theory with an inductive teaching approach. This method encourages critical

thinking, active learning, and the application of mathematical concepts in a variety of settings^{61,92}.

2.2.2 Sociocultural Theory

Russian psychologist Lev Vygotsky developed the sociocultural theory, which offers a comprehensive framework for understanding human growth and learning. This theory emphasizes the critical role that social interaction, cultural context, and a culture's tools and symbols play in influencing an individual's cognitive development and acquisition of knowledge and skills⁹⁸. The Zone of Proximal Development, also known as a "scaffolder" or "More Knowledgeable Other" (MKO), is the area between what a learner can accomplish on their own and what they can accomplish with the help of a more knowledgeable person. Vygotsky believed that when people are functioning in accordance with their ZPD, development and learning take place most efficiently. It emphasizes how crucial it is to give students the right amount of support so they can achieve their maximum potential. Scaffolding is the temporary assistance given by a more experienced individual to help a student complete a task or find a solution to a problem inside their ZPD. The scaffolding is gradually removed as the learner's skills advance, enabling them to assume more responsibility⁹⁹.

Social interaction is emphasized heavily in sociocultural theory as the main means of cognitive development. People converse, work together, and solve problems in groups through social contacts with parents, teachers, peers, and others. Language, intellect, and a number of other skills are developed as a result of these interactions¹⁰⁰. Language, symbols, and physical relics are examples of cultural tools that are crucial for cognitive

development. Particularly in a cultural setting, language is viewed as a powerful instrument that mediates thought and enables communication and knowledge sharing between people. People's perceptions and attempts to make sense of the world are influenced by the usage of culturally appropriate tools and symbols¹⁰¹.

Vygotsky's theory frequently places history and culture in a cultural-historical perspective, highlighting how these elements influence how people acquire their cognitive abilities. The manner that knowledge is communicated and how people learn and develop can be influenced by a society's historical and cultural background¹⁰². The sociocultural theory places a strong emphasis on how learning and development take place in particular cultural environments. Each culture has its own customs, beliefs, and practices that influence how people think and act. Although learning is not a universal process, but the cultural context in which it occurs has a significant impact. Through internalization, cultural practices and social interactions from the outside are transformed into internal mental processes. The knowledge, abilities, and thought processes that learners have picked up from social interactions are gradually internalized through this process. Then, these internalized cognitive processes are incorporated into the individual's independent cognitive functioning¹⁰³.

Numerous professions, including anthropology, psychology, and education, have been significantly impacted by sociocultural theory. The sociocultural theory has significantly influenced educational policy and teaching methods. In order to facilitate students' cognitive development, it is recommended that teachers design learning settings that encourage social engagement, collaborative learning, and the use of cultural materials. This theory also emphasizes how crucial it is to take cultural diversity and

context into account while developing educational interventions and evaluating learners' aptitudes. In conclusion, sociocultural theory has given us important new understandings about the social and cultural aspects of human learning and development^{104,105}.

When teaching Further Mathematics, integrating Lev Vygotsky's Social Cultural Theory with the deductive teaching method can offer a strong framework for promoting student comprehension and engagement. The Social Cultural Theory of Vygotsky highlights the critical role that social interaction and cultural background play in the formation of cognition. Using the deductive teaching approach, a broad idea or principle is first introduced, then particular applications and examples. This approach is frequently compared to inductive learning, in which students determine rules by looking at instances. Integrating Social Cultural Theory with Deductive teaching in Further Mathematics starts by outlining the broad theories and principles of mathematics that are expected of the students. When properly scaffold, these fall within the students' zone of proficiency. Using a step-by-step approach, the instructor, in their role as the MKO, leads students through challenging issues. For instance, when learning calculus, begin with the general formula for differentiation and work through easier problems before advancing to more intricate ones^{59,98}.

Provide scaffolding in the classroom by illustrating how to apply general mathematical principles to particular situations. Worked examples, methodical approaches to problem-solving, and questioning strategies that encourage critical thinking and autonomous application of concepts are a few examples of this. Students can be encouraged to collaborate with one another to solve challenges while offering support and guidance to one another. Make use of mathematical symbols and language as cultural

tools to aid students in internalizing abstract ideas. Since Vygotsky highlighted the role that language plays in cognitive development, it is essential to talk about and express mathematical reasoning. Urge students to provide written or spoken explanations of their reasoning and mental processes. This helps the teacher identify areas that need further scaffolding while also reiterating what they have learned^{60,101}.

Give students quick feedback so they can clear up mistakes and misunderstandings. This is consistent with Vygotsky's theory of responsive education in the ZPD. Assess student comprehension using formative evaluations so that the amount of support can be modified appropriately. This guarantees that students stay challenged within their Zone of Proximal Development without experiencing frustration. Teachers can establish a learning environment that fosters deep knowledge and mastery of Further Mathematics through directed interaction, scaffolding, and the appropriate use of cultural tools by integrating Vygotsky's Social Cultural Theory with the deductive teaching approach. This method develops students' critical thinking and autonomous problem-solving abilities in addition to aiding them in understanding difficult Mathematical ideas^{61,98}.

2.2.3 Constructivist Theory

Constructivism, commonly referred to as constructivist theory, is a learning theory that suggests individuals actively construct their knowledge and understanding of the world based on their experiences, interactions, and mental processes. Several important principles and ideas are connected to this theory, which has had an impact on the domains of education, psychology, and cognitive science¹⁰⁶. Constructivism holds

that students actively interact with information rather than being passive recipients of knowledge. Through encounters, curiosity, and problem-solving, they develop their understanding. In other words, learning is an active process in which people relate new knowledge to what they already know. To organize and make sense of information, learners create mental models called schemata. These cognitive frameworks; known as schemata, aid people in classifying, interpreting, and remembering information. People incorporate new knowledge into their existing schemata or modify them to make room for it as they come into contact with it¹⁰⁷.

The Zone of Proximal Development (ZPD), while not exclusive to constructivism (it is also a notion in sociocultural theory), describes the variety of tasks that a learner may complete with the aid of a more experienced person or supervision. Constructivist teachers frequently use the ZPD to give learners the right challenges and assistance so they can increase their knowledge and abilities. Constructivism places a strong emphasis on the individual's ability to create knowledge, although social interaction is also important¹⁰⁸. Peer, teacher, and environment interactions can offer chances for conversation, collaboration, and the exchange of viewpoints and ideas, which can improve learning. Problem-solving and critical thinking are frequently emphasized in constructivist learning contexts. Activities that demand for critical thought, information analysis, and the creation of solutions to issues in the actual world are recommended for learners to participate in¹⁰⁹.

An individual's awareness and ability to direct their own cognitive processes is referred to as metacognition. By helping students to evaluate their educational experiences, create objectives, and track their progress, constructivist teaching strategies

encourage metacognitive awareness. Learning strategies that are more successful can result from this metacognitive awareness¹¹⁰. Constructivist theory acknowledges that circumstance influences learning. The particular circumstances, events, and situations in which learning takes place have an impact on knowledge and understanding. As a result, learning is not just about acquiring facts but also about comprehending how knowledge is used in various circumstances. Individualizing instruction to meet the needs and interests of each learner is a common component of constructivist pedagogy. Teachers can improve motivation and engagement by giving students the freedom to investigate subjects that interest them and by offering opportunities for choice^{111,112}.

Consideration of many viewpoints and information interpretations is encouraged by constructivism. Students are exposed to several points of view, which might result in a more thorough and adaptable understanding of a subject¹¹³. Constructivist theory has influenced a number of teaching strategies and educational approaches, including project-based learning, problem-based learning, and inquiry-based learning. These approaches seek to encourage critical thinking, active participation, and the creation of useful information. It is important to recognize that there are differences in how educators apply and interpret constructivism in practice, despite the fact that it has gotten a lot of attention in the field of education. Constructivism is also frequently compared to other learning theories, such as behaviorism and cognitivism, demonstrating the range of viewpoints in the study of education and psychology^{114,115}.

In order to integrate constructivist learning theory with conventional teaching approaches in the context of teaching Further Mathematics, conventional instructional methods such as lectures, demonstrations, and practice exercises must be combined with

constructivist principles such as active learning, student-centered activities, and the building of knowledge through experiences. Constructivist learning theory holds that knowledge is created by students via their interactions and experiences with the outside world. Conventional methods of teaching include tactics such as practice problems, lessons with a structure, assessments, and direct instruction. These approaches, which prioritize knowledge transfer from teacher to student, are usually teacher-centered^{106,116}.

Combining Conventional Teaching with Constructivist Learning Theory in Further Mathematics starts with conventional lectures to present the basic theories and concepts of mathematics. To actively involve students, incorporate interactive questions and conversations. For example, when teaching differential equations, take short breaks and ask students to solve small portions of the problem or predict what will happen next. Give practice questions that are easy to start with and get harder as you go. Initially, encourage students to solve these challenges in small groups or pairs to promote peer learning and social engagement. Review relevant topics that students have already learnt before presenting a new topic. For instance, to assist students understand the links and expand on their prior knowledge, go over the concepts of limits and summation from earlier sessions when teaching about integrals^{111,117}.

Include real-world scenarios where students must use mathematical principles. Use calculus optimization issues related to physics or economics, for instance. Constructivism's basic premise is that learning becomes more meaningful and relevant as a result. Assess understanding using conventional examinations and quizzes, but also be sure to provide students thorough feedback so they can recognize and grow from their errors. The constructivist notion of learning as an ongoing process of building is

supported by this iterative approach. Include assignments that demand that students investigate mathematical ideas in-depth and use their creativity to do so. For example, working on a project that uses differential equations to estimate population increase can provide you hands-on experience with abstract ideas. Constructivist ideas can be incorporated into conventional teaching techniques to help teachers create a more dynamic and productive learning environment for higher mathematics. This strategy draws on students' past knowledge and real-world experiences, while also leveraging the benefits of conventional approaches to promote a deeper and more engaged learning experience^{114,118}.

2.3 Review of Empirical Studies

2.3.1 Gender and Academic Achievement in Further Mathematics

The gender gap in students' academic achievement has been a major subject of discussion for many people involved in the field of science education, especially in the context of technological advancement. For instance, a study found that both male and female students who received their Mathematics instruction through the use of Computer Assisted Instruction (CAI) programme performed better in Further Mathematics. Particularly, male students outperformed their female counterparts in class. While the past study came to the conclusion that male and female perceive poor instructional strategies and subject coverage of the teaching and learning of Further Mathematics equally, the latest research found no statistically significant difference between male and female performance in Further Mathematics. In the study conducted, male outperformed female in subjects like science, technology, and Mathematics. In certain studies on the

difference between male and female academic achievement, it was shown that female did better than male in specific situations. Findings showed that female tend to attribute their achievements and failures to external influences, and that when they attribute them internally; they tend to attribute them to talent rather than effort¹¹⁹.

Findings regarding the gender gap in Mathematics achievement of secondary school students confirmed that there was a significant achievement gap between male and female students, which is why the study revealed that male students outperform female counterparts in algebra. In the same vein, a study that focused on the gender gap in the academic achievement of students in physics revealed that there is a significant difference between the academic achievement of male and female students in this subject. In an effort to determine the effect of gender on students' achievement, it was found that boys performed significantly better than girls in a self-created Mathematics test. Additionally, results claimed that gender had significant effects on students' achievement in their studies¹¹⁹.

Inquiry on the Further Mathematics Curriculum's effects in Nigeria, as well. The findings indicated both male and female students held the same opinions on the poor teaching strategies and content coverage of the teaching and learning Further Mathematics. Analysis revealed no significant difference between male and female students' performance in Further Mathematics among the senior secondary school in Zaria metropolis of Kaduna state. Studies revealed no difference in gender influence on students' achievement in Mathematics. Males tend to think of themselves as being better than their female counterparts in almost every aspect of human endeavors, yet there are several areas in which female actually outperform male¹¹⁹.

Study the impact of teaching strategies, gender, and school location on secondary school students' Mathematics achievement in Kano State, Nigeria. The results indicated that males are more likely to study Mathematics than females, with gender having a substantial influence. In Ekiti State, research on the relationship between gender and Mathematics achievement found that girls at federal government colleges do better than boys in numeracy and other mathematical skills¹¹⁹.

When the aforementioned studies are considered collectively, it can be concluded that further empirical research has to be done to compare the academic achievement of male and female in Further Mathematics utilizing WASSCE and NECO results. Particularly, there hasn't been much research done to compare male and female achievement using two different examination bodies. In view of the foregoing, this study considered WASSCE and NECO examinations as significant factors that can be utilized to determine students' academic achievement in Further Mathematics based on gender¹¹⁹.

In Kwara State, Nigeria, this study evaluated the academic achievement of male and female students in SSCE Further Mathematics. There were two developed research objectives and questions. Ex-post facto descriptive research methodology was used. The research population consists of all senior secondary schools offering Further Mathematics within Ilorin Metropolis. It was decided to adopt secondary data consisting of students' WASSCE and NECO results from 2007 to 2016 with a photo album that shows the gender of the students. Percentage and auto-regressive (AR) processes were used to examine the data in order to model time series analysis¹¹⁹.

Results showed that in the WASSCE, the proportion of male students who received credit ranged from 26.5 to 91.0; passes ranged from 9.0 to 50.60; and failures

ranged from 0.0 to 41.2, whereas the proportion of female students who received credit ranged from 12.5 to 86.2; passes ranged from 13.8 to 66.7; and failures ranged from 0.0 to 52.6. In NECO, the proportion of male students who received credit ranged from 14.6 to 84.4, with passes between 14.7 and 72.9 and failures between 0.0 and 19.8, whereas the percentage of female students who received credit ranged from 11.8 to 70.4, with passes between 14.8 and 62.5 and failures between 0.0 and 40.0. Results regarding the difference in students' achievement in Further Mathematics revealed that male students received more credit than female students in both examinations. The findings led to recommendations that educational policy makers hire more trained instructors of Further Mathematics and that female involvement in Further Mathematics should be promoted by school principals and teachers¹¹⁹.

2.3.2 Teaching Strategies and Academic Achievement in Further Mathematics

The research endeavors to examine the effects of the Inductive Teaching Method (ITM) and the Deductive Teaching Method (DTM) on the basic science performance of junior secondary school III (JSS III) students. A pretest-posttest quasi-experimental approach was used in the investigation. In the Federal Capital Territory (FCT) of Nigeria, specifically within the Abuja Municipal Area Council (AMAC), six (6) junior secondary schools (JSS III) were selected. There were two hundred and sixty-five (265) and three hundred and fifty-five (355) male students among the six hundred and twenty (620) participants in the study⁵⁹.

Each of the chosen schools used an intact class, and the Basic Science Performance Test (BSPT) was the instrument used to collect data. Using the Statistical

Package for Social Sciences (SPSS) version 26, the arithmetic means standard variation and One-way Analysis of Covariance (ANCOVA) were used to test two hypotheses at the 0.05 level of significance. The data gathered satisfied the normalcy assumption, there were few outliers, and the variance was homogeneous, according to the preliminary test result. The primary finding indicated that the inductive teaching approach is the most common and effective one⁵⁹.

The mean performance of the male student varied significantly between the three groups [$F_{(2,351)} = 25.911, p=0.000$]. After controlling for the pretest score, the study similarly found no statistically significant difference in the mean performance of the female students between the three groups [$F_{(2,260)} = 0.154, p = 0.857$]. The findings imply that the inductive teaching approach should be promoted and that school administrators should supply the facilities and tools required for a successful rollout⁵⁹.

Study was carried out to examine how teaching strategies and learning styles affect students' academic achievement in Mathematics. 277 randomly chosen grade 9 pupils and five purposefully selected Mathematics teachers were surveyed. The majority of the student respondents, according to the findings, combine dependent, collaborative, and independent learning styles. Only the independent learning style, according to multiple regression study, significantly affects grade 9 students' academic achievement. It was discovered that four teaching methods—cooperative learning, deductive approach, inductive approach, and integrative approach—had a substantial impact on academic achievement. Teachers will be led in developing various techniques to help students enhance learning for their enhanced performance in Mathematics if they have a clear understanding of their students' learning preferences¹²⁰.

The evidence points to contradictory conclusions about the link between academic achievement and critical thinking, with some studies finding a high effect and others finding no link; few researches, if any, have looked into the connection between students' critical thinking abilities and academic achievement in Nigeria. Further research was necessary to determine whether the development of critical thinking can be used to predict academic achievement in secondary school students in light of the contradictory empirical reports and the dearth of studies on the topic in Nigeria. Critical thinking is a crucial 21st century life skill that may be essential to the growth and development of higher-order scientific reasoning and ability. Few studies have looked at the connection between students' academic achievement and critical thinking in Nigeria¹²¹.

The critical thinking of 500 senior secondary school science students was compared to their scholastic success in Mathematics, a core and required subject, in this correlation study. The Mathematics Achievement Test (MAT with KR-20=0.88) was employed as a benchmark measure for mathematical performance, and the California Critical Thinking Skills Test-Form B (CCTST with KR-20=0.76) was utilized to assess the critical thinking of scientific students. Using the mean, standard deviation, Pearson product moment correlation coefficient, and multiple regression analysis at the 0.05 level of significance, the study's three research objectives were answered. The results revealed that science students' critical thinking skills were lacking. Science students' proficiency in Mathematics was positively and statistically significantly correlated with their critical thinking skills. Based on these conclusions, it was suggested that science teachers use learner-centered educational practices and tactics that can boost their students' capacity for critical thought¹²¹.

There is no significant relationship between critical thinking skills acquisition and achievement in Mathematics of SSS 2 students. The relationship between CT abilities and mathematical achievement was examined using Pearson product moment correlation on the data gathered from the CCTST and MAT scores. The hypothesis was also put to the test. Findings revealed a link between mathematical achievement and critical thinking, including its subscales. It revealed a significant positive correlation between the achievement of science students in Mathematics and analysis ($r=.404$, $p<.01$), evaluation ($r=.496$, $p<.01$), inference ($r=.149$, $p<.01$), deductive reasoning ($r=.135$, $p<.01$), inductive reasoning ($r=.170$, $p<.01$), and aggregate critical thinking ($r=.228$, $p<.01$). Since each of the critical thinking dimensions represents a different set of abilities, low correlations between them are a good thing¹²¹.

Critical thinking skills will not significantly predict achievement in Mathematics of senior secondary school science students. The predictors (analysis, evaluation, inference, deductive reasoning, and inductive reasoning) together provided a multiple regression coefficient of 0.709 and a multiple correlation square of 0.503 to the prediction of the mathematical achievement of senior secondary school science students. This means that the combination of the five independent factors accounted for 50.3% of the total variation in students' Mathematics achievement. The analysis of variance of the data from the multiple regressions, which produced an F-ratio value significant at the 0.001 level ($F_{(5, 494)} = 100.112$; $p<.01$), further supports this conclusion¹²¹.

The results of the marginal contributions of the predictors to the forecasting of the Mathematics achievement of senior secondary school science students, evaluation was the most powerful significant positive contributor to the prediction of students'

Mathematics achievement ($\beta = .663$, $t = 17.10$, $p=.000$), and analysis was the next significant positive contributor ($\beta = .313$, $t = 9.19$, $p=.000$). The use of inductive reasoning came next, which considerably improved the ability to predict Mathematics achievement ($\beta = .282$, $t = 8.32$, $p=.000$). The second major factor that significantly improved the ability to predict Mathematics proficiency was inference ($\beta =.260$, $t = 7.34$, $p=.000$). The least significant positive contribution to the prediction of Mathematics achievement was made by deductive reasoning ($\beta =.194$, $t = 5.49$, $p=.000$). The hypothesis is thus disproved. Science students' arithmetic achievement was predicted statistically significantly by critical thinking¹²¹.

Differentiated instruction is a teaching strategy that adjusts teaching strategies, content, and assessments to meet the diverse learning needs, preferences, and readiness levels of students in a single classroom. Its aim is to foster a welcoming and inclusive learning environment where all students, regardless of their abilities or backgrounds, have the opportunity to learn effectively. All students are encouraged to succeed academically and personally in the classroom by using differentiated instruction. Teachers may create a more encouraging and productive learning environment by identifying and addressing each student's unique strengths and weaknesses¹²².

In the past ten years, differentiated teaching has gained popularity in the field of educational research as a method of instruction that responds to the increasingly diverse student population found in today's classrooms. Thus, very little empirical evidence, even if it is mixed, or analyses of the causal mechanisms that would support such statements, particularly for Mathematics, are accessible. Furthermore, despite being a teaching strategy for addressing literacy issues, there is no quantitative evidence on the

effectiveness of differentiated instruction. A study's findings indicated that using a differentiated instructional style instead of the traditional one was more likely to encourage meaningful learning and raise Mathematics students' achievement levels. In line with the study, differentiated instruction had a positive relationship with Mathematics achievement, meaning that the more the teacher differentiated, the higher the students' Mathematics achievement was. However, this relationship was not statistically significant¹²³.

Classrooms in Nigeria nowadays are getting more culturally and academically diverse. Students who do not speak English as their first language, students from different cultural origins, and students of both genders are typically found in classrooms. Additionally, classes frequently include students who possess a variety of unique characteristics and clearly different practical experiences. The bottom line is that these students unquestionably learn and operate at various readiness levels, have varying interests, and acquire knowledge, understanding, and accomplishing in a variety of methods. In a classroom where students are at different readiness and experiential levels, it will undoubtedly be difficult for Mathematics teachers to consistently use only tasks that are ascetically thought-provoking for all students. Therefore, the current study examined the impact of differentiated instruction on senior secondary school students' Mathematics achievement in Lagos State, Nigeria¹²⁴.

Pre-test and post-test non-equivalent control group quasi-experimental research design was used to assess the impact of differentiated instruction on senior secondary school students' Mathematics achievement in Nigeria. Three research questions and three null hypotheses were used to lead the study, which included 220 students as the sample.

For eight weeks, the experimental group received instruction using differentiated instruction, whereas the control group received instruction using the traditional teaching strategy. Data were gathered using the McKenzie Multiple Intelligences Inventory (Cronbach = 0.90), the Felder-Soloman Index of Learning Styles (Cronbach = 0.92), and the Mathematics Achievement Test (KR-20=0.89), three reliable and valid tools¹²³.

Results showed that students in the differentiated instruction group outperformed those in the traditional teaching style group by a large margin. The accomplishment of male and female students taught Mathematics with differentiated instruction did not differ significantly, but male students did perform marginally better than female students using differentiated instruction. The achievement of students in Mathematics was not significantly impacted by gender. The impact of treatment and gender on students' Mathematics achievement was also not statistically significant. Differentiated instruction made lessons more engaging, stress-free, and encouraged student cooperation. Therefore, it was advised that Nigerian Mathematics teachers use differentiated instruction when instructing students in senior secondary school¹²³.

Parents, teachers, and students are all very concerned about the rising failure rate of kids taking final year exams, such as the West Africa Senior School Certificate Examination (WASSCE) in Mathematics. The achievement of students in Mathematics knowledge, particularly in Oyo State's private senior secondary schools, has been declining, according to a National Bureau of figures analysis of the WASSCE results figures (2016-2018). For instance, while the performance dropped to 16.8% in 2017 and stayed at 17.2% in 2018, the percentage of students with 5% credits or more, including Mathematics, was 24% in 2016. In addition, an analysis of the Chief Examiner's

comments from 2009 to 2018 regarding students' deficiencies in general Mathematics paper two reveals that these weaknesses are predominantly seen in the areas of circle geometry and its application, word problems, and graph interpretation. The Chief Examiner recommended that teachers use instructional aids in the teaching and learning processes, present more worked examples during class lessons, and use a more appropriate teaching technique to address these inadequacies. In order to determine whether a change in teaching methodology will affect students' academic achievement in Mathematics; particularly in two selected private senior secondary schools in Afijio Local Government Area of Oyo State, then research was conducted. The Traditional (chalk and chat) and the Montessori (self-discovery) approaches were used by the researcher in the study. The Mathematics Achievement Test (M.A.T), interviews, and field observations were the instruments employed for data gathering. A review of the data showed that students who were taught utilizing the Montessori approach had a cumulative pass rate of 57.1%. Comparatively, their contemporaries who employed the conventional method had an overall pass rate of 49.6%. These results showed that participants from the experimental group outperformed students from the control group¹²⁴.

2.3.3 Teacher skills and Academic Achievement in Further Mathematics

Students' academic achievement fundamentally depends on the communication skills of their teachers. Speaking, listening, and reading are all components of effective communication. For the purpose of conveying knowledge and managing interactions with pupils in the classroom, teachers must have effective communication skills. To accomplish three goals in the classroom, teachers employ communication: to elicit

pertinent knowledge from students; to react to what students say; and to share their classroom experiences with students. For a teacher to be successful in the classroom, communication skills must be strong. It is advised that teachers communicate in a clear and understandable manner as having poor communication skills might lead to students failing academically¹²⁵.

In essence, a research that aimed to evaluate how students felt about the contribution of teachers' communication skills to their academic achievement. Comprehensive questionnaire containing information including social economic and demographic aspects of the study was designed by the researcher to achieve the set objectives. All universities that offered programmes in sports sciences and physical education were included in the study's population. The empirical information on the impact of a teacher's communication skills on students' academic achievement was gathered from samples taken from 14 institutions in Pakistan, totaling 418 (38% from each university). Personal interactions and the use of the created scale were used to obtain the data from the respondents. Regression was used to analyze the data after it had been collected and finally organized in the form of tables. Following data analysis, the researcher came to the conclusion that teachers' communication skills significantly influence the student's academic achievement¹²⁶.

Teacher commitment is one of the skills of teachers that affect students' academic achievement. Teacher commitment is an internal drive that motivates instructors to put in more time and effort to maintain participation in school activities. In order to create a successful learning environment where students can develop their potential for higher achievement in academic work, teachers must be committed to doing so. Among the

commitments teachers make are those to their students, the profession of teaching, the school, and their professional knowledge. An important element that affects students' achievement is the commitment of the teacher to her subject. Additionally, teachers with a high level of commitment can influence how much knowledge their students acquire. Teachers that are committed to their work are happy with what they do and work hard to build positive relationships with their students they teach. Their commitment to the school is undeniable, and it is clear that they want to see the school's goals achieved. A key component that helps teachers focus on students' needs is teacher commitment. Additionally, dedicated teachers know how to motivate students to actively engage in the teaching and learning process¹²⁵.

Another factor in this study is teachers' motivation. Motivation is the internal force or energy that drives someone to take a certain activity in pursuit of a specific goal. In this sense, motivation energizes and drives one towards action and the realization of a vision. Passions that drive instructors to act are referred to as teacher motivation. The academic achievement of students would be hindered if teachers lacked sufficient motivation. As a result, the researchers in Ogun State, Nigeria, examined teachers' skills as indicators of students' academic achievement in Mathematics. In every nation, teachers play a critical role in ensuring that educational goals are fully implemented. Students' academic success and failure depend heavily on the teaching skills of their teachers. Achievement of students is a reflection of teachers' skills¹²⁵.

In Ogun State, Nigeria, the study looked at teachers' skills as indicators of students' academic achievement in Mathematics. The study used a survey approach. Four hundred twenty (420) respondents total including seventy (70) instructors and three

hundred fifty (350) students were chosen at random from seven public secondary schools located in four local government areas of the Ogun-Central senatorial region in Ogun State for the study. The seven (7) schools were chosen using a Purposive sampling technique. Ten (10) teachers and fifty (50) students were chosen at random from each school. The Teachers' Skills of Commitment, Motivation and Communication Questionnaire (TSCMCQ, $r = 0.68$) and the Mathematics Achievement Test (MAT, $r = 0.74$) are the two instruments utilized to collect data. At the 0.05 level of significance, four hypotheses were developed and tested. Multiple Regression Analysis (MRA) was used to analyze the data. The findings of the study revealed that students' academic achievement in Mathematics will be significantly predicted by the teachers' commitment, motivation, and communication skills when combined. It was suggested, among other things, that teachers should be encouraged to actively participate in in-service training courses and workshops to keep up with the latest information and pedagogical techniques¹²⁵.

2.3.4 Students' Attitude and Academic Achievement in Further Mathematics

Attitude can be defined as the way in which a person responds to situations, objects, people, and problems. The behaviour or tendency to react in a specific way to a situation or item might still be perceived as attitudes. A person's attitude is a driving force that exerts a directed, dynamic effect; it is not only a passive outcome of their prior experiences. Persuasion is another method for influencing attitudes. A state of readiness or a tendency to act or react a certain way when faced with certain stimuli is known as attitude. In relation to learning especially, attitude is a feeling towards something or

someone that occasionally manifests itself in behaviour. An individual's attitudes are mostly shaped by their experiences in the classroom. Interaction with other people improves attitudes even more. Depending on whether a person likes or dislikes something or someone, attitude can be either good or negative. Retrospectively, based on happy memories of the past, or prospectively, in anticipation of future benefit, attitude serves to make goals easier to achieve. There is a definite connection between attitudes towards learning a specific task and the learner's subsequent performance in that task¹²⁷.

In many different countries, a number of studies and researches have been conducted to identify the variables that affect students' academic achievement in Mathematics. One significant component that has been regularly researched is students' attitudes towards Mathematics. Studies on how students' attitudes and academic achievement are related frequently reveal a favorable association. Therefore, a key component that may have an impact on students' academic achievement is their attitude towards Mathematics. As a result, numerous studies have been carried out in various nations to ascertain students' attitudes towards Mathematics and to use the information gathered to suggest reasons for students' poor academic achievement¹²⁷.

The relationship between students' attitude towards Mathematics and their academic achievement in Mathematics from the study carried out to establish the relationship between each of study habit, self-concept and students' attitude as correlates of students' academic achievement in Mathematics among senior secondary school students in Oyo metropolis. The findings indicate a strong connection of .202** between the students' attitude towards Mathematics and their academic achievement. At the 0.01 level of significant (2 tailed), the correlation is statistically significant¹²⁷.

Study habits are intentional behavior patterns that are focused on understanding, observing, questioning, reading, reciting, and reviewing material in an effort to master a task. A study habit involves setting aside a specific amount of time, preferably uninterrupted, to devote to learning. Without it, one stagnates in life and adopts self-imposed limitations. A person's study habits indicate how much he will learn, how far he wants to go, and how much money he wants to make. All of these could be determined during the course of a person's life with the aid of their study habits. The significance of good study habits in a student's life is that they contribute significantly to their academic achievement because nobody succeeds without them. Students that have good study habits perform better in school¹²⁷.

The manner an individual study will have an impact on how well they succeed in Mathematics and science classes. The study of Mathematics and other science-related subjects always necessitates intense concentration in order to observe, classify, manipulate, and make deductions. Attention is the initial step in the concentration process. The learner will be able to focus if the subject matter is interesting to them and they feel the need to study it; when studying, uninterrupted attention leads to concentration. A study analyzed students' study habits, self-concept, and science achievement in junior secondary public and private schools in Ogun State, Nigeria. From the Egba and Ijebu divisions of the state, 12 secondary schools were chosen at random. The survey's findings showed that there was no significant difference in study habit and self-concept of students in public and private schools. The combination of a student's study habits and self-concept also predicted science achievement in both public and private schools¹²⁷.

A study reveals a significant link between high school students' study habits and academic achievement. In a separate study, the significance of study skill development as a component of a strategy for treating test anxiety was also established. When the level of study habit competence is disregarded, these researchers came to the conclusion that a reduction in test-anxiety is not a guarantee of subsequent improvement in academic achievement. In order to improve students' study habits and academic achievement, regular counseling services to teach them study skills strategies were recommended. a research came to this conclusion after conducting a study to find out how students' academic achievement in essential subjects at the junior secondary school level in Ondo state, Nigeria was related to their study habits¹²⁷.

The relationship between study habit and Mathematics student achievement from the study carried out to establish the relationship between each of study habit, self-concept and students' attitude as correlates of students' academic achievement in Mathematics among senior secondary school students in Oyo metropolis. The findings showed that students' academic achievement is positively and significantly correlated with their study habits. It has a .194** positive correlation. The significance level for correlation is 0.01 (2-tailed). In any student's academic life, developing effective study habits is essential. It is clear from this that a successful candidate would have developed excellent study skills¹²⁷.

Self-concept is a result of one's ability to reflect; it is the idea that an individual has of himself as a physical, social, moral, and living being. Each of us is conscious of our unique selves. The knowledge we have about ourselves, what we believe about who we are, is known as the self-concept. Self-concept can also be thought of as our attempt

to justify ourselves to ourselves, to create a framework that arranges our ideas, feelings, and methods towards ourselves. However, this plan is not permanent, included, or static. Our ideas of ourselves change depending on the circumstance throughout every stage of life. It can be challenging to come up with strategies for improving student performance without also considering how to boost their self-confidence as learners. At the same time, it is nearly impossible to support students in developing a positive self-concept without also helping them identify strategies to enhance their academic achievement¹²⁷.

The factors influencing one's success or failure in Mathematics, as well as one's subjective knowledge and feelings about those factors, are the most crucial components of one's self-concept in that field. A study discovered a highly specific connection between academic achievement and one's self-concept. Academic achievement was shown to be unrelated to general self-concept and non-academic components, but moderately connected to general academic self-concept. Academic achievement in that content area was found to be strongly correlated with particular measures of subject-related self-concepts. Research has also backed the idea that academic achievement and self-concept are mutually reinforcing to the point where a good (or negative) change in one facilitates a comparable change in the other. Some self-concept studies have claimed that a positive self-concept has a causal advantage over academic achievement, while others have stated that the contrary is true and that their research supports the idea that a positive self-concept comes before academic achievement¹²⁷.

Academic achievement is more closely correlated with academic self-concept than is general self-concept. Self-concept and achievement are dynamically interactive and reciprocal, and each is mutually reinforcing to the extent that a positive (or negative)

change in one facilitates a commensurate change in the other. Students who have high self-concept typically approach school-related tasks with confidence, and their success at such tasks only serves to strengthen that confidence. For students with poor academic self-concepts, the reverse tendency is more likely to manifest. Investigating the impacts of age, gender, and achievement on high school students' academic self-concept using the Academic Self-Concept Scale; the findings indicated a significant positive link between academic self-concept and achievement. A study on university students' academic achievement and self-perception as it relates to their psychological adjustment. It was shown that there was a substantial and positive correlation between academic achievement and self-concept ($p < 0.05$)¹²⁷.

A study to determine how important self-concept is in predicting students' academic achievement at the higher secondary level; a sample of 321 students from various school types and educational systems was selected at the higher secondary school. The results of the study showed that, in comparison to students from other boards, students from central board schools had stronger self-concepts and academic achievements. Additionally, there is a considerable and favorable correlation between students' academic achievement at the higher secondary level and their self-concept. An investigation on how closely Port Harcourt students' self-concept relates to their general academic achievement and Mathematics performance. The study's key finding was that self-concept and Mathematics, and general academic achievement of students are so closely associated that a change in self-concept makes a change in achievement easier¹²⁷.

The relationship between self-concept of students and their academic achievement in Mathematics from the study carried out to establish the relationship between each of

study habit, self-concept and students' attitude as correlates of students' academic achievement in Mathematics among senior secondary school students in Oyo metropolis. The findings indicated a significant and advantageous link between students' academic achievement and self-concept. It has a.220** positive correlation. The significance level for correlation is 0.01 (2-tailed). There appears to be a positive association and statistical significance¹²⁷.

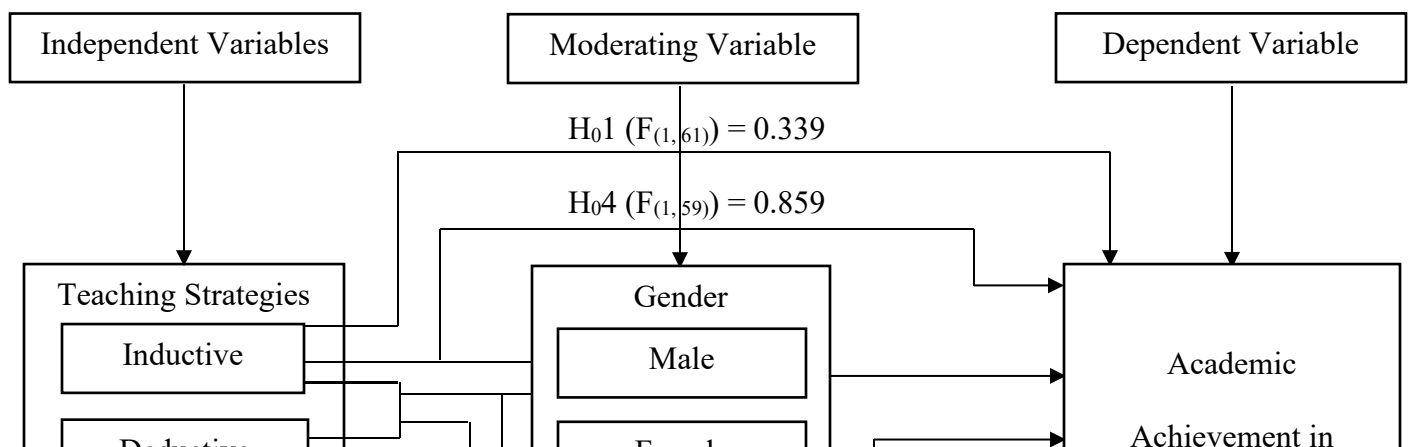
For a very long time, educational scholars and Mathematics educators have focused on the crucial role that certain psychological factors, such as study habits, self-concept, and students' attitudes, play in the acquisition of Mathematics. To determine the connection between each study habit, self-concept, and student attitude, a study was conducted. For the purposes of this investigation, five research questions were posed. Six hundred (600) senior secondary students (S.S. 2) from 20 different schools in the Oyo metropolis served as the study's sample population. A mathematical achievement test was combined with three sets of questionnaires. The relevant statistical techniques were applied to the data that were collected. To address the research topics, the researcher used correlation, multiple regression, and analysis of variance (ANOVA). The analysis of the data yielded the finding that each of the independent variables (study habit, self-concept, and attitude) was positively and significantly correlated with the students' achievement in Mathematics. The combined variables (study habit, self-concept, and attitude) and students' achievement in Mathematics were positively and significantly correlated, according to the multiple correlation coefficients R of 0.269. These separate factors worked together to account for 7.2% of the variation in students' academic achievement in Mathematics¹²⁷.

Investigating why there are more male than female Mathematics students in secondary school when there appear to be no gender differences in achievement in earlier years is important. The purpose of the research was to look into the impact of female students' attitudes towards Mathematics on their academic achievement in comparison to that of male students, as well as to look into the connection between attitudes and academic achievement in Mathematics. 240 students from Wolkite Town's General Secondary and Preparatory School in grades 10 and 12 participated in the study. Utilizing stratified random sampling, these students were chosen. The Mathematics Achievement Test (MAT) score was used to determine students' achievement, while the Attitude Towards Mathematics Inventory (ATMI) was utilized to determine their attitude towards Mathematics. Statistical Package for Social Sciences (SPSS) version 20 was used to analyze the acquired data. Descriptive statistics, multiple linear regression models, independent samples t-tests, and Pearson correlation coefficient were all used¹²⁸.

The results showed that students at all grade levels had a favorable attitude towards Mathematics, although at the medium level, female students performed less well than male students. The components of attitude towards Mathematics scales were accurately predicted by the regression models to influence students' achievement. In this regard, the three variables—the enjoyment, motivation, and confidence attitude scales—joined accounted for 42.8% (Grade 10) and 55.4% (Grade 12) of the difference in students' academic achievement. Although attitudes towards Mathematics did not differ significantly between genders at each school level, but females displayed a bigger fall in attitudes as the grade level increased. The achievement gap between male and female, however, was quite large. Students' achievement and attitude towards Mathematics were

substantially associated ($r = .660$; $p.001$ for grade 10 and $r = .735$; $p.001$ for grade 12). As a result, the study proposes that action be taken by the school, instructors, parents, and other concerned parties to improve students' attitudes towards and performance in Mathematics, particularly among female students¹²⁸.

2.4 Conceptual Model



$$H_03 (F_{(1, 105)}) = 2.149$$

$$H_07 (F_{(3, 101)}) = 1.525$$

$$H_06 (F_{(2, 104)}) = 10.128$$

$$H_05 (F_{(2, 61)}) = 0.443$$

$$H_02 (F_{(1, 63)}) = 11.321$$

Figure 2.1: Conceptual Model of Inductive and Deductive Teaching Strategies on Academic Achievement in Further Mathematics

Source: *Fieldwork, 2024*

2.5 Summary of Literature Reviewed

The literature review conducted for “Effect of Inductive and Deductive Teaching Strategies on Senior Secondary School Students’ Academic Achievement in Further Mathematics in Oyo State” encompasses a comprehensive examination of various key concepts and theories relevant to the study. This review is structured into conceptual, theoretical and empirical segments, providing a clear understanding of the existing knowledge in the field.

In the conceptual review, the study delves into fundamental concepts such as academic achievement, teaching strategies, gender, Further Mathematics, and calculus. Academic achievement is discussed as the primary outcome variable, highlighting its

significance in educational research. The different teaching strategies, specifically inductive and deductive approaches, are outlined, emphasizing their distinct instructional methods. Gender is introduced as a crucial factor, as it pertains to the performance and learning outcomes of students. Further Mathematics and calculus concepts are introduced, setting the stage for the specific subject matter of the study.

The theoretical review section explores the theoretical frameworks that underpin the research. The Social Cognitive Theory, Sociocultural Theory, and Constructivist Theory are discussed in detail. These theories provide a foundation for understanding how social interactions, cultural contexts, and individual cognitive processes can influence students' academic achievement.

The empirical review portion focuses on prior research findings related to academic achievement. Gender and its impact on academic achievement are examined, as well as the role of teaching strategies, teachers' skills and students' attitudes. These empirical studies offer insights into the multifaceted factors that can affect students' academic achievement and help contextualize the research problem in the Oyo state setting.

The literature review provides a thorough exploration of the key concepts, theoretical frameworks, and previous research relevant to the thesis. It lays the groundwork for the investigation into how Inductive and Deductive teaching strategies may influence academic achievement in Further Mathematics among senior secondary school students in Oyo state, offering a comprehensive understanding of the existing knowledge in this area of study.

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Chapter Three

Methodology

This chapter describes the methods and techniques that will be applied in order to accomplish the aim and objectives of this study. It was organized under the following subheadings: research design, population of the study, sample and sampling techniques, instrument for data collection, validity of the instrument, reliability of the instrument, method of data collection and method of data analysis.

3.1 Research Design

This research adopted quasi-experimental research design. Three separate treatments — Inductive, Deductive and Conventional teaching strategies — were administered to three different groups (Two Experimental and One Control groups) as part of the quasi-experimental design. It compares the academic achievement of students of different gender (male and female) that were taught Calculus concept in Experimental groups (Group A using the Inductive teaching strategy and Group B using Deductive teaching strategy) and in Control group (Group C using the conventional teaching strategy). The research employed pretest-posttest strategy in this study. In a pretest-posttest strategy, the dependent variable (academic achievement) was measured once before the application of the treatment (teaching strategies). Following the application of the treatment, the dependent variable was measured again. Further information regarding the research design can be found in Table 3.1 and 3.2.

Table 3.1: Factorial Design

Group	1 (Pretest)	Treatment	2 (Posttest)
E ₁	O ₁	X ₁	O ₂
E ₂	O ₃	X ₂	O ₄
E ₃	O ₅	X ₃	O ₆

Source: *Fieldwork, 2024*

Where O₁, O₃, O₅ = Pretest Scores

O₂, O₄, O₆ = Posttest Scores

E₁, E₂, E₃ = Treatment Groups

X₁ = Treatment 1 (Inductive Teaching Strategy)

X₂ = Treatment 2 (Deductive Teaching Strategy)

X₃ = Control (Conventional Teaching Strategy)

Table 3.2: Schematic Representation of the 3 × 2 × 1 Factorial Matrix

Treatment	Gender	Academic Achievement
Inductive Teaching Strategy X ₁	Male / Female	
Deductive Teaching Strategy X ₂	Male / Female	
Conventional Teaching Strategy X ₃	Male / Female	

Source: *Fieldwork*, 2024

Variables in the study

1. Independent variable includes: Treatment Method at Three Levels

Treatment 1 (Inductive Teaching Strategy)

Treatment 2 (Deductive Teaching Strategy)

Control (Conventional Teaching Strategy)

2. Moderating variable includes: Gender at Two Levels

Male

Female

3. Dependent variable includes: Academic Achievement at One Level
Academic Achievement in Further Mathematics

3.2 Population of the Study

The population for this study consists of One thousand six hundred and four (1,604) senior secondary school II students which comprised Seven hundred and eighty-two (782) male students and Eight hundred and twenty-two (822) female students from Seven (7) Schools of Science in Oyo State as of the time of conducting this research. Further information regarding the study population can be found in Table 3.3.

Table 3.3: Population of the Study

LGA	Name of School of Science	SS II Students Enrolments		
		Male	Female	Total
1. Akinyele	School of Science, Pade	102	101	203
2. Atiba	School of Science, Oyo	111	121	232
3. Ib. South East	Wesley College of Science, Elekuro	135	120	255
4. Ib. South West	Oladipo Alayande School of Science	245	252	497
5. Ibarapa Central	School of Science, Idere	54	48	102
6. Kajola	School of Science, Okeho	43	55	98

7. Ogbomoso North School of Science, Ogbomoso		92	125	217
Total	7	782	822	1,604

Source¹:

3.3 Sample and Sampling Techniques

Multistage sampling procedure was adopted for selecting three (3) schools of science for this study. First stage, Oyo state Local Government Area (LGA) was stratified into three (3) senatorial districts (Oyo North, Oyo Central and Oyo South) with thirty-three (33) LGA in total. Oyo North consists of thirteen (13) LGA; Oyo Central consists of Eleven (11) LGA; and Oyo South consists of Nine (9) LGA. Second stage involves purposive selection of each school of science from each of the three (3) senatorial districts in Oyo state as thus:

From two (2) schools of science (Okeho and Ogbomoso in Kajola and Ogbomoso North LGA respectively) found in Oyo North senatorial district; School of Science, Ogbomoso in Ogbomoso North LGA was purposively selected for Group A treatment using Inductive Teaching Strategy.

From two (2) schools of science (Pade and Oyo in Akinyele and Atiba LGA respectively) found in Oyo Central senatorial district; School of Science, Pade in Akinyele LGA was purposively selected for Group B treatment using Deductive Teaching Strategy.

From three (3) schools of science (Elekuro (Wesley College), Oke-Bola (Oladipo Alayande) and Idere in Ibadan South East, Ibadan South West and Ibarapa Central LGA respectively) found in Oyo South senatorial district; Wesley College of Science, Elekuro

in Ibadan South East LGA was purposively selected for Group C treatment using Conventional Teaching Strategy.

The three (3) schools of science (Ogbomoso, Pade and Elekuro (Wesley College)) were purposively selected for this study because they were the oldest schools of science, from each senatorial district in Oyo state. Further information regarding the purposive selected schools of science for this study can be found in Table 3.4.

Table 3.4: Selected Schools of Science for the Study

Senatorial Districts	Total LGA	Purposive Selected Schools of Science	
		LGA	
1. Oyo North	Saki West, Saki East, Atisbo, Irepo, Olorunsogo, Kajola, Iwajowa, Ogbomoso North, Ogbomoso South, Iseyin, Oorelope, Orire and Itesiwaju	Ogbomoso North	School of Science, Ogbomoso
2. Oyo Central	Afijio, Akinyele, Egbeda, Ogo-Oluwa, Surulere, Lagelu, Oluyole, Ona-Ara, Oyo East, Oyo West and Atiba.	Akinyele	School of Science, Pade
3. Oyo South	Ib. North, Ib. North East, Ib. North West, Ib. South East,	Ibadan South	Wesley College of Science, Elekuro

Ib. South West, Ibarapa East, East
Ibarapa Central,, Ibarapa North
and Ido.

Total **33** **3** **3**

Source: *Fieldwork, 2024*

For the study sample, intact class was used in each of the three (3) selected schools of science in Oyo State.

From the field work, forty-two (42) participants were found in SS 2B intact class which consists of seventeen (17) male and twenty-five (25) female students in School of Science, Ogbomoso that was purposively selected for Group A treatment using Inductive Teaching Strategy.

Forty-four (44) participants were found in SS 2K intact class which consists of twenty-two (22) male and twenty-two (22) female students in School of Science, Pade that was purposively selected for Group B treatment using Deductive Teaching Strategy.

Twenty-two (22) participants were found in SS 2E intact class which consists of eleven (11) male and eleven (11) female students in Wesley College of Science, Elekuro that was purposively selected for Group C treatment using Conventional Teaching Strategy. Further information regarding the study sample can be found in Table 3.5.

Table 3.5: Study Sample

Group	Purposive Selected Schools of Science	Classes	Gender		Total
			Male	Female	
Group A	School of Science, Ogbomoso	SS 2B	17	25	42
Group B	School of Science, Pade	SS 2K	22	22	44
Group C	Wesley College of	SS 2E	11	11	22

Science, Elekuro

Total	3	3	50	58	108
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Source: *Fieldwork, 2024*

3.4 Description of the Research Instruments

The following instruments were developed, validated and used to collect data for this study. These are;

1. Differential and Integral Calculus Achievement Test (DICAT)
2. Teaching and Learning Instructional Guides (TLIG)

3.4.1 Differential and Integral Calculus Achievement Test (DICAT)

This was used as instrument to collect data for the study to measure students' achievement in Calculus concept. The instrument consists of Fifty (50) different items taking from Secondary Certificate Examination (SSCE) past questions. The DICAT has multiple-choice items with four lettered (A to D) alternative choices, which was expected by the students to encircle only one answer at a time from the given answer's options and the given time frame to finish the whole test was one hour, fifteen minutes (1hr 15mins). The instrument contain two (2) sections namely section A and B.

Section A contains items on demographic characteristics of participants such as school name, gender, class, age range, group type and test type. Section B contains Fifty (50) multiple-choice items to measure the students' achievement in Differential Calculus, which involves the following differential calculus topics: derivative rules (power rule, product rule, quotient rule, and chain rule), higher-order derivatives, implicit

differentiation, parametric differentiation, trigonometric differentiation, logarithmic differentiation, exponential differentiation, optimization problems (finding maximum and minimum values), Tangents and normal to curves. Also, to measure the students' achievement in Integral Calculus, which involves the following integral calculus topics: techniques of integration (integration by substitution, integration by partial fractions and trigonometric integrals), definite and indefinite integrals, area under curves and volumes of solids; This Section B had 50 items spread over the higher-order cognitive domains of analysis, synthesis, application and evaluation, as can be seen from the Table of Specification.

Table 3.6: Differential and Integral Calculus Achievement Test (DICAT) Item Specification

Contents	Cognitive Level				Total
	Application	Analysis	Synthesis	Evaluation	
1. Differentiation	3	2	1	2	8
2. Differential Equations	3	1	3	2	9
3. Applications of Differentiation	3	1	2	2	8
4. Integration	2	2	3	2	9
5. Techniques of Integration	3	2	2	2	9
6. Applications of Integration	2	1	2	2	7
Total	16	9	13	12	50

Source: *Fieldwork, 2024*

3.4.2 Teaching and Learning Instructional Guides (TLIG)

These consist of lesson notes that clearly outline the key roles that both the teacher and the students played in the study. The following details can be found in the lesson notes: School, Subject, Class, Topic, Sub-Topics, Number in Class, Average age, Gender, Duration, Date, Instructional Objectives, Instructional Materials, Presentation and Assessment.

These involve three distinct lesson notes with their steps as follow:

1. Lesson Note I: Instructional Guide for Experimental Group A (Inductive Teaching Strategy)

Step 1: Introduction

Step 2: Analyses of Given Examples

Step 3: Synthesizes of Analyzed Examples

Step 4: Identification of Differential Coefficient and Basic Integrals of the synthesized functions

Step 5: Application of General Rules

Step 6: Evaluation

Further information regarding the Instructional Guide for Experimental Group A can be found in Appendix II

2. Lesson Note II: Instructional Guide for Experimental Group B (Deductive Teaching Strategy)

Step 1: Introduction

Step 2: Application of General Rules

Step 3: Identification of Differential Coefficient and Basic Integrals of the synthesized functions

Step 4: Synthesizes of given Examples

Step 5: Analyses of synthesized Examples

Step 6: Evaluation

Further information regarding the Instructional Guide for Experimental Group B can be found in Appendix III

3. Lesson Note III: Instructional Guide for Control Group C (Conventional Teaching Strategy)

Step 1: Introduction

Step 2: Identification of Differential Coefficient and Basic Integrals of different types of functions

Step 3: Analyses of Given Examples

Step 4: Synthesizes of Analyzed Examples

Step 5: Application of Rules and Techniques

Step 6: Evaluation

Further information regarding the Instructional Guide for Control Group C can be found in Appendix IV

3.5 Validity of the Differential and Integral Calculus Achievement Test (DICAT)

To make sure that a test is measuring what it is intended to measure, it is essential to confirm the validity of any achievement test used in a quasi-experimental study design.

Establishing the validity of an achievement test is an ongoing process that requires careful consideration of the context, content, and purpose of the assessment tool. This study adopted both face and content validity assessment. To achieve this, the supervisor carefully examined the research instrument (DICAT) against any necessary correction before it was administered.

3.6 Reliability of the Differential and Integral Calculus Achievement Test (DICAT)

Reliability of the research instrument (DICAT) were carried out on a sample of twenty (20) students from Oladipo Alayande School of Science, Oke-Bola in Ibadan South West LGA found in Oyo South senatorial district which was not part of the purposive selected schools of science for the study but similar in attributes. Kuder-Richardson (KR-20) was used to calculate the reliability of the instrument (DICAT) with reliability value of 0.84.

3.7 Method of Data Collection

When conducting a quasi-experimental study with an achievement test, data collection involves systematically gathering information on participants' achievement or results in relation to the particular construct being examined. To administer the achievement test successfully for data collection, the researcher obtained a letter of introduction from the Head of Department to seek for necessary permission from the selected schools' principals and respective Mathematics teachers. Then, informed consent was given to the participants which includes the study's aims, methods, and any risks or advantages that might exist. Teachers (Research Assistants) received training. During the

training session; It was thoroughly discussed both the goal of the study and the procedural steps to be taken to conduct it within Eight (8) weeks.

The process will adhere to the following time schedule:

Week One: Training of research assistants

Week Two: Administration of pre-test

Week Three – Seven: Carrying out the treatment

Week Eight: Administration of post-test

Week One

Training of Research Assistants

The first week was used to train the research assistants on purpose of the study and the three separate treatments— Inductive, Deductive and Conventional teaching strategies adopted for this study.

Week Two

Administration of Pre-test

The second week was used to administer the Differential and Integral Calculus Achievement Test (DICAT) on all SS II Further Mathematics students in each of the selected schools as the pre-test before the treatments for the groups.

Week Three – Seven

Carrying out the Treatment

The third week to seventh week (approximately five (5) weeks) were used to carry out the three separate treatments— Inductive, Deductive and Conventional teaching

strategies on the three different groups (Two Experimental and One Control groups) using the prepared lesson notes for experimental group A, experimental group B and control group C to teach students in their respective schools by the researcher and the research assistants.

Week Eight

Administration of Post-test

The eighth week was used to administer the Differential and Integral Calculus Achievement Test (DICAT) on all SS II Further Mathematics students in each of the selected schools as the post-test after the treatments for the groups.

3.7.1 Data Administration

Mathematics teachers (Research Assistants) from the selected schools for the study were trained on how to guide the participants in experimental group A using the Inductive teaching strategy, experimental group B using Deductive teaching strategy and control group C using the conventional teaching strategy in teaching and learning process using the prepared lesson notes provided by the researcher. After the training; the researcher examined the Mathematics teachers or research assistants by allowing them to perform what they have been taught for 30 minutes and they carried on with the experiment while the researcher monitored them during the experiment. Same length of time (periods) was used for participants in both experimental and control groups. The treatments was carried out in their respective schools using double periods every week for five (5) weeks (week three to week seven). Pre-test was administered on the

participants before the commencement of the experiment while the Post-test was administered on the participants after the end of the experiment.

3.8 Method of Data Analysis

Inferential statistics was employed to assess the significant differences by using Analysis of Covariance (ANCOVA) at the 0.05 level of significance.

Endnote

1. M. K. Oladejo, *SS II Students Enrolments in Seven (7) Schools of Science in Oyo State*, Oyo State Ministry of Education, Science and Technology, 2023.

Chapter Four

Results and Discussion of Findings

This chapter presents the analysis of data collected at the 0.05 level of significance, results tables, the interpretation of results and discussion of findings.

4.1 Demographic Data Analysis

Table 4.1.0: Inductive Teaching Strategy, Deductive Teaching Strategy and Gender

Teaching Strategies	Gender		Total
	Male	Female	

Inductive	17	25	42
Deductive	22	22	44
Conventional	11	11	22
Total	50	58	108

Source: *Fieldwork, 2024*

4.2 Presentation of Data

4.2.1 Hypotheses

H₀₁: There will be no significant main effect of Inductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics.

The Analysis of Covariance (ANCOVA) result on the effect of teaching strategy on senior secondary school students' academic achievement in Further Mathematics after being taught with inductive strategy was; $F_{(1, 61)} = 0.339$ and $\text{Sig.} = 0.563$. Since $P > 0.05$ the null hypothesis H_{01} is retained. There was no significant main effect of Inductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics [$F_{(1, 61)} = 0.339$, $P > 0.05$]. The size of the effect of the conventional and inductive teaching methods is given by the partial Eta Squared value of 0.006, which implies that the effect is small because its value falls between (0.1 – 0.2). The result also indicates that 0.6% of the variance in the students' performance is explained by the inductive and conventional teaching strategies. The coefficient results presented under the parameter estimates in (Table 4.1.2) shows that inductive strategy positively and insignificantly affect the students' performance in Further Mathematics ($\beta=0.866$,

Sig.=0.563). The result implies that a unit increase in inductive teaching strategy will lead to 0.866 increases in the students' performance in Further Mathematics.

Table 4.1.1: Summary of Senior Secondary School Students' Academic Achievement in Further Mathematics ANCOVA Result of the Difference in Posttest Mean for Inductive Teaching Strategy

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	29.804 ^a	2	14.902	0.472	0.626	0.015
Intercept	1942.107	1	1942.107	61.472	0.000	0.502
Strategy	10.704	1	10.704	0.339	0.563	0.006
Pretest	21.939	1	21.939	0.694	0.408	0.011
Error	1927.180	61	31.593			
Total	41907.000	64				
Corrected Total	1956.984	63				

a. R Squared = 0.015 (Adjusted R Squared = -0.017)

Source: *Fieldwork, 2024*

Table 4.1.2: Parameter Estimates of Senior Secondary School Students' Academic Achievement in Further Mathematics for Inductive Teaching Strategy

Dependent Variable: Posttest

Parameter	B	Std. Error	T	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	22.985	2.839	8.097	0.000	17.309	28.662	0.518
[Strategy= Inductive]	-0.866	1.487	-0.582	0.563	-3.839	2.108	0.006
[Strategy= Conventional]	0.000 ^a	0.000	0.000	0.000	0.000	0.000	0.000
Pretest	0.178	0.213	0.833	0.408	-0.248	0.603	0.011

a. This parameter is set to zero because it is redundant.

Source: *Fieldwork, 2024*

Table 4.1.3: Pairwise Comparisons of Senior Secondary School Students' Academic Achievement in Further Mathematics for Inductive Teaching Strategy

(I) Strategy	(J) Strategy	Mean Difference (I-J)	Std. Error	Sig. ^a	95% Confidence Interval for Difference ^a	
					Lower Bound	Upper Bound
Conventional	Inductive	-0.866	1.487	0.563	-3.839	2.108
Inductive	Conventional	0.866	1.487	0.563	-2.108	3.839

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Source: *Fieldwork, 2024*

H₀₂: There will be no significant main effect of Deductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics.

The Analysis of Covariance (ANCOVA) result on the effect of teaching strategy on senior secondary school students' academic achievement in Further Mathematics after being taught with deductive methods was; $F_{(1, 63)} = 11.321$ and $\text{Sig.} = 0.001$. Since $P < 0.05$ the null hypothesis H₀₂ is rejected. There was a significant main effect of Deductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics [$F_{(1, 63)} = 11.321$, $P < 0.05$]. The coefficient results presented under the parameter estimates in (Table 4.2.2) shows that deductive teaching strategy positively and significantly affect the students' performance in Further Mathematics ($\beta=4.261$, $\text{Sig.}=0.001$).

Table 4.2.1: Summary of Senior Secondary School Students' Academic Achievement in Further Mathematics ANCOVA Result of the Difference in Posttest Mean for Deductive Teaching Strategy

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	290.380 ^a	2	145.190	6.258	0.003	0.166
Intercept	2106.574	1	2106.574	90.802	0.000	0.590

Pretest	11.107	1	11.107	0.479	0.492	0.008
Strategy	262.636	1	262.636	11.321	0.001	0.152
Error	1461.575	63	23.200			
Total	32519.000	66				
Corrected Total	1751.955	65				

a. R Squared = 0.166 (Adjusted R Squared = 0.139)

Source: *Fieldwork, 2024*

Table 4.2.2: Parameter Estimates of Senior Secondary School Students' Academic Achievement in Further Mathematics for Deductive Teaching Strategy

Parameter	B	Std. Error	T	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	21.876	2.616	8.361	0.000	16.647	27.104	0.526
Pretest	-0.122	0.176	-0.692	0.492	-0.475	0.230	0.008
[Strategy= Deductive]	4.261	1.266	3.365	0.001	1.730	6.792	0.152
[Strategy= Conventional]	0.000 ^a	0.000	0.000	0.000	0.000	0.000	0.000

a. This parameter is set to zero because it is redundant.

Source: *Fieldwork, 2024*

H₀₃: There will be no significant main effect of Gender on Senior Secondary School Students' Academic Achievement in Further Mathematics.

The Analysis of Covariance (ANCOVA) result on effect of gender on senior secondary school students' academic achievement in Further Mathematics after being taught with teaching strategies was; $F_{(1,105)} = 2.149$ and Sig. = 0.146. Since $P > 0.05$ the null hypothesis H₀₃ is retained. There was no significant main effect of Gender on Senior Secondary School Students' Academic Achievement in Further Mathematics [$F_{(1,105)} = 2.149$, $P > 0.05$]. The pairwise comparison of students' performance in Further Mathematics using adjustment for multiple comparisons (Bonferroni) presented in (Table 4.3.3) shows that; there was no significant difference between male and female academic achievement ($P > 0.05$).

Table 4.3.1: Summary of Senior Secondary School Students' Academic Achievement in Further Mathematics ANCOVA Result of the Difference in Posttest Mean for Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	90.680 ^a	2	45.340	1.308	0.275	0.024
Intercept	3976.715	1	3976.715	114.766	0.000	0.522
Gender	74.453	1	74.453	2.149	0.146	0.020
Pretest	26.426	1	26.426	0.763	0.384	0.007
Error	3638.311	105	34.651			
Total	60907.000	108				
Corrected Total	3728.991	107				

a. R Squared = 0.024 (Adjusted R Squared = 0.006)

Source: *Fieldwork, 2024*

Table 4.3.2: Parameter Estimates of Senior Secondary School Students' Academic Achievement in Further Mathematics for Gender

Parameter	B	Std. Error	T	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	25.887	2.488	10.406	0.000	20.955	30.820	0.508
[Gender=Female]	-1.680	1.146	-1.466	0.146	-3.953	0.593	0.020
[Gender=Male]	0.000 ^a	0.000	0.000	0.000	0.000	0.000	0.000
Pretest	-0.147	0.168	-0.873	0.384	-0.480	0.186	0.007

a. This parameter is set to zero because it is redundant.

Source: *Fieldwork, 2024*

Table 4.3.3: Pairwise Comparisons of Senior Secondary School Students' Academic Achievement in Further Mathematics for Gender

(I) Gender	(J) Gender	Mean Difference (I-J)	Std. Error	Sig. ^a	95% Confidence Interval for Difference ^a	
					Lower Bound	Upper Bound
Female	Male	-1.680	1.146	0.146	-3.953	0.593
Male	Female	1.680	1.146	0.146	-0.593	3.953

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Source: *Fieldwork, 2024*

H₀₄: There will be no significant interaction effect of Inductive Teaching Strategy and Gender on Senior Secondary School Students' Academic Achievement In Further Mathematics.

The Analysis of Covariance (ANCOVA) result on interaction effect of inductive strategy and gender on senior secondary school students' academic achievement in Further Mathematics after being taught with inductive teaching strategy was; $F_{(1,59)} = 0.859$ and $\text{Sig.} = 0.358$. Since $P > 0.05$ the null hypothesis H₀₄ is retained. There was no significant interaction effect of inductive teaching strategy and gender on senior secondary school students' academic achievement in Further Mathematics [$F_{(1,59)} = 0.859$, $P > 0.05$]. The pairwise comparison of students' performance in Further Mathematics using adjustment for multiple comparisons (Bonferroni) presented in (Table 4.4.3) shows that; there was no significant difference between male and female academic achievement ($P > 0.05$).

Table 4.4.1: Summary of Senior Secondary School Students' Academic Achievement in Further Mathematics ANCOVA Result of the Difference in Posttest Mean for Inductive Teaching Strategy and Gender (a)

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	154.356 ^a	4	38.589	1.263	0.295	0.079
Intercept	1946.837	1	1946.837	63.720	0.000	0.519
Strategy	20.032	1	20.032	0.656	0.421	0.011
Gender	62.168	1	62.168	2.035	0.159	0.033
Pretest	20.261	1	20.261	0.663	0.419	0.011
Strategy * Gender	26.253	1	26.253	0.859	0.358	0.014

Error	1802.629	59	30.553
Total	41907.000	64	
Corrected Total	1956.984	63	

a. R Squared = 0.079 (Adjusted R Squared = 0.016)

Source: *Fieldwork, 2024*

Table 4.4.2: Summary of Senior Secondary School Students' Academic Achievement in Further Mathematics ANCOVA Result of the Difference in Posttest Mean for Inductive Teaching Strategy and Gender (b)

Parameter	B	Std. Error	T	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	25.116	2.992	8.395	0.000	19.129	31.103	0.544
[Strategy= Inductive]	-2.558	2.163	-1.183	0.242	-6.887	1.770	0.023
[Strategy= Conventional]	0.000 ^a	0.000	0.000	0.000	0.000	0.000	0.000
[Gender=Female]	-3.467	1.738	-1.995	0.051	-6.944	0.010	0.063
[Gender=Male]	0.000 ^a	0.000	0.000	0.000	0.000	0.000	0.000
Pretest	0.172	0.211	0.814	0.419	-0.251	0.595	0.011
[Strategy= Inductive] *							
[Gender=Female]	2.733	2.948	0.927	0.358	-3.166	8.632	0.014
[Strategy= Inductive] *							
[Gender=Male]	0.000 ^a	0.000	0.000	0.000	0.000	0.000	0.000
[Strategy= Conventional] *							
[Gender=Female]	0.000 ^a	0.000	0.000	0.000	0.000	0.000	0.000
[Strategy= Conventional] *							
[Gender=Male]	0.000 ^a	0.000	0.000	0.000	0.000	0.000	0.000

a. This parameter is set to zero because it is redundant.

Source: *Fieldwork, 2024*

Table 4.4.3: Pairwise Comparisons of Senior Secondary School Students' Academic Achievement in Further Mathematics for Inductive Teaching Strategy and Gender (a)

(I) Strategy	(J) Strategy	Mean Difference (I-J)	Std. Error	Sig. ^a	95% Confidence Interval for Difference ^a	
					Lower Bound	Upper Bound
Conventional	Inductive	-1.192	1.472	0.421	-4.138	1.754
Inductive	Conventional	1.192	1.472	0.421	-1.754	4.138

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Source: *Fieldwork, 2024*

Table 4.4.4: Pairwise Comparisons of Senior Secondary School Students' Academic Achievement in Further Mathematics for Inductive Teaching Strategy and Gender (b)

(I) Gender	(J) Gender	Mean Difference (I-J)	Std. Error	Sig. ^a	95% Confidence Interval for Difference ^a	
					Lower Bound	Upper Bound
Female	Male	-2.100	1.472	0.159	-5.046	0.846
Male	Female	2.100	1.472	0.159	-0.846	5.046

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Source: *Fieldwork, 2024*

Table 4.4.5: Pairwise Comparisons of Senior Secondary School Students' Academic Achievement in Further Mathematics for Inductive Teaching Strategy and Gender (c)

Gender	Strategy	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Female	Inductive	24.052 ^a	1.668	20.715	27.389
	Conventional	23.877 ^a	1.106	21.663	26.091
Male	Inductive	24.786 ^a	1.687	21.410	28.162
	Conventional	27.344 ^a	1.342	24.659	30.030

a. Covariates appearing in the model are evaluated at the following values: Pretest = 12.938.

Source: *Fieldwork, 2024*

H₀₅: There will be no significant interaction effect of Deductive Teaching Strategy and Gender on Senior Secondary School Students' Academic Achievement in Further Mathematics.

The Analysis of Covariance (ANCOVA) result on effect of deductive teaching strategy and gender on senior secondary school students' academic achievement in Further Mathematics after being taught with deductive teaching strategy was; $F_{(2,61)} = 0.443$ and $Sig. = 0.644$. Since $P > 0.05$ the null hypothesis H₀₅ is retained. There was no

significant interaction effect of Deductive Teaching Strategy and Gender on Senior Secondary School Students' Academic Achievement in Further Mathematics [$F_{(2,61)} = 0.443, P > 0.05$].

Table 4.5.1: Summary of Senior Secondary School Students' Academic Achievement in Further Mathematics ANCOVA Result of the Difference in Posttest Mean for Deductive Teaching Strategy and Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	311.315 ^a	4	77.829	3.295	0.016	0.178
Intercept	2108.084	1	2108.084	89.261	0.000	0.594
Strategy	258.968	1	258.968	10.965	0.002	0.152
Pretest	17.452	1	17.452	0.739	0.393	0.012
Strategy * Gender	20.936	2	10.468	0.443	0.644	0.014
Error	1440.639	61	23.617			
Total	32519.000	66				
Corrected Total	1751.955	65				

a. R Squared = 0.178 (Adjusted R Squared = 0.124)

Source: *Fieldwork, 2024*

Table 4.5.2: Parameter Estimates of Senior Secondary School Students' Academic Achievement in Further Mathematics for Deductive Teaching Strategy and Gender

Parameter	B	Std. Error	T	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	22.912	2.892	7.923	0.000	17.129	28.694	0.507
[Strategy= Deductive]	4.303	1.799	2.392	0.020	0.706	7.900	0.086
[Strategy= Conventional]	0.000 ^a	0.000	0.000	0.000	0.000	0.000	0.000
Pretest	-0.156	0.182	-0.860	0.393	-0.519	0.207	0.012
[Strategy= Deductive] * [Gender=Female]	-1.241	2.091	-0.594	0.555	-5.423	2.940	0.006

[Strategy= Deductive] * [Gender=Male]	0.000 ^a	0.000	0.000	0.000	0.000	0.000	0.000
[Strategy= Conventional] * [Gender=Female]	-1.101	1.482	-0.743	0.461	-4.064	1.863	0.009
[Strategy= Conventional] * [Gender=Male]	0.000 ^a	0.000	0.000	0.000	0.000	0.000	0.000

a. This parameter is set to zero because it is redundant.

Source: *Fieldwork, 2024*

Table 4.5.3: Pairwise Comparisons of Senior Secondary School Students' Academic Achievement in Further Mathematics for Deductive Teaching Strategy and Gender

(I) Strategy	(J) Strategy	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
Conventional	Deductive	4.232*	1.278	0.002	1.677	6.788
Deductive	Conventional	-4.232*	1.278	0.002	-6.788	-1.677

Based on estimated marginal means

a. The mean difference is significant at the 0.05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Source: *Fieldwork, 2024*

H₀₆: There will be no significant interaction effect of Inductive and Deductive Teaching Strategies on Senior Secondary School Students' Academic Achievement in Further Mathematics.

The Analysis of Covariance (ANCOVA) result on effect of inductive and deductive strategies on senior secondary school students' academic achievement in Further Mathematics after being taught with was; $F_{(2,104)}=10.128$ and $\text{Sig.}=0.000$. Since $P < 0.05$ the null hypothesis H₀₆ is rejected. There was a significant interaction effect of inductive and deductive teaching strategies on senior secondary school students' academic achievement in Further Mathematics [$F_{(2,104)}=10.128, P < 0.05$].

Table 4.6.1: Summary of Senior Secondary School Students' Academic Achievement in Further Mathematics ANCOVA Result of the Difference in Posttest Mean for Interaction Effect of Inductive and Deductive Teaching Strategies

Source	Type III	Df	Mean		Sig.	Partial Eta Squared
	Sum of Squares		Square	F		
Corrected Model	621.497 ^a	3	207.166	6.933	0.000	0.167
Intercept	3266.210	1	3266.210	109.312	0.000	0.512
Pretest	0.807	1	0.807	0.027	0.870	0.000
Strategy	605.270	2	302.635	10.128	0.000	0.163
Error	3107.494	104	29.880			
Total	60907.000	108				
Corrected Total	3728.991	107				

a. R Squared = 0.167 (Adjusted R Squared = 0.143)

Source: *Fieldwork*, 2024

Table 4.6.2: Parameter Estimates of Senior Secondary School Students' Academic Achievement in Further Mathematics for Interaction Effect of Inductive and Deductive Teaching Strategies (a)

Parameter	B	Std. Error	T	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	24.909	2.174	11.458	0.000	20.598	29.220	0.558
Pretest	0.026	0.158	0.164	0.870	-0.287	0.339	0.000
[Strategy= Inductive]	-0.757	1.443	-0.524	0.601	-3.618	2.105	0.003
[Strategy=Deductive]	-5.142	1.205	-4.269	0.000	-7.531	-2.753	0.149
[Strategy= Conventional]	0.000 ^a	0.000	0.000	0.000	0.000	0.000	0.000

a. This parameter is set to zero because it is redundant.

Source: *Fieldwork*, 2024

Table 4.6.3: Parameter Estimates of Senior Secondary School Students' Academic Achievement in Further Mathematics for Interaction Effect of Inductive and Deductive Teaching Strategies (b)

Strategy	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Inductive	24.502 ^a	1.165	22.191	26.813
Deductive	20.116 ^a	0.833	18.464	21.768
Conventional	25.258 ^a	0.852	23.568	26.949

a. Covariates appearing in the model are evaluated at the following values: Pretest = 13.472.

Source: *Fieldwork, 2024*

H₀₇: There will be no significant interaction effect of Inductive Teaching Strategy, Deductive Teaching Strategy and Gender on Senior Secondary School Students' Academic Achievement in Further Mathematics.

The Analysis of Covariance (ANCOVA) result on interaction effect of inductive, deductive teaching strategies and gender on senior secondary school students' academic achievement in Further Mathematics after being taught with was; $F_{(3,101)} = 1.525$ and $Sig. = 0.213$. Since the $P > 0.05$ the null hypothesis H₀₇ is retained. There was no significant interaction effect of Inductive Teaching Strategy, Deductive Teaching Strategy and Gender on Senior Secondary School Students' Academic Achievement in Further Mathematics [$F_{(3,101)} = 1.525, P > 0.05$].

Table 4.7.1: Summary of Senior Secondary School Students' Academic Achievement in Further Mathematics ANCOVA Result of the Difference in Posttest Mean for Inductive Teaching Strategy, Deductive Teaching Strategy and Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	756.152 ^a	6	126.025	4.282	0.001	0.203
Intercept	3276.152	1	3276.152	111.305	0.000	0.524
Pretest	0.142	1	0.142	0.005	0.945	0.000
Strategy	652.605	2	326.302	11.086	0.000	0.180
Strategy * Gender	134.656	3	44.885	1.525	0.213	0.043
Error	2972.839	101	29.434			

Total	60907.000	108
Corrected Total	3728.991	107

a. R Squared = 0.203 (Adjusted R Squared = 0.155)

Source: *Fieldwork, 2024*

Table 4.7.2: Parameter Estimates of Senior Secondary School Students' Academic Achievement in Further Mathematics for Inductive Teaching Strategy, Deductive Teaching Strategy and Gender

Parameter	B	Std. Error	T	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	27.155	2.400	11.315	0.000	22.394	31.916	0.559
Pretest	0.011	0.159	0.069	0.945	-0.304	0.326	0.000
[Strategy= Inductive]	-2.311	2.113	-1.093	0.277	-6.503	1.881	0.012
[Strategy= Deductive]	-6.728	1.787	-3.765	0.000	-10.272	-3.183	0.123
[Strategy= Conventional]	0.000 ^a	0.000	0.000	0.000	0.000	0.000	0.000
[Strategy= Inductive] * [Gender=Female]	-0.983	2.326	-0.423	0.674	-5.598	3.632	0.002
[Strategy= Inductive] * [Gender=Male]	0.000 ^a	0.000	0.000	0.000	0.000	0.000	0.000
[Strategy=Deductive] * [Gender=Female]	-0.896	1.647	-0.544	0.588	-4.163	2.372	0.003
[Strategy=Deductive] * [Gender=Male]	0.000 ^a	0.000	0.000	0.000	0.000	0.000	0.000

[Strategy= Conventional] * [Gender=Female]	-3.455	1.706	-2.026	0.045	-6.838	-0.072	0.039
[Strategy= Conventional] * [Gender=Male]	0.000 ^a	0.000	0.000	0.000	0.000	0.000	0.000

a. This parameter is set to zero because it is redundant.

Source: *Fieldwork, 2024*

Table 4.7.3: Parameter Estimates of Senior Secondary School Students' Academic Achievement in Further Mathematics for Inductive Teaching Strategy, Deductive Teaching Strategy and Gender

Gender	Strategy	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Female	Inductive	24.009 ^a	1.641	20.754	27.265
	Deductive	19.680 ^a	1.157	17.385	21.975
	Conventional	23.848 ^a	1.092	21.683	26.014
Male	Inductive	24.992 ^a	1.640	21.740	28.245
	Deductive	20.576 ^a	1.178	18.240	22.912
	Conventional	27.303 ^a	1.322	24.680	29.926

a. Covariates appearing in the model are evaluated at the following values: Pretest = 13.472.

Source: *Fieldwork, 2024*

4.3 Discussion of Findings

Findings show that there was no significant main effect of Inductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics which is not in line with previous study that investigates Critical Thinking Acquisition of Senior Secondary School Science Students in Lagos State, Nigeria: A Predictor of Academic Achievement¹. The reason being the fact that in the previous study; Inductive reasoning was used as part of predictors in Critical thinking skills to examine significant relationship and to predict achievement in Mathematics of senior secondary school science students which positively contributed significantly to the forecasting of achievement in Mathematics and also shows that there was a significant positive correlation between the science students' achievement in Mathematics. Also, the current

result is not in agreement with the previous study that examine the Understanding of Learning Styles and Teaching Strategies towards Improving the Teaching and Learning of Mathematics². The previous study result reveals the significant influence of Inductive approach among four (4) other teaching strategies have on the academic performance of Grade 9 students in Mathematics which is not congruent with the current study result because, the previous study was conducted to understand the influence of learning styles and teaching strategies.

Result shows that there was a significant main effect of Deductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics which is in line with previous study that investigates the Critical Thinking Acquisition of Senior Secondary School Science Students in Lagos State, Nigeria: A Predictor of Academic Achievement¹. Though in previous study, Deductive reasoning made the smallest significant positive contribution to the prediction of achievement in Mathematics but both the current and previous studies show similar results that there was a significant main effect of Deductive reasoning on science students' achievement in Mathematics. This also in line with previous study that examine the Understanding of Learning Styles and Teaching Strategies towards Improving the Teaching and Learning of Mathematics². Though, four (4) teaching strategies have significant influence on the academic performance of Grade 9 students in Mathematics from previous study result where Deductive approach was inclusive which implies that students enjoy and content with the deductive method of instruction.

Findings revealed that there was no significant main effect of Gender on Senior Secondary School Students' Academic Achievement in Further Mathematics; that is,

there was no significant difference between male and female academic achievement from the pairwise comparison of students' performance in Further Mathematics which is not in line with the previous study that examined the effect of Inductive and Deductive Teaching Methods on Students' Performance in Basic Science among Junior Secondary Schools Students: A Gender Study³. Although, the previous study also discovered no significant difference in the female student's mean performance between the three groups while adjusting for the pretest score but there was a significant difference in the male student's mean performance between the three groups.

Result reveals that there was no significant interaction effect of inductive teaching strategy and gender on senior secondary school students' academic achievement in Further Mathematics which is not in line with previous study that investigates the effect of Inductive and Deductive Teaching Methods on Students' Performance in Basic Science among Junior Secondary Schools Students: A Gender Study³. This is due to previous study mean achievement result that indicates high performance of both the male and female students taught Basic Science through Inductive teaching method.

Findings show that there was no significant interaction effect of Deductive Teaching Strategy and Gender on Senior Secondary School Students' Academic Achievement in Further Mathematics which is in line with previous study that investigates the effect of Inductive and Deductive Teaching Methods on Students' Performance in Basic Science among Junior Secondary Schools Students: A Gender Study³. The previous study mean achievement result also revealed the low performance of both the male and female students taught Basic Science through Deductive teaching method which makes it similar with current study result.

Result indicates that there was a significant interaction effect of Inductive and Deductive teaching strategies on senior secondary school students' academic achievement in Further Mathematics; this is in line with the previous study that examine the Understanding of Learning Styles and Teaching Strategies towards Improving the Teaching and Learning of Mathematics². Although, their subjects matter, geographical locations and educational levels are not the same but as a result of treatment, the previous study result also revealed that Inductive and Deductive approach among four (4) other teaching strategies that were found to have a significant influence on the academic performance of Grade 9 students in Mathematics is in agreement with the current study result. This current findings is not in line with previous study that investigates the effect of Inductive and Deductive Teaching Methods on Students' Performance in Basic Science among Junior Secondary Schools Students: A Gender Study³. The previous study result revealed that the experimental group two (students taught basic science through inductive teaching method) performed better than the experiment group one (students taught basic science through deductive teaching method) and the control group (student taught using combined teaching methods); that is, the students taught basic science through inductive teaching method had a high achievement, while the students taught basic science through deductive and combined methods had a lower mean achievement which is not in agreement with current study result, since the students taught basic science through combined methods (Inductive and Deductive methods) had a lower mean achievement.

Findings indicate that there was no significant interaction effect of Inductive Teaching Strategy, Deductive Teaching Strategy and Gender on Senior Secondary School

Students' Academic Achievement in Further Mathematics which is in line with previous study that investigates the effect of Inductive and Deductive Teaching Methods on Students' Performance in Basic Science among Junior Secondary Schools Students: A Gender Study³. This occurred due to previous study mean achievement result that indicates low performance of both male and female students taught Basic Science through combined methods (Inductive and Deductive methods) which is congruent with current study result.

The main result obtained from the current study opposed the previous study that examined the effect of Inductive and Deductive Teaching Methods on Students' Performance in Basic Science among Junior Secondary Schools Students: A Gender Study³. The previous findings indicated that the Inductive teaching approach is the most common and effective one. The findings imply that the Inductive teaching approach should be promoted and that school administrators should supply the facilities and tools required for a successful rollout. From the results of current study, it is concluded that the most effective and preferred teaching strategy is the Deductive Teaching Strategy (DTS). Base on the findings, it is suggested that application of Deductive teaching strategy or combined Inductive and Deductive teaching strategies should be considered to improve students' academic achievement in Further Mathematics; though the previous study was limited to the Basic Science performance of Junior Secondary School III (JSS III) students while the current study was limited to Senior Secondary School II (SSS II) Students' Academic Achievement in Further Mathematics. This could be the factors which resulted to the difference in the findings of the studies.

Endnotes

1. R. O. Okunuga, A. O. A. Awofala & U. Osarenren, *Critical Thinking Acquisition of Senior Secondary School Science Students in Lagos State, Nigeria: A Predictor of Academic Achievement*, **Journal of Curriculum and Instruction**, 13(1), 2020, 44 – 56.
2. J. M. Cardino Jr. & R. A. Ortega-Dela Cruz, *Understanding of learning styles and teaching strategies towards improving the teaching and learning of Mathematics*, **LUMAT General Issue**, 8(1), 2020, 19–43. Available online: <https://doi.org/10.31129/LUMAT.8.1.1348>
3. S. O. Adams, R. U. Onwadi & J. U. Idika, *Effect of Inductive and Deductive Teaching Methods on Students' Performance in Basic Science among Junior Secondary Schools Students: A Gender Study*, **American Journal of Education and Information Technology**, 5(1), 2021, 27-36. Available online: doi: 10.11648/j.ajeit.20210501.15

Chapter Five

Conclusion

5.1 Summary of Findings

This study investigates the Effect of Inductive and Deductive Teaching Strategies on Senior Secondary School Students' Academic Achievement in Further Mathematics in Oyo State. Forty-two (42) participants (seventeen (17) male and twenty-five (25) female students) were taught with Inductive Teaching Strategy. Forty-four (44) participants (twenty-two (22) male and twenty-two (22) female students) were taught with Deductive Teaching Strategy. Twenty-two (22) participants (eleven (11) male and eleven (11) female students) were taught with Conventional Teaching Strategy.

From the Analysis of Covariance (ANCOVA) results: There was no significant main effect of Inductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics [$F_{(1, 61)} = 0.339, P > 0.05$]. Since $P > 0.05$ the null hypothesis H_01 is retained.

There was a significant main effect of Deductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics [$F_{(1, 63)} = 11.321, P < 0.05$]. Since $P < 0.05$ the null hypothesis H_02 is rejected.

There was no significant main effect of Gender on Senior Secondary School Students' Academic Achievement in Further Mathematics [$F_{(1,105)} = 2.149, P > 0.05$]. Since $P > 0.05$ the null hypothesis H_03 is retained.

There was no significant interaction effect of inductive teaching strategy and gender on senior secondary school students' academic achievement in Further Mathematics [$F_{(1,59)} = 0.859, P > 0.05$]. Since $P > 0.05$ the null hypothesis H_04 is retained.

There was no significant interaction effect of Deductive Teaching Strategy and Gender on Senior Secondary School Students' Academic Achievement in Further Mathematics [$F_{(2,61)} = 0.443, P > 0.05$]. Since $P > 0.05$ the null hypothesis H_05 is retained.

There was a significant interaction effect of inductive and deductive teaching strategies on senior secondary school students' academic achievement in Further Mathematics [$F_{(2,104)} = 10.128, P < 0.05$]. Since $P < 0.05$ the null hypothesis H_06 is rejected.

There was no significant interaction effect of Inductive Teaching Strategy, Deductive Teaching Strategy and Gender on Senior Secondary School Students'

Academic Achievement in Further Mathematics [$F_{(3,101)} = 1.525, P > 0.05$]. Since the $P > 0.05$ the null hypothesis H_0 is retained.

5.2 Conclusion

From the results of this study, it is concluded that the most effective and preferred teaching strategy is the Deductive Teaching Strategy (DTS) since there was no significant main effect of Inductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics [$F_{(1,61)} = 0.339, P > 0.05$] but there was a significant main effect of Deductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics [$F_{(1,63)} = 11.321, P < 0.05$]

5.3 Recommendations

Base on the findings of this study, the following recommendations are made.

- i. Other teaching strategies apart from inductive teaching strategy should be considered for teaching and learning Further Mathematics.
- ii. Deductive teaching strategy should be considered applying in teaching and learning Further Mathematics.
- iii. Further Mathematics teachers should concentrate on other factors to improve Senior Secondary School Students' Academic Achievement in Further Mathematics rather than gender factor.
- iv. Students should be allowed to explore real-life problems that relate to the concepts in Further Mathematics, identify patterns and develop their own understanding of underlying principles.

- v. Apart from Deductive teaching strategy, other strategies should be employed to facilitate female students' academic achievement in Further Mathematics.
- vi. Using of combined Inductive and Deductive teaching strategies should be encouraged to enhance academic achievement in Further Mathematics.
- vii. Further Mathematics teachers are to concentrate more on female students to improve their subject performance.

5.4 Suggested Area for Further Research

Researchers should explore more on investigating effects of other teaching strategies and/or examine influence of other factors such as: gender inequalities, poor Mathematics teacher quality, low motivation, inappropriate peer groups, low retention, negative student attitudes or interest in Further Mathematics, and ineffective teaching strategies on Senior Secondary School Students' Academic Achievement in Further Mathematics.

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Dissertation

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Appendix I

Differential and Integral Calculus Achievement Test (DICAT)

Instructions:

In Section A: Please provide an appropriate answer to the following questions

In Section B: Please encircle only one answer at a time from the given answer's options

Duration:

1 hour 15 minutes

Section A

Demographic Characteristics of Participants

School Name:	_____		
Gender:	Male ()	Female ()	
Class:	_____		
Age Range:	12 – 14yrs ()	15 – 16yrs ()	17yrs + ()
Group Type:	Group A ()	Group B ()	Group C ()
Test Type:	Pre-test ()	Post-test ()	

Section B

1. Find the differential coefficient, with respect to x of the function: $y = 4x^3 + 2x^2 - 3x + 4$
- $12x^2 - 4x + 3$
 - $12x^2 + 4x - 3$
 - $12x^3 - 4x + 3$
 - $12x^3 + 4x - 3$
2. If $y = x^{-3/2}$ then $\frac{dy}{dx}$ is
- $-\frac{2}{3}x^{1/2}$
 - $-\frac{3}{2}x^{-1/2}$
 - $-\frac{2}{3}x^{-5/2}$
 - $-\frac{3}{2}x^{-5/2}$
3. If $y = x \sin x$, find $\frac{dy}{dx}$ when $x = \frac{\pi}{2}$
- $-\frac{\pi}{2}$
 - -1
 - 1
 - $\frac{\pi}{2}$
4. Find the derivative of $(2 + 3x)(1 - x)$ with respect to x .
- 6
 - -3
 - $1 - 6x$
 - $6x - 1$
5. If $y = \frac{x}{(x^2 - 1)^{1/2}}$ find $\frac{dy}{dx}$
- $\frac{2}{(x^2 - 1)^3}$
 - $\frac{-1}{(x^2 - 1)^{3/2}}$
 - $\frac{1}{(x^2 - 1)^3}$
 - $\frac{-2x^2 + 1}{(x^2 - 1)^{3/2}}$
6. The derivative of $\frac{\sin 3x}{e^{-2x}}$ with respect to x is
- $\frac{3\cos 3x + 2\sin 3x}{e^{-2x}}$
 - $\frac{3\sin 3x + 2\cos 3x}{e^{-2x}}$
 - $\frac{3\cos 3x + 2\sin 3x}{e^{-4x}}$
 - $\frac{3\cos 3x - 2\sin 3x}{e^{-2x}}$

7. Use the chain rule to find the derivative $y = \sqrt{1 - x^3}$

- A. $\frac{3x^2}{2\sqrt{1-x^3}}$
- B. $\frac{-3x^2}{2\sqrt{1-x^3}}$
- C. $\frac{2x^2}{3\sqrt{1-x^3}}$
- D. $\frac{-2x^2}{3\sqrt{1-x^3}}$

8. Find $\frac{dy}{dx}$ if $y = \cos(3x^2 - 4)$

- A. $-3x \sin(3x^2 - 4)$
- B. $-6x \sin(3x^2 - 4)$
- C. $(6x - 4) \sin(3x^2 - 4)$
- D. $-5x \sin(3x^2 - 4)$

9. If $f(x) = (2x + 1)^4$, then the $f''(x)$ of $f(x)$ at $x = 0$ is

- A. 0
- B. 48
- C. 240
- D. 80

10. Find $\frac{d^2y}{dx^2}$, given that $y = e^{x^4}$

- A. $12x^2e^{x^4} + 16x^6e^{x^4}$
- B. $4x^3e^{x^4}$
- C. $24xe^{x^4} + 48x^5e^{x^4} + 96x^5e^{x^4}$
- D. $12x^2e^{x^4} + 24x^5e^{x^4} + 16x^6e^{x^4}$

11. If $x^2 + xy + y^3 = 0$, then, in term of x and y , $\frac{dy}{dx} =$

- A. $-\frac{2x+y}{x+3y^3-1}$
- B. $-\frac{2x+y}{x+3y^2}$
- C. $-\frac{x+3y^3}{2x+y}$
- D. $\frac{-2x}{x+3y^3}$

12. If $xy^2 + 2xy = 8$, that at the point $(1, 2)$, $\frac{dy}{dx}$ is

- A. $-\frac{5}{2}$
- B. $-\frac{4}{3}$
- C. -1

- D. $-\frac{1}{2}$
13. If $x = t^3 - t$, and $y = \sqrt{3t + 1}$, then $\frac{dy}{dx}$ at $t = 1$ is...
- A. $\frac{1}{8}$
B. $\frac{3}{8}$
C. $\frac{3}{4}$
D. 8
14. If $y = \cos t$ and $x = \sin t$. Find $\frac{dy}{dx}$
- A. $\frac{\cos t}{\sin t}$
B. $\tan t$
C. $-\operatorname{cosec} t$
D. $-\tan t$
15. Differentiate the function $y = e^{\frac{3}{2}x^4}$ with respect to x
- A. $6x^2 e^{\frac{3}{2}x^4}$
B. $6x^3 e^{\frac{3}{2}x^4}$
C. $12x^2 e^{\frac{3}{2}x^4}$
D. $24x^3 e^{\frac{3}{2}x^4}$
16. Find the derivate of the function $y = \log \sqrt{x}$ with respect to x
- A. $\frac{1}{2\sqrt{x}}$
B. $\frac{1}{x}$
C. $\frac{2}{3x}$
D. $\frac{1}{2x}$
17. The gradient of the curve $y = 3x^2 + 11x + 7$ at the point P (x, y) is -1 . Find the co-ordinates of P.
- A. $(-2, +3)$
B. $(-2, -3)$
C. $(-1, -\frac{5}{2})$
D. $(-3, -2)$
18. The slope of the tangent to the curve $y = 3x^2 - 2x + 5$ at the point (1, 6) is
- A. 6
B. 5
C. 4
D. 1

19. Find the equation of the tangent to the curve $y = x^2 - 4x + 3$ at the point $(3, 1)$
- $y = 2x + 5$
 - $y = 2x - 5$
 - $y + 2x + 5 = 0$
 - $y - 2x - 5 = 0$
20. After t seconds a particle has travelled a distance s meters, where $s = -17t + 15t^2 - t^3$ find the acceleration after 6 seconds.
- -6 m/s^2
 - 45 m/s^2
 - 18 m/s^2
 - -30 m/s^2
21. For what value of x does $6\sin(2x - 25)^\circ$ attain its maximum value in the range $0^\circ \leq x \leq 180^\circ$?
- $12\frac{1}{2}$
 - $32\frac{1}{2}$
 - $57\frac{1}{2}$
 - $14\frac{1}{2}$
22. A swimming pool is treated periodically to control harmful bacterial growth. The concentration of bacterial *per* cm^3 after t days is given by $C(t) = 30t^2 - 240t + 500$. In how many days after a treatment will the concentration be minimal?
- 10
 - 8
 - 6
 - 4
23. Given that $f(x, y, z) = 2x^2y + x2z + y^2z^2$. Find f_{zy}
- $2xy$
 - $4xz$
 - $2y^2$
 - $4yz$
24. If $F(x, y) = x^4 + 5x^3y^2 + 3y$, find $\frac{dF}{dy}$
- $4x^3 + 15x^2y^2$
 - $10x^3y + 3$
 - $4x^3 + 15x^2y^2 + 3$
 - $4x^3 + 10x^3y + 3x$
25. If $f(x) = (x - 1)^2 \sin x$, then $f'(0) =$
- 0
 - 5

- C. -1
D. 1

26. Integrate $\frac{1-x}{x^3}$ with respect to x

- A. $\frac{x-x^2}{x^4} + k$
B. $\frac{4}{x^4} - \frac{3}{x^3} + k$
C. $\frac{1}{x} - \frac{1}{2x^2} + k$
D. $\frac{1}{3x^2} - \frac{1}{2x} + k$

27. Integrate $\frac{1}{x} + \cos x$ with respect to x

- A. $-\frac{1}{x^2} + \sin x + k$
B. $\ln x + \sin x + k$
C. $\ln x - \sin x + k$
D. $-\frac{1}{x^2} - \sin x + k$

28. If $\frac{dy}{dx} = x^3 - 2x^2 - 3x + 1$, find y

- A. $\frac{x^4}{4} - \frac{2x^3}{3} - \frac{3x^2}{2} + x + c$
B. $\frac{x^4}{4} - \frac{2x^3}{3} - \frac{2x^2}{2} + \frac{x}{2} + c$
C. $4x^4 - \frac{3x^3}{2} - \frac{3x^2}{2} - x + c$
D. $4x^4 - \frac{2x^3}{3} - \frac{3x^2}{2} - x + c$

29. Simplify $\int \frac{x^2+3x+2}{x+1} dx$

- A. $\frac{x^3}{3} + \frac{3x^2}{2} + 2x + c$
B. $\frac{x^3}{3} + 2x + c$
C. $\frac{2x}{2} + 3 + c$
D. $\frac{x^2}{2} + 2x + c$

30. Integrate $2x(2x^2 - 3x + 4)$ with respect to x

- A. $12x^2 - 12x + 8 + c$
B. $x^4 - x^3 + 8x^2 + c$
C. $x^4 - x^3 + x^2 + c$
D. $x^4 - 2x^3 + 4x^2 + c$

31. A function whose derivative is $\frac{1}{x^2}$ has its integral as

- A. $-\frac{1}{2x} + k$

- B. $\frac{1}{x} + k$
C. $-\frac{1}{x} + k$
D. $\frac{2}{x} + k$
32. Integrate $\tan^2 x$
A. $\tan x - x + c$
B. $\tan^2 x - 2x + c$
C. $x - \tan^2 x + c$
D. $x - \tan x + c$
33. If $\frac{dy}{dx} = x + \cos x$, find y .
A. $\frac{x^2}{2} - \sin x + c$
B. $x^2 - \sin x + c$
C. $\frac{x^2}{2} + \sin x + c$
D. $x^2 + \sin x + c$
34. Integrate $x^2(x + 2)$ with respect to x
A. $x^4 + x^3 + 4 + c$
B. $\frac{x^3}{4} + \frac{x^4}{3} + 7 + c$
C. $x^3 + x^2 + c$
D. $\frac{x^4}{4} + \frac{2x^3}{3} + c$
35. Evaluate $\int (\cos 3x + \sin 4x) dx$
A. $\frac{1}{3} \sin 3x + \frac{1}{4} \cos 4x + k$
B. $\frac{1}{3} \sin 3x - \frac{1}{4} \cos 4x + k$
C. $3 \sin 3x + 4 \cos 4x + k$
D. $\sin^3 x + 4 \cos^4 x + k$
36. Evaluate $\int_2^5 (3x^2 - 4x + 2) dx$
A. -81
B. 81
C. -25
D. 25
37. Evaluate $\int_2^\pi (\sec^2 x - \tan^2 x) dx$
A. $\frac{\pi}{2}$
B. $\pi - 2$
C. $\frac{\pi}{3}$
D. $\pi - 3$

38. Evaluate $\int_{-2}^1 (x - 1)^2 dx$
- A. $-3\frac{1}{3}$
 - B. 7
 - C. 9
 - D. 11
39. If $y = x(x^4 + x^2 + 1)$, evaluate $\int_{-1}^1 y dx$
- A. $\frac{11}{12}$
 - B. $\frac{11}{16}$
 - C. $\frac{5}{6}$
 - D. 0
40. Evaluate $\int \frac{x}{\sqrt{3x^2 + 5}} dx$
- A. $\frac{1}{12}(3x^2 + 5)^{1/2} + c$
 - B. $\frac{1}{3}(3x^2 + 5)^{1/2} + c$
 - C. $\frac{3}{2}(3x^2 + 5)^{3/2} + c$
 - D. $\frac{1}{9}(3x^2 + 5)^{3/2} + c$
41. Evaluate the integral $\int_{\pi/12}^{\pi/4} 2\cos 2x dx$
- A. $-\frac{1}{2}$
 - B. -1
 - C. $\frac{1}{2}$
 - D. 1
42. Evaluate $\int \frac{e^x}{(1+e^x)^2} dx$
- A. $(1 + e^x)^2 + c$
 - B. $\frac{1}{1 + e^x} + c$
 - C. $\frac{1}{1 - e^x} + c$
 - D. $\frac{2x}{1 + e^{2x}} + c$
43. Find the value of $\int \cos^5 x \sin x dx$
- A. $\frac{1}{4}\cos^4 x + c$
 - B. $\frac{1}{5}\cos^6 x + c$
 - C. $-\frac{1}{5}\cos^6 x + c$

- D. $-\frac{1}{6}\cos^6x + c$
44. Evaluate $\int_2^3 \frac{3}{(x-1)(x+2)} dx$
- $\ln\left(\frac{8}{5}\right)$
 - $\ln 2$
 - $\ln\left(\frac{5}{2}\right)$
 - $\ln\left(\frac{2}{5}\right)$
45. Given that $\frac{x}{x^2-3x+2} = \frac{2}{x-2} - \frac{1}{x-1}$ find $\int \frac{x}{x^2-3x+2} dx$
- $\log \frac{x-2}{x-1} + k$
 - $\log(x-2)^2(x-1) + k$
 - $\log(x-2)(x-1) + k$
 - $\log \frac{(x-2)^2}{(x-1)} + k$
46. Evaluate $\int \frac{dx}{x(x+2)}$
- $\frac{1}{2}\log_e\left(\frac{x+2}{x}\right) + c$
 - $2\log_e\left(\frac{x}{x+12}\right) + c$
 - $\frac{1}{2}\log_e\left(\frac{x}{x+2}\right) + c$
 - $2\log_e\left(\frac{x+2}{x}\right) + c$
47. Two variables x and y are such that $\frac{dy}{dx} = 4x - 3$ and $y = 5$ when $x = 2$. Find y in terms of x
- $2x^2 - 3x + 5$
 - $2x^2 - 3x + 3$
 - $2x^2 - 3x$
 - 4
48. Ice forms on a refrigerator ice – box at the rate of $(4 - 0.6t)$ g per minute after t minutes. If initially there are 2g of ice in the box, find the mass of ice formed in 5 minutes.
- 19.5
 - 17.0
 - 14.5
 - 12.5
49. A student blows a balloon and its volume increases at a rate of $\pi(20 - t^2)$ cm^3/s after t seconds. If the initial volume is 0 cm^3 , find the Volume of the balloon after 2 seconds

- A. 37.00π
- B. 37.33π
- C. 40.00π
- D. 42.67π

50. The area of the finite region bounded by the curve $y = kx^2 + 4$, x axis, lines $x = 2$ and $x = 4$ is 36 units. Find the value of the constant k .

- A. $\frac{8}{3}$
- B. $\frac{9}{4}$
- C. $\frac{3}{2}$
- D. $\frac{4}{3}$

Answer:

- | | | | | |
|--------------|--------------|--------------|--------------|--------------|
| 1. B | 2. D | 3. C | 4. C | 5. B |
| 6. A | 7. B | 8. B | 9. B | 10. A |
| 11. B | 12. B | 13. B | 14. D | 15. B |
| 16. D | 17. B | 18. C | 19. B | 20. A |
| 21. C | 22. D | 23. D | 24. B | 25. D |
| 26. C | 27. B | 28. A | 29. D | 30. D |
| 31. C | 32. A | 33. C | 34. D | 35. B |
| 36. B | 37. B | 38. C | 39. D | 40. C |
| 41. B | 42. B | 43. D | 44. A | 45. D |
| 46. C | 47. B | 48. C | 49. B | 50. C |

Appendix II

Teaching and Learning Instructional Guides (TLIG)

Instructional Guide for Experimental Group A

Lesson Note I

School:	As Applicable
Subject:	Further Mathematics
Class:	SSII
Topic:	Calculus
Sub-Topics:	Differential and Integral Calculus
Number in Class:	As Applicable
Average age:	16 years

Gender: Mixed
Duration: 80 Minutes
Date: As Applicable

Instructional Objectives:

Differential Calculus

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

- i. Differentiate various given functions such as; algebraic, implicit, parametric form, trigonometric, exponential and logarithmic functions using the rule that if $y = Ax^n$, then $\frac{dy}{dx} = Anx^{n-1}$
- ii. Use the chain rule, product rule and quotient rule to differentiate complex algebraic expressions.
- iii. Apply differential calculus to determine rates of change including gradients (slope and equation of tangent and normal), turning points on a curve (maximum and minimum value problems), rectilinear motion (velocity and acceleration)

Integral Calculus

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

- i. Use the inverse of differentiation to find the general solutions of simple differential equations by using the general rule when integrating simple terms in x that if $\frac{dy}{dx} = x^n$, then $y = \frac{x^{n+1}}{n+1} + c$; where c is an arbitrary constant.
- ii. Evaluate definite integrals in the form $\int_b^a f(x)dx$ and indefinite integrals in the form $\int f(x)dx$

- iii. Apply the techniques of integration (by substitution and by partial fraction) to integrate complex given functions such as; algebraic, trigonometric and exponential functions.
- iv. Find the area under the curve by integrating between limits and volume of solids of revolution.

Instructional Materials:

Differential Calculus

Chart showing definition of Derivation with notations

Integral Calculus

Chart showing Integral General Rule

Previous Knowledge:

Differential Calculus

Students have been taught algebraic expressions, indices, slope and trigonometry (ratio and identities).

Integral Calculus

Students were familiar with polynomial, partial fraction, logarithmic rule and trigonometry (ratio and identities).

Presentation:

Content Development	Time (Mins)	Teacher's Activities	Students' Activities
Step 1 Introduction	10	Differential Calculus Teacher probes into students' previous knowledge through practical examples for questioning on algebraic expressions, indices, slope and trigonometry (ratio and identities). He then introduces the topic by giving the definition of derivative with the aid of instructional materials as	Students answered the questions asked by the teacher and showed enthusiasm towards the topics through their responses.

follows:

If $y = f(x)$, the derivative of y or $f(x)$ with respect to x is defined as: $\frac{dy}{dx} =$

$$\lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} = \lim_{\Delta x \rightarrow 0} \frac{f(x+\Delta x) - f(x)}{\Delta x}$$

where $h = \Delta x$. The derivative is also denoted by y' , df/dx or $f'(x)$. The process of taking a derivative is called differentiation.

The second, third and higher derivatives are defined as follows:

Second derivative

$$\frac{d}{dx} \left(\frac{dy}{dx} \right) = \frac{d^2y}{dx^2} = f''(x) = y''$$

Third derivative

$$\frac{d}{dx} \left(\frac{d^2y}{dx^2} \right) = \frac{d^3y}{dx^3} = f'''(x) = y'''$$

n th derivative

$$\frac{d}{dx} \left(\frac{d^{n-1}y}{dx^{n-1}} \right) = \frac{d^ny}{dx^n} = f^{(n)}(x) = y^{(n)}$$

Integral Calculus

Teacher probes into students' previous knowledge through practical examples for questioning on polynomial, partial fraction, logarithmic rule and trigonometry (ratio and identities). He then introduces the topic through the use of the inverse of differentiation to find the general solutions of simple differential equations by using the general rule when integrating simple terms in x that:

if $\frac{dy}{dx} = x^n$, then $y = \frac{x^{n+1}}{n+1} + c$; where c is an arbitrary constant. The result of integration, called integral can be indefinite or definite.

It is indefinite when the limit of integration is not given. The integral is

		<p>presented as variables and accompanied by an arbitrary constant c or k. e.g $\int x^2 = \frac{x^3}{3} + c$ or $\frac{x^3}{3} + k$.</p> <p>Also note! $\int af(x)dx = a \int f(x)dx$; $\int \frac{1}{af(x)} dx = \frac{1}{a} \int \log_e f(x) + c$</p> <p>An integral is <u>definite</u> when the limit of integration is given. Hence the values given are substituted in turn in the integral to have a result other than variables.</p> <p>e.g $\int_b^a x^2$ means integral of x^2 between a and $x = b$;</p> <p>$\int_b^a x^2 = \left \frac{x^3}{3} \right _b^a = \left \frac{a^3}{3} - \frac{b^3}{3} \right$ where $a =$ upper limit, $b =$ lower limit.</p> <p>Makes known to the students the teaching technique and its demand on them</p>	
Step 2 Analyses of Given Examples	10	Different functions and application of derivative and Integral topics examples were pointed out by the teacher for students to analyze and discover their various types and differences	Students discovered different types of functions and application of derivative and integral topics examples through their analyses.
Step 3 Synthesizes of Analyzed Examples	10	<p>Students were asked to participate in grouping of similar applications of derivative and integral topics, types of functions and their equation structured pattern as thus:</p> <ul style="list-style-type: none"> • If $y = u^v$; i.e the equation is in power form. • If $y = \sqrt{u}$; i.e the equation is in root form. • If $y = (uv)$; i.e the equation is in product form. • If $y = \frac{u}{v}$; i.e the equation is in quotient form. 	Students participate by figuring out relative applications of derivative and integral examples and the structured pattern of similar types of functions.

<p>Step 4 Identification of Differential Coefficients and Basic Integrals of the Synthesized Functions</p>	10	<p>Teacher writes out differential coefficients and basic integrals of given functions to be identified by students in tabular form as thus:</p> <table border="1" data-bbox="618 342 1156 701"> <thead> <tr> <th><i>Functions</i></th> <th><i>Differentiation</i></th> <th><i>Integration</i></th> </tr> </thead> <tbody> <tr> <td>$y = f(x)$</td> <td>If $\frac{dy}{dx} = f(x)$</td> <td>If $y = \int f(x)dx$</td> </tr> <tr> <td>x^n</td> <td>$n x^{n-1}$</td> <td>$\frac{x^{n+1}}{n+1} + c$</td> </tr> <tr> <td>e^x</td> <td>e^x</td> <td>$e^x + c$</td> </tr> <tr> <td>k</td> <td>0</td> <td>$kx + c$</td> </tr> <tr> <td>$\frac{1}{x}$</td> <td>$-\frac{1}{x^2}$</td> <td>$\ln x + c$</td> </tr> <tr> <td>$\sin x$</td> <td>$\cos x$</td> <td>$-\cos x + c$</td> </tr> <tr> <td>$\cos x$</td> <td>$-\sin x$</td> <td>$\sin x + c$</td> </tr> </tbody> </table>	<i>Functions</i>	<i>Differentiation</i>	<i>Integration</i>	$y = f(x)$	If $\frac{dy}{dx} = f(x)$	If $y = \int f(x)dx$	x^n	$n x^{n-1}$	$\frac{x^{n+1}}{n+1} + c$	e^x	e^x	$e^x + c$	k	0	$kx + c$	$\frac{1}{x}$	$-\frac{1}{x^2}$	$\ln x + c$	$\sin x$	$\cos x$	$-\cos x + c$	$\cos x$	$-\sin x$	$\sin x + c$	<p>Students identified various differential coefficients and basic integrals of the synthesized functions.</p>
<i>Functions</i>	<i>Differentiation</i>	<i>Integration</i>																									
$y = f(x)$	If $\frac{dy}{dx} = f(x)$	If $y = \int f(x)dx$																									
x^n	$n x^{n-1}$	$\frac{x^{n+1}}{n+1} + c$																									
e^x	e^x	$e^x + c$																									
k	0	$kx + c$																									
$\frac{1}{x}$	$-\frac{1}{x^2}$	$\ln x + c$																									
$\sin x$	$\cos x$	$-\cos x + c$																									
$\cos x$	$-\sin x$	$\sin x + c$																									
<p>Step 5 Application of General Rules</p>	25	<p>Teacher instructs students to merge the following general rules to each similar equation structured pattern and application of derivatives and integrals:</p> <p style="text-align: center;">Differential Calculus</p> <p><u>Derivable Functions</u> <i>Method of differentiation using the established relationship between quantities i.e techniques such as the following general rules of differentiation:</i></p> $\frac{d}{dx}(uv) = u \frac{dv}{dx} + v \frac{du}{dx} \text{ (Product rule)}$ <p style="text-align: center;"><i>where $y = uv$</i></p> $\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{v \frac{du}{dx} - u \frac{dv}{dx}}{v^2} \text{ (Quotient rule)}$ <p style="text-align: center;"><i>where $y = \frac{u}{v}$</i></p> $\frac{d}{dx}\left(\frac{uv}{w}\right) = y \left\{ \frac{1}{u} \cdot \frac{du}{dx} + \frac{1}{v} \cdot \frac{dv}{dx} - \frac{1}{w} \cdot \frac{dw}{dx} \right\}$ <p style="text-align: center;"><i>(Log. function) where $y = \frac{uv}{w}$</i></p> <p><i>Note! The (-) and (+) sign in the formulae were from the function $\left(\frac{uv}{w}\right)$ arrangement.</i></p> $\frac{d}{dx}(u^n) = nu^{n-1} \frac{du}{dx}$ <p style="text-align: center;"><i>(implicit function) when $f(x, y) = 0$</i></p> $\frac{dy}{dx} = \frac{dy}{du} \cdot \frac{du}{dx} \text{ (Chain rule)}$	<p>Students merged each rule with their respective equation structured pattern and application of derivatives and integrals for solving given questions.</p>																								

Where $y = (a + x)^n$

$$\frac{dy}{dx} = \frac{dy}{du} \div \frac{dx}{du} = \frac{dy}{du} \times \frac{du}{dx}$$

(parametric form of function)

where $y = f(u)$ and $x = g(u)$

Note: $\frac{du}{dx} = \frac{1}{dx/du}$

Application of the Derivative

Gradient = $m = \frac{dy}{dx}$; so at the point

(x_1, y_1) :

The equation of the tangent

$$y - y_1 = m(x - x_1)$$

The equation of the normal

$$y - y_1 = -\frac{1}{m}(x - x_1)$$

(Equations of Tangent and Normal)

At the Minimum or Maximum Point $\frac{dy}{dx} = 0$

(Turning Points)

If V is velocity, then $V = \frac{dx}{dt}$; where x is displacement and t is time. Therefore:

$A = \frac{dv}{dt} = \frac{d}{dt}(V) = \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d^2x}{dt^2}$ where A is acceleration.

(Rectilinear Motion)

Integral Calculus

These are methods of integration functions that do not conform to the general rule. Examples include powers of polynomials, roots and product of functions. The basic techniques are:

1. Partial fraction
2. Substitution

Integration by partial fraction:

This is used when a fraction is not in its simplest form. Examples include

i. Occurrence of a polynomial of the same or higher degree in the numerator e.g

$$\frac{ax + b}{ax - b} \quad \text{or} \quad \frac{ax^2 + bx + c}{ax - b}$$

	<p>This is simplified by factorizing the numerator in terms of the denominator if factorable or dividing the numerator by the denominator if not. Thus $\frac{P}{D} = Q + \frac{R}{D}$ where, P, D, Q and R are polynomial, divisor, quotient and remainder respectively.</p> <p>ii. Occurrence of linear factors or factorable expressions in the denominator: This is simplified as in partial fraction by separating the factors using fractions combined by addition whose numerators are represented by letters and determined</p> <p>e.g $\frac{P}{(ax + b)(ax + d)} = \frac{A}{(ax + b)} + \frac{C}{(ax + d)}$</p> <p>Note: from partial fraction that the introduced letters can be simply found using: $\frac{N_f}{D_o}$ as $D_s = 0$; where N_f = Numerator of the function given; D_o = Denominator of others apart from the one to be found, D_s = Denominator of the unknown variable to be found or self-denominator. Hence $A = \frac{P}{D_c}$ as $D_A = 0$; $C = \frac{P}{D_A}$ as $D_c = 0$.</p> <p><u>Integration by Substitution:</u></p> <p>This is a method of integrating a function by replacing a part with another variable. This will however affects the derivative of integration which shows the direction in which the integration is performed. Hence, it must be expressed in terms of the newly introduced variable. This is usually by differentiation. Thus, integration by substitution involves both differentiation and integration. Substitution is commonly used in:</p> <p>i. Composite or function of function ii. Combination of functions with fractional power iii. Combination of powered functions.</p>	
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Composite Function (Function of function) :- as in differentiation, this can deal with functions that do not conform to the general rule e.g the rule holds for x^n , $\sin x$ etc, and not for $(x - 1)^n$ or $\sin nx$.

Then, $\int (x - 1)^n dx$ will be written as

$\int U^n dx$ where $U = x - 1$ as U can only be integrated with respect to u , dx has to be written in form of du and this is done by differentiation from the other side. i.e $U = x - 1$, $\frac{du}{dx} = 1 - 0 = 1$ or $du = 1 dx = dx$. This is an example of where du and dx are the same

$$\therefore \int (x - 1)^n dx = \int U^n dx =$$

$$\int U^n du = \frac{U^{n+1}}{n+1} +$$

C Also $\int \sin Nx dx =$

$\int \sin U dx$ where $U = Nx$ and $du =$

$N dx$ or $\frac{dU}{N} = dx \quad \therefore$

$\int \sin Nx dx = \int \sin U dx =$

$$\int \sin U \cdot \frac{dU}{N} = \frac{1}{N} \int (\sin U du) =$$

$$\frac{1}{N} [-\cos U] = \frac{1}{N} [-\cos Nx] + C$$

Combination of functions with fractional powers:- This deals with product or division of variables with one having a fraction power or root sign. Substitution is generally done for the complex part which is usually the expression or factor with the fractional power or root sign.

e.g $\int x \sqrt{1+x} dx =$

$$\int x (1+x)^{1/2} dx =$$

$$\int x (u)^{1/2} dx$$

Where $u = 1 + x$ and $du = (0 + 1) dx$,

$du = dx$. Also $x = u - 1 \quad \therefore \int x (1 +$

$x)^{1/2} dx = \int x (u)^{1/2} dx = \int (u -$

$1)u^{1/2} du = \int (u^{3/2} - u^{1/2}) du$

$$= \frac{u^{3/2+1}}{3/2+1} -$$

$$\frac{u^{1/2+1}}{1/2+1} = \frac{u^{5/2}}{5/2} - \frac{u^{3/2}}{3/2} = \frac{2}{5} U^{5/2} -$$

$$\frac{2}{3} U^{3/2} = \frac{2}{5} (1+x)^{5/2} - \frac{2}{3} (1+x)^{3/2}$$

$$\text{Also in } \int \frac{x}{(1+x^2)^{3/2}} dx$$

$$\text{where } U = 1 + x^2$$

(i.e. item raised to fractional power)

$$\therefore du = (0 + 2x) dx, \quad du = 2x dx, \quad \frac{du}{2x} = dx$$

$$\therefore \int \frac{x}{(1+x^2)^{3/2}} dx = \int \frac{x}{U^{3/2}} \cdot \frac{du}{2x} =$$

$$\int \frac{1}{2U^{3/2}} du = \frac{1}{2} \int U^{-3/2} du =$$

$$\frac{1}{2} \left| \frac{U^{-3/2+1}}{-3/2+1} \right| = \frac{1}{2} \left(\frac{U^{-1/2}}{-1/2} \right) =$$

$$\frac{1}{2} \cdot \frac{-2}{1} (U^{-1/2}) = -U^{-1/2} \text{ i.e. } -(1+x^2)^{-1/2}$$

Combination of powered numbers: - This deals with product or division of variables with integers or whole numbers as the power. Substitution is done for the term with even power or highest power where all are even or odd. e.g

$$(a) \int (x+1)(2-x)^4 dx,$$

$$\text{where } u = 2 - x$$

(the term with even power)

$$du = (0 - 1) dx, \quad du = -dx \text{ or } dx = -du. \text{ Also, from } u = 2 - x, \quad x = 2 - u$$

$$\int (x+1)(2-x)^4 dx = \int (2-u+1)u^4 \cdot (-du) = -\int (3-u)u^4 du = -$$

$$\int 3u^4 - u^5 = -\left(\frac{3u^5}{5} - \frac{u^6}{6}\right) = -\frac{3u^5}{5} + \frac{u^6}{6} = \frac{u^6}{6} - \frac{3u^5}{5} = \frac{(2-x)^6}{6} - \frac{3(2-x)^5}{5}$$

$$(b) \int \frac{x^2}{(1+x^3)^2} dx$$

(both powers are even,

thus the complex part is taken)

$$u = 1 + x^3, \quad du = (0 + 3x^2) dx, \quad du = 3x^2 dx,$$

$$\frac{du}{3x^2} = dx$$

$$\therefore \int \frac{x^2}{(1+x^3)^2} dx =$$

$$\int \frac{x^2}{u^2} \cdot \frac{du}{3x^2} = \int \frac{1}{3u^2} du = \frac{1}{3} \int \frac{1}{u^2} du =$$

$$\frac{1}{3} \int (u^{-2}) du = \frac{1}{3} \left(\frac{u^{-2+1}}{-2+1} \right) = \frac{1}{3} \left(\frac{u^{-1}}{-1} \right) =$$

$$-\frac{u^{-1}}{3} = -\frac{(1+x^3)^{-1}}{3}$$

$$(c) \int (x-3)(x^2-6x+5)^3 dx$$

		<p>(both powers are odd, thus the higher power is taken) i.e $u = x^2 - 6x + 5$, $du = (2x - 6)$ dx , $dx = \frac{du}{2x-6} = \frac{du}{2(x-3)}$ $\therefore \int (x - 3)(x^2 - 6x + 5)^3 dx = \int (x - 3) \cdot u^3 \cdot \frac{du}{2(x-3)} = \frac{1}{2} \int u^3 du = \frac{1}{2} \left(\frac{u^4}{4}\right) = \frac{1}{8} u^4 = \frac{1}{8} (x^2 - 6x + 5)^4$</p> <p><u>Application of Integration</u> <u>Indefinite Integral</u> If $\frac{dA}{dx} = f(x)$, then $A = \int f(x)dx$; where A is the Area under a curve.</p> <p><u>Definite Integral</u> The area under a curve $y = f(x)$ between values of x from $x = b$ to $x = a$ is given by $\int_b^a ydx$.</p>	
Step 6 Evaluation	15	<p>Teacher evaluates the students by giving them class-works on differential and integral calculus. He marks and does corrections with them.</p> <p><u>Differential Calculus</u></p> <ol style="list-style-type: none"> 1. If $y = x^{-3/2}$ then $\frac{dy}{dx}$ is 2. If $y = x \sin x$, find $\frac{dy}{dx}$ when $x = \frac{\pi}{2}$ 3. Find the derivate of $(2 + 3x)(1 - x)$ with respect to x. 4. If $y = \frac{x}{(x^2 - 1)^{1/2}}$ find $\frac{dy}{dx}$ 5. Use the chain rule to find the derivative $y = \sqrt{1 - x^3}$ 6. If $f(x) = (2x + 1)^4$, then the $f''(x)$ of $f(x)$ at $x = 0$ is 7. Find $\frac{d^2y}{dx^2}$, given that $y = e^{x^4}$ 8. If $x^2 + xy + y^3 = 0$, then, in term of x and y, $\frac{dy}{dx} =$ 9. If $x = t^3 - t$, and $y = \sqrt{3t + 1}$, then $\frac{dy}{dx}$ at $t = 1$ is... 10. Find the derivate of the function $y = \log \sqrt{x}$ with respect to x 	Students applied the general rules to answer the given class-works and did their corrections after marking.

	<p>11. The gradient of the curve $y = 3x^2 + 11x + 7$ at the point P (x, y) is -1. Find the co-ordinates of P.</p> <p>12. After t seconds a particle has travelled a distance s meters, where $s = -17t + 15t^2 - t^3$ find the acceleration after 6 seconds.</p> <p style="text-align: center;"><u>Integral Calculus</u></p> <p>1. Simplify $\int \frac{x^2+3x+2}{x+1} dx$</p> <p>2. Evaluate $\int (\cos 3x + \sin 4x) dx$</p> <p>3. Evaluate $\int_2^5 (3x^2 - 4x + 2) dx$</p> <p>4. Evaluate $\int_2^\pi (\sec^2 x - \tan^2 x) dx$</p> <p>5. Evaluate $\int_{-2}^1 (x - 1)^2 dx$</p> <p>6. If $y = x(x^4 + x^2 + 1)$, evaluate $\int_{-1}^1 y dx$</p> <p>7. Evaluate $\int \frac{x}{\sqrt{3x^2 + 5}} dx$</p> <p>8. Evaluate the integral $\int_{\pi/12}^{\pi/4} 2\cos 2x dx$</p> <p>9. Evaluate $\int \frac{e^x}{(1+e^x)^2} dx$</p> <p>10. Evaluate $\int_2^3 \frac{3}{(x-1)(x+2)} dx$</p> <p>11. Ice forms on a refrigerator ice – box at the rate of $(4 - 0.6t)g$ per minute after t minutes. If initially there are 2g of ice in the box, find the mass of ice formed in 5 minutes.</p> <p>12. A student blows a balloon and its volume increases at a rate of $\pi(20 - t^2) cm^3/s$ after t seconds. If the initial volume is $0 cm^3$, find the Volume of the balloon after 2 seconds</p>	
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Appendix III

Teaching and Learning Instructional Guides (TLIG)

Instructional Guide for Experimental Group B

Lesson Note II

School:	As Applicable
Subject:	Further Mathematics
Class:	SSII
Topic:	Calculus
Sub-Topics:	Differential and Integral Calculus

Number in Class: As Applicable

Average age: 16 years

Gender: Mixed

Duration: 80 Minutes

Date: As Applicable

Instructional Objectives:

Differential Calculus

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

- i. Differentiate various given functions such as; algebraic, implicit, parametric form, trigonometric, exponential and logarithmic functions using the rule that if $y = Ax^n$, then $\frac{dy}{dx} = Anx^{n-1}$
- ii. Use the chain rule, product rule and quotient rule to differentiate complex algebraic expressions.
- iii. Apply differential calculus to determine rates of change including gradients (slope and equation of tangent and normal), turning points on a curve (maximum and minimum value problems), rectilinear motion (velocity and acceleration)

Integral Calculus

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

- i. Use the inverse of differentiation to find the general solutions of simple differential equations by using the general rule when integrating simple terms in x that if $\frac{dy}{dx} = x^n$, then $y = \frac{x^{n+1}}{n+1} + c$; where c is an arbitrary constant.
- ii. Evaluate definite integrals in the form $\int_b^a f(x)dx$ and indefinite integrals in the form $\int f(x)dx$

- iii. Apply the techniques of integration (by substitution and by partial fraction) to integrate complex given functions such as; algebraic, trigonometric and exponential functions.
- iv. Find the area under the curve by integrating between limits and volume of solids of revolution.

Instructional Materials:

Differential Calculus

Chart showing definition of Derivation with Denotations

Integral Calculus

Chart showing Integral General Rule

Previous Knowledge:

Differential Calculus

Students have been taught algebraic expressions, indices, slope and trigonometry (ratio and identities).

Integral Calculus

Students were familiar with polynomial, partial fraction, logarithmic rule and trigonometry (ratio and identities).

Presentation:

Content Development	Time (Mins)	Teacher's Activities	Students' Activities
Step 1 Introduction	10	Differential Calculus Teacher probes into students' previous knowledge through practical examples for questioning on algebraic expressions, indices, slope and trigonometry (ratio and identities). He then introduces the topic by giving the definition of derivative with the aid of instructional materials as	Students answered the questions asked by the teacher and showed enthusiasm towards the topics through their responses.

follows:

If $y = f(x)$, the derivative of y or $f(x)$ with respect to x is defined as: $\frac{dy}{dx} =$

$$\lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} = \lim_{\Delta x \rightarrow 0} \frac{f(x+\Delta x) - f(x)}{\Delta x}$$

where $h = \Delta x$. The derivative is also denoted by y' , df/dx or $f'(x)$. The process of taking a derivative is called differentiation.

The second, third and higher derivatives are defined as follows:

Second derivative

$$\frac{d}{dx} \left(\frac{dy}{dx} \right) = \frac{d^2y}{dx^2} = f''(x) = y''$$

Third derivative

$$\frac{d}{dx} \left(\frac{d^2y}{dx^2} \right) = \frac{d^3y}{dx^3} = f'''(x) = y'''$$

n th derivative

$$\frac{d}{dx} \left(\frac{d^{n-1}y}{dx^{n-1}} \right) = \frac{d^ny}{dx^n} = f^{(n)}(x) = y^{(n)}$$

Integral Calculus

Teacher probes into students' previous knowledge through practical examples for questioning on polynomial, partial fraction, logarithmic rule and trigonometry (ratio and identities). He then introduces the topic through the use of the inverse of differentiation to find the general solutions of simple differential equations by using the general rule when integrating simple terms in x that:

if $\frac{dy}{dx} = x^n$, then $y = \frac{x^{n+1}}{n+1} + c$; where c is an arbitrary constant. The result of integration, called integral can be indefinite or definite.

It is indefinite when the limit of integration is not given. The integral is

		<p>presented as variables and accompanied by an arbitrary constant c or k. e.g $\int x^2 = \frac{x^3}{3} + c$ or $\frac{x^3}{3} + k$.</p> <p>Also note! $\int af(x)dx = a \int f(x)dx$; $\int \frac{1}{af(x)} dx = \frac{1}{a} \int \log_e f(x) + c$</p> <p>An integral is <u>definite</u> when the limit of integration is given. Hence the values given are substituted in turn in the integral to have a result other than variables.</p> <p>e.g $\int_b^a x^2$ means integral of x^2 between a and $x = b$;</p> <p>$\int_b^a x^2 = \left \frac{x^3}{3} \right _b^a = \left \frac{a^3}{3} - \frac{b^3}{3} \right$ where $a =$ upper limit, $b =$ lower limit.</p> <p>Makes known to the students the teaching technique and its demand on them</p>	
<p>Step 2 Application of General Rules</p>	<p>25</p>	<p>Teacher instructs students to merge the following general rules to each similar equation structured pattern and application of derivatives and integrals:</p> <p style="text-align: center;">Differential Calculus</p> <p><u>Derivable Functions</u></p> <p>Method of differentiation using the established relationship between quantities i.e techniques such as the following general rules of differentiation:</p> $\frac{d}{dx}(uv) = u \frac{dv}{dx} + v \frac{du}{dx} \text{ (Product rule)}$ <p style="text-align: center;">where $y = uv$</p> $\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{v \frac{du}{dx} - u \frac{dv}{dx}}{v^2} \text{ (Quotient rule)}$ <p style="text-align: center;">where $y = \frac{u}{v}$</p> $\frac{d}{dx}\left(\frac{uv}{w}\right) = y \left\{ \frac{1}{u} \cdot \frac{du}{dx} + \frac{1}{v} \cdot \frac{dv}{dx} - \frac{1}{w} \cdot \frac{dw}{dx} \right\}$ <p>(Log. function) where $y = \frac{uv}{w}$</p> <p>Note! The (-) and (+) sign in the</p>	<p>Students merged each rule with their respective equation structured pattern and application of derivatives and integrals for solving given questions.</p>

formulae were from the function $\left(\frac{uv}{w}\right)$ arrangement.

$$\frac{d}{dx}(u^n) = nu^{n-1} \frac{du}{dx}$$

(implicit function) when $f(x, y) = 0$

$$\frac{dy}{dx} = \frac{dy}{du} \cdot \frac{du}{dx} \text{ (Chain rule)}$$

where $y = (a + x)^n$

$$\frac{dy}{dx} = \frac{dy}{du} \div \frac{dx}{du} = \frac{dy}{du} \times \frac{du}{dx}$$

(parametric form of function)
where $y = f(u)$ and $x = g(u)$

Note: $\frac{du}{dx} = \frac{1}{dx/du}$

Application of the Derivative

Gradient = $m = \frac{dy}{dx}$; so at the point

(x_1, y_1) :

The equation of the tangent

$$y - y_1 = m(x - x_1)$$

The equation of the normal

$$y - y_1 = -\frac{1}{m}(x - x_1)$$

(Equations of Tangent and Normal)

At the Minimum or Maximum Point $\frac{dy}{dx} = 0$

(Turning Points)

If V is velocity, then $V = \frac{dx}{dt}$; where x is displacement and t is time. Therefore:

$$A = \frac{dv}{dt} = \frac{d}{dt}(V) = \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d^2x}{dt^2}$$

where A is acceleration.

(Rectilinear Motion)

Integral Calculus

These are methods of integration functions that do not conform to the general rule. Examples include powers of polynomials, roots and product of functions. The basic techniques are:

3. Partial fraction
4. Substitution

Integration by partial fraction:

This is used when a fraction is not in its simplest form. Examples include

iii. Occurrence of a polynomial of the same or higher degree in the numerator e.g

$$\frac{ax + b}{ax - b} \quad \text{or} \quad \frac{ax^2 + bx + c}{ax - b}$$

This is simplified by factorizing the numerator in terms of the denominator if factorable or dividing the numerator by the denominator if not. Thus $\frac{P}{D} = Q + \frac{R}{D}$ where, P, D, Q and R are polynomial, divisor, quotient and remainder respectively.

iv. Occurrence of linear factors or factorable expressions in the denominator: This is simplified as in partial fraction by separating the factors using fractions combined by addition whose numerators are represented by letters and determined

$$\text{e.g } \frac{P}{(ax + b)(ax + d)} = \frac{A}{(ax + b)} + \frac{C}{(ax + d)}$$

Note: from partial fraction that the introduced letters can be simply found using:

$\frac{N_f}{D_o}$ as $D_s = 0$; where N_f = Numerator of the function given; D_o = Denominator of others apart from the one to be found; D_s = Denominator of the unknown variable to be found or self-denominator. Hence $A = \frac{P}{D_c}$ as $D_A = 0$;

$$C = \frac{P}{D_A} \text{ as } D_c = 0.$$

Integration by Substitution:

This is a method of integrating a function by replacing a part with another variable. This will however affects the derivative of integration which shows the direction in which the integration is performed. Hence, it must be expressed in terms of the newly introduced variable. This is usually by

differentiation. Thus, integration by substitution involves both differentiation and integration. Substitution is commonly used in:

- iv. Composite or function of function*
- v. Combination of functions with fractional power*
- vi. Combination of powered functions.*

Composite Function (Function of function) :- *as in differentiation, this can deal with functions that do not conform to the general rule e.g the rule holds for x^n , $\sin x$ etc, and not for $(x - 1)^n$ or $\sin nx$.*

Then, $\int (x - 1)^n dx$ will be written as $\int U^n dx$ where $U = x - 1$ as U can only be integrated with respect to u , dx has to be written in form of du and this is done by differentiation from the other side. i.e $U = x - 1$, $\frac{du}{dx} = 1 - 0 = 1$ or $du = 1dx = dx$. This is an example of where du and dx are the same

$$\therefore \int (x - 1)^n dx = \int U^n dx =$$

$$\int U^n du = \frac{U^{n+1}}{n+1} +$$

$$C \text{ Also } \int \sin Nx dx =$$

$$\int \sin U dx \text{ where } U = Nx \text{ and } du =$$

$$Ndx \text{ or } \frac{dU}{N} = dx \quad \therefore$$

$$\int \sin Nx dx = \int \sin U dx =$$

$$\int \sin U \cdot \frac{dU}{N} = \frac{1}{N} \int (\sin U du) =$$

$$\frac{1}{N} [-\cos U] = \frac{1}{N} [-\cos Nx] + C$$

Combination of functions with fractional powers:- *This deals with product or division of variables with one having a fraction power or root sign. Substitution is generally done for the complex part which is usually the expression or factor with the fractional power or root sign.*

$$\begin{aligned} \text{e.g } \int x \sqrt{1+x} dx &= \\ \int x (1+x)^{1/2} dx &= \\ \int x (u)^{1/2} dx & \end{aligned}$$

Where $u = 1 + x$ and $du = (0 + 1) dx$, $du = dx$. Also $x = u - 1 \quad \therefore \int x (1 +$

$$\begin{aligned} x^{1/2} dx &= \int x (u)^{1/2} dx = \int (u - 1)u^{1/2} du = \int (u^{3/2} - u^{1/2}) du \\ &= \frac{u^{3/2+1}}{3/2+1} - \frac{u^{1/2+1}}{1/2+1} \\ &= \frac{u^{5/2}}{5/2} - \frac{u^{3/2}}{3/2} = \frac{2}{5}u^{5/2} - \frac{2}{3}u^{3/2} \\ &= \frac{2}{5}(1+x)^{5/2} - \frac{2}{3}(1+x)^{3/2} \end{aligned}$$

$$\text{Also in } \int \frac{x}{(1+x^2)^{3/2}} dx$$

$$\text{where } U = 1 + x^2$$

(i. e item raised to fractional power)

$$\therefore du = (0 + 2x) dx, du = 2x dx, \frac{du}{2x} = dx$$

$$\therefore \int \frac{x}{(1+x^2)^{3/2}} dx = \int \frac{x}{U^{3/2}} \cdot \frac{du}{2x} =$$

$$\int \frac{1}{2U^{3/2}} du = \frac{1}{2} \int U^{-3/2} du =$$

$$\frac{1}{2} \left| \frac{U^{-3/2+1}}{-3/2+1} \right| = \frac{1}{2} \left(\frac{U^{-1/2}}{-1/2} \right) =$$

$$\frac{1}{2} \cdot \frac{-2}{1} (U^{-1/2}) = -U^{-1/2} \text{ i. e. } - (1+x^2)^{-1/2}$$

Combination of powered numbers: - This deals with product or division of variables with integers or whole numbers as the power. Substitution is done for the term with even power or highest power where all are even or odd. e.g

$$(a) \int (x+1)(2-x)^4 dx,$$

$$\text{where } u = 2 - x$$

(the term with even power)

$$du = (0 - 1) dx, du = -dx \text{ or } dx = -du. \text{ Also, from } u = 2 - x, x = 2 - u$$

$$\int (x+1)(2-x)^4 dx = \int (2-u+1)u^4 \cdot (-du) = - \int (3-u)u^4 du = -$$

$$\int 3u^4 - u^5 = - \left(\frac{3u^5}{5} - \frac{u^6}{6} \right) = - \frac{3u^5}{5} + \frac{u^6}{6}$$

$$= \frac{u^6}{6} - \frac{3u^5}{5} = \frac{(2-x)^6}{6} - \frac{3(2-x)^5}{5}$$

$$(b) \int \frac{x^2}{(1+x^3)^2} dx$$

(both powers are even,

thus the complex part is taken)

$$u = 1 + x^3, du = (0 + 3x^2) dx, du = 3x^2 dx$$

		$x, \frac{du}{3x^2} = dx \quad \therefore \int \frac{x^2}{(1+x^3)^2} dx =$ $\int \frac{x^2}{u^2} \cdot \frac{du}{3x^2} = \int \frac{1}{3u^2} du = \frac{1}{3} \int \frac{1}{u^2} du =$ $\frac{1}{3} \int (u^{-2}) du = \frac{1}{3} \left(\frac{u^{-2+1}}{-2+1} \right) = \frac{1}{3} \left(\frac{u^{-1}}{-1} \right) =$ $-\frac{u^{-1}}{3} = -\frac{(1+x^3)^{-1}}{3}$ <p>(c) $\int (x-3)(x^2-6x+5)^3 dx$ <i>(both powers are odd, thus the higher power is taken)</i> <i>i.e</i> $u = x^2 - 6x + 5$, $du = (2x-6) dx$, $dx = \frac{du}{2x-6} = \frac{du}{2(x-3)}$ $\therefore \int (x-3)(x^2-6x+5)^3 dx = \int (x-3) \cdot u^3 \cdot \frac{du}{2(x-3)} = \frac{1}{2} \int u^3 du = \frac{1}{2} \left(\frac{u^4}{4} \right) = \frac{1}{8} u^4 = \frac{1}{8} (x^2-6x+5)^4$</p> <p style="text-align: center;"><u>Application of Integration</u> <u>Indefinite Integral</u> <i>If</i> $\frac{dA}{dx} = f(x)$, then $A = \int f(x) dx$; where A is the Area under a curve.</p> <p style="text-align: center;"><u>Definite Integral</u> <i>The area under a curve</i> $y = f(x)$ between values of x from $x = b$ to $x = a$ is given by $\int_b^a y dx$.</p>																									
Step 3 Identification of Differential Coefficients and Basic Integrals of given Functions	10	<p>Teacher writes out differential coefficients and basic integrals of given functions to be identified by students in tabular form as thus:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;"><i>Functions</i></th> <th style="text-align: left;"><i>Differentiation</i></th> <th style="text-align: left;"><i>Integration</i></th> </tr> </thead> <tbody> <tr> <td>$y = f(x)$</td> <td><i>If</i> $\frac{dy}{dx} = f(x)$</td> <td><i>If</i> $y = \int f(x) dx$</td> </tr> <tr> <td>x^n</td> <td>$n x^{n-1}$</td> <td>$\frac{x^{n+1}}{n+1} + c$</td> </tr> <tr> <td>e^x</td> <td>e^x</td> <td>$e^x + c$</td> </tr> <tr> <td>k</td> <td>0</td> <td>$kx + c$</td> </tr> <tr> <td>$\frac{1}{x}$</td> <td>$-\frac{1}{x^2}$</td> <td>$\ln x + c$</td> </tr> <tr> <td>$\sin x$</td> <td>$\cos x$</td> <td>$-\cos x + c$</td> </tr> <tr> <td>$\cos x$</td> <td>$-\sin x$</td> <td>$\sin x + c$</td> </tr> </tbody> </table>	<i>Functions</i>	<i>Differentiation</i>	<i>Integration</i>	$y = f(x)$	<i>If</i> $\frac{dy}{dx} = f(x)$	<i>If</i> $y = \int f(x) dx$	x^n	$n x^{n-1}$	$\frac{x^{n+1}}{n+1} + c$	e^x	e^x	$e^x + c$	k	0	$kx + c$	$\frac{1}{x}$	$-\frac{1}{x^2}$	$\ln x + c$	$\sin x$	$\cos x$	$-\cos x + c$	$\cos x$	$-\sin x$	$\sin x + c$	Students identified various differential coefficients and basic integrals of given functions.
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Step 4 Synthesizes of given	10	Students were asked to participate in grouping of similar applications of derivative and integral topics, types of	Students participate by figuring out relative applications																								

Examples		<p>functions and their equation structured pattern as thus:</p> <ul style="list-style-type: none"> • If $y = u^v$; i.e the equation is in power form. • If $y = \sqrt{u}$; i.e the equation is in root form. • If $y = (uv)$; i.e the equation is in product form. • If $y = \frac{u}{v}$; i.e the equation is in quotient form. 	of derivative and integral examples and the structured pattern of similar types of functions.
Step 5 Analyses of synthesized Examples	10	Each functions and application of similar derivative and Integral topics examples were pointed out by the teacher for students to analyze by applying their respective general rules and discover their various types and differences	Students discovered different types of functions and application of derivative and integral topics examples through their analyses.
Step 6 Evaluation	15	<p>Teacher evaluates the students by giving them class-works on differential and integral calculus. He marks and does corrections with them.</p> <p style="text-align: center;"><u>Differential Calculus</u></p> <ol style="list-style-type: none"> 1. If $y = x^{-3/2}$ then $\frac{dy}{dx}$ is 2. If $y = x \sin x$, find $\frac{dy}{dx}$ when $x = \frac{\pi}{2}$ 3. Find the derivate of $(2 + 3x)(1 - x)$ with respect to x. 4. If $y = \frac{x}{(x^2 - 1)^{1/2}}$ find $\frac{dy}{dx}$ 5. Use the chain rule to find the derivative $y = \sqrt{1 - x^3}$ 6. If $f(x) = (2x + 1)^4$, then the $f''(x)$ of $f(x)$ at $x = 0$ is 7. Find $\frac{d^2y}{dx^2}$, given that $y = e^{x^4}$ 8. If $x^2 + xy + y^3 = 0$, then, in term of x and y, $\frac{dy}{dx} =$ 9. If $x = t^3 - t$, and $y = \sqrt{3t + 1}$, then $\frac{dy}{dx}$ at $t = 1$ is... 10. Find the derivate of the function $y = \log \sqrt{x}$ with respect to x 11. The gradient of the curve $y = 3x^2 +$ 	Students applied the general rules to answer the given class-works and did their corrections after marking.

		<p>$11x + 7$ at the point P (x, y) is -1. Find the co-ordinates of P.</p> <p>12. After t seconds a particle has travelled a distance s meters, where $s = -17t + 15t^2 - t^3$ find the acceleration after 6 seconds.</p> <p><u>Integral Calculus</u></p> <ol style="list-style-type: none"> 1. Simplify $\int \frac{x^2+3x+2}{x+1} dx$ 2. Evaluate $\int (\cos 3x + \sin 4x) dx$ 3. Evaluate $\int_2^5 (3x^2 - 4x + 2) dx$ 4. Evaluate $\int_2^\pi (\sec^2 x - \tan^2 x) dx$ 5. Evaluate $\int_{-2}^1 (x - 1)^2 dx$ 6. If $y = x(x^4 + x^2 + 1)$, evaluate $\int_{-1}^1 y dx$ 7. Evaluate $\int \frac{x}{\sqrt{3x^2 + 5}} dx$ 8. Evaluate the integral $\int_{\pi/12}^{\pi/4} 2\cos 2x dx$ 9. Evaluate $\int \frac{e^x}{(1+e^x)^2} dx$ 10. Evaluate $\int_2^3 \frac{3}{(x-1)(x+2)} dx$ 11. Ice forms on a refrigerator ice – box at the rate of $(4 - 0.6t)$g per minute after t minutes. If initially there are 2g of ice in the box, find the mass of ice formed in 5 minutes. 12. A student blows a balloon and its volume increases at a rate of $\pi(20 - t^2)$ cm^3/s after t seconds. If the initial volume is $0 cm^3$, find the Volume of the balloon after 2 seconds 	
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Appendix IV

Teaching and Learning Instructional Guides (TLIG)

Instructional Guide for Control Group C

Lesson Note III

School:	As Applicable
Subject:	Further Mathematics
Class:	SS II
Topic:	Calculus
Sub-Topics:	Differential and Integral Calculus
Number in Class:	As Applicable

Average age:	16 years
Gender:	Mixed
Duration:	80 Minutes
Date:	As Applicable

Instructional Objectives:

Differential Calculus

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

- i. Differentiate various given functions such as; algebraic, implicit, parametric form, trigonometric, exponential and logarithmic functions using the rule that if $y = Ax^n$, then $\frac{dy}{dx} = Anx^{n-1}$
- ii. Use the chain rule, product rule and quotient rule to differentiate complex algebraic expressions.
- iii. Apply differential calculus to determine rates of change including gradients (slope and equation of tangent and normal), turning points on a curve (maximum and minimum value problems), rectilinear motion (velocity and acceleration)

Integral Calculus

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

- i. Use the inverse of differentiation to find the general solutions of simple differential equations by using the general rule when integrating simple terms in x that if $\frac{dy}{dx} = x^n$, then $y = \frac{x^{n+1}}{n+1} + c$; where c is an arbitrary constant.
- ii. Evaluate definite integrals in the form $\int_b^a f(x)dx$ and indefinite integrals in the form $\int f(x)dx$

- iii. Apply the techniques of integration (by substitution and by partial fraction) to integrate complex given functions such as; algebraic, trigonometric and exponential functions.
- iv. Find the area under the curve by integrating between limits and volume of solids of revolution.

Instructional Materials:

Differential Calculus

Chart showing definition of Derivation with notations

Integral Calculus

Chart showing Integral General Rule

Previous Knowledge:

Differential Calculus

Students have been taught algebraic expressions, indices, slope and trigonometry (ratio and identities).

Integral Calculus

Students were familiar with polynomial, partial fraction, logarithmic rule and trigonometry (ratio and identities).

Presentation:

Content Development	Time (Mins)	Teacher's Activities	Students' Activities
Step 1 Introduction	10	Differential Calculus Teacher probes into students' previous knowledge through practical examples for questioning on algebraic expressions, indices, slope and trigonometry (ratio and identities). He then introduces the topic by giving the definition of derivative with the aid of instructional materials as	Students answered the questions asked by the teacher and showed enthusiasm towards the topics through their responses.

follows:

If $y = f(x)$, the derivative of y or $f(x)$ with respect to x is defined as: $\frac{dy}{dx} =$

$$\lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} = \lim_{\Delta x \rightarrow 0} \frac{f(x+\Delta x) - f(x)}{\Delta x}$$

where $h = \Delta x$. The derivative is also denoted by y' , df/dx or $f'(x)$. The process of taking a derivative is called differentiation.

The second, third and higher derivatives are defined as follows:

Second derivative

$$\frac{d}{dx} \left(\frac{dy}{dx} \right) = \frac{d^2y}{dx^2} = f''(x) = y''$$

Third derivative

$$\frac{d}{dx} \left(\frac{d^2y}{dx^2} \right) = \frac{d^3y}{dx^3} = f'''(x) = y'''$$

n th derivative

$$\frac{d}{dx} \left(\frac{d^{n-1}y}{dx^{n-1}} \right) = \frac{d^ny}{dx^n} = f^{(n)}(x) = y^{(n)}$$

Integral Calculus

Teacher probes into students' previous knowledge through practical examples for questioning on polynomial, partial fraction, logarithmic rule and trigonometry (ratio and identities). He then introduces the topic through the use of the inverse of differentiation to find the general solutions of simple differential equations by using the general rule when integrating simple terms in x that:

if $\frac{dy}{dx} = x^n$, then $y = \frac{x^{n+1}}{n+1} + c$; where c is an arbitrary constant. The result of integration, called integral can be indefinite or definite.

It is indefinite when the limit of integration is not given. The integral is

		<p>presented as variables and accompanied by an arbitrary constant c or k. e.g $\int x^2 = \frac{x^3}{3} + c$ or $\frac{x^3}{3} + k$.</p> <p>Also note! $\int af(x)dx = a \int f(x)dx$; $\int \frac{1}{af(x)} dx = \frac{1}{a} \int \log_e f(x) + c$</p> <p>An integral is <u>definite</u> when the limit of integration is given. Hence the values given are substituted in turn in the integral to have a result other than variables.</p> <p>e.g $\int_b^a x^2$ means integral of x^2 between a and $x = b$;</p> <p>$\int_b^a x^2 = \left \frac{x^3}{3} \right _b^a = \left \frac{a^3}{3} - \frac{b^3}{3} \right$ where $a =$ upper limit, $b =$ lower limit.</p> <p>Makes known to the students the teaching technique and its demand on them</p>																									
<p>Step 2 Identification of Differential Coefficients and Basic Integrals of different types of Functions</p>	10	<p>Teacher writes out differential coefficients and basic integrals of given functions to be identified by students in tabular form as thus:</p> <table border="1"> <thead> <tr> <th>Functions</th> <th>Differentiation</th> <th>Integration</th> </tr> </thead> <tbody> <tr> <td>$y = f(x)$</td> <td>If $\frac{dy}{dx} = f(x)$</td> <td>If $y = \int f(x)dx$</td> </tr> <tr> <td>x^n</td> <td>$n x^{n-1}$</td> <td>$\frac{x^{n+1}}{n+1} + c$</td> </tr> <tr> <td>e^x</td> <td>e^x</td> <td>$e^x + c$</td> </tr> <tr> <td>k</td> <td>0</td> <td>$kx + c$</td> </tr> <tr> <td>$\frac{1}{x}$</td> <td>$-\frac{1}{x^2}$</td> <td>$\ln x + c$</td> </tr> <tr> <td>$\sin x$</td> <td>$\cos x$</td> <td>$-\cos x + c$</td> </tr> <tr> <td>$\cos x$</td> <td>$-\sin x$</td> <td>$\sin x + c$</td> </tr> </tbody> </table>	Functions	Differentiation	Integration	$y = f(x)$	If $\frac{dy}{dx} = f(x)$	If $y = \int f(x)dx$	x^n	$n x^{n-1}$	$\frac{x^{n+1}}{n+1} + c$	e^x	e^x	$e^x + c$	k	0	$kx + c$	$\frac{1}{x}$	$-\frac{1}{x^2}$	$\ln x + c$	$\sin x$	$\cos x$	$-\cos x + c$	$\cos x$	$-\sin x$	$\sin x + c$	Students identified various differential coefficients and basic integrals of different types of functions.
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<p>Step 3 Analyses of Given Examples</p>	10	<p>Different functions and application of derivative and Integral topics examples were pointed out by the teacher for students to analyze and discover their various types and differences</p>	Students discovered different types of functions and application of derivative and integral topics examples through their analyses.																								

<p>Step 4 Synthesizes of Analyzed Examples</p>	<p>10</p>	<p>Students were asked to participate in grouping of similar applications of derivative and integral topics, types of functions and their equation structured pattern as thus:</p> <ul style="list-style-type: none"> • If $y = u^v$; i.e the equation is in power form. • If $y = \sqrt{u}$; i.e the equation is in root form. • If $y = (uv)$; i.e the equation is in product form. • If $y = \frac{u}{v}$; i.e the equation is in quotient form. 	<p>Students participate by figuring out relative applications of derivative and integral examples and the structured pattern of similar types of functions.</p>
<p>Step 5 Application of Rules and Techniques</p>	<p>25</p>	<p>Teacher instructs students to merge the following rules and techniques to each similar equation structured pattern and application of derivatives and integrals:</p> <p style="text-align: center;">Differential Calculus</p> <p><u>Derivable Functions</u></p> <p><i>Method of differentiation using the established relationship between quantities i.e techniques such as the following general rules of differentiation:</i></p> $\frac{d}{dx}(uv) = u \frac{dv}{dx} + v \frac{du}{dx} \text{ (Product rule)}$ <p style="text-align: center;"><i>where $y = uv$</i></p> $\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{v \frac{du}{dx} - u \frac{dv}{dx}}{v^2} \text{ (Quotient rule)}$ <p style="text-align: center;"><i>where $y = \frac{u}{v}$</i></p> $\frac{d}{dx}\left(\frac{uv}{w}\right) = y \left\{ \frac{1}{u} \cdot \frac{du}{dx} + \frac{1}{v} \cdot \frac{dv}{dx} - \frac{1}{w} \cdot \frac{dw}{dx} \right\}$ <p><i>(Log. function) where $y = \frac{uv}{w}$</i></p> <p><i>Note! The (-) and (+) sign in the formulae were from the function $\left(\frac{uv}{w}\right)$ arrangement.</i></p> $\frac{d}{dx}(u^n) = nu^{n-1} \frac{du}{dx}$ <p><i>(implicit function) when $f(x, y) = 0$</i></p> $\frac{dy}{dx} = \frac{dy}{du} \cdot \frac{du}{dx} \text{ (Chain rule)}$	<p>Students merged each rule and technique with their respective equation structured pattern and application of derivatives and integrals for solving given questions.</p>

where $y = (a + x)^n$

$$\frac{dy}{dx} = \frac{dy}{du} \div \frac{dx}{du} = \frac{dy}{du} \times \frac{du}{dx}$$

(parametric form of function)

where $y = f(u)$ and $x = g(u)$

Note: $\frac{du}{dx} = \frac{1}{dx/du}$

Application of the Derivative

Gradient = $m = \frac{dy}{dx}$; so at the point

(x_1, y_1) :

The equation of the tangent

$$y - y_1 = m(x - x_1)$$

The equation of the normal

$$y - y_1 = -\frac{1}{m}(x - x_1)$$

(Equations of Tangent and Normal)

At the Minimum or Maximum Point $\frac{dy}{dx} = 0$

(Turning Points)

If V is velocity, then $V = \frac{dx}{dt}$; where x is displacement and t is time. Therefore:

$$A = \frac{dv}{dt} = \frac{d}{dt}(V) = \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d^2x}{dt^2}$$

where A is acceleration.

(Rectilinear Motion)

Integral Calculus

These are methods of integration functions that do not conform to the general rule. Examples include powers of polynomials, roots and product of functions. The basic techniques are:

5. Partial fraction
6. Substitution

Integration by partial fraction:

This is used when a fraction is not in its simplest form. Examples include

v. Occurrence of a polynomial of the same or higher degree in the numerator e.g

$$\frac{ax + b}{ax - b} \quad \text{or} \quad \frac{ax^2 + bx + c}{ax - b}$$

	<p><i>This is simplified by factorizing the numerator in terms of the denominator if factorable or dividing the numerator by the denominator if not. Thus $\frac{P}{D} = Q + \frac{R}{D}$ where, P, D, Q and R are polynomial, divisor, quotient and remainder respectively.</i></p> <p><i>vi. Occurrence of linear factors or factorable expressions in the denominator: This is simplified as in partial fraction by separating the factors using fractions combined by addition whose numerators are represented by letters and determined</i></p> <p><i>e.g $\frac{P}{(ax + b)(ax + d)} = \frac{A}{(ax + b)} + \frac{C}{(ax + d)}$</i></p> <p><i>Note: from partial fraction that the introduced letters can be simply found using: $\frac{N_f}{D_o}$ as $D_s = 0$; where N_f = Numerator of the function given; D_o = Denominator of others apart from the one to be found, D_s = Denominator of the unknown variable to be found or self-denominator. Hence $A = \frac{P}{D_c}$ as $D_A = 0$; $C = \frac{P}{D_A}$ as $D_c = 0$.</i></p> <p><u>Integration by Substitution:</u></p> <p><i>This is a method of integrating a function by replacing a part with another variable. This will however affects the derivative of integration which shows the direction in which the integration is performed. Hence, it must be expressed in terms of the newly introduced variable. This is usually by differentiation. Thus, integration by substitution involves both differentiation and integration. Substitution is commonly used in:</i></p> <p><i>vii. Composite or function of function</i></p> <p><i>viii. Combination of functions with fractional power</i></p> <p><i>ix. Combination of powered functions.</i></p>	
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Composite Function (Function of function) :- as in differentiation, this can deal with functions that do not conform to the general rule e.g the rule holds for x^n , $\sin x$ etc, and not for $(x - 1)^n$ or $\sin nx$.

Then, $\int (x - 1)^n dx$ will be written as $\int U^n dx$ where $U = x - 1$ as U can only be integrated with respect to u , dx has to be written in form of du and this is done by differentiation from the other side. i.e $U = x - 1$, $\frac{du}{dx} = 1 - 0 = 1$ or $du = 1 dx = dx$. This is an example of where du and dx are the same

$\therefore \int (x - 1)^n dx = \int U^n dx = \int U^n du = \frac{U^{n+1}}{n+1} + C$

Also $\int \sin Nx dx = \int \sin U dx$ where $U = Nx$ and $du = N dx$ or $\frac{dU}{N} = dx$ \therefore

$$\int \sin Nx dx = \int \sin U dx = \int \sin U \cdot \frac{dU}{N} = \frac{1}{N} \int (\sin U du) = \frac{1}{N} [-\cos U] = \frac{1}{N} [-\cos Nx] + C$$

Combination of functions with fractional powers:- This deals with product or division of variables with one having a fraction power or root sign. Substitution is generally done for the complex part which is usually the expression or factor with the fractional power or root sign.

e.g $\int x \sqrt{1+x} dx = \int x (1+x)^{1/2} dx = \int x (u)^{1/2} dx$

$$\text{Where } u = 1 + x \text{ and } du = (0 + 1) dx, du = dx. \text{ Also } x = u - 1 \therefore \int x (1+x)^{1/2} dx = \int x (u)^{1/2} dx = \int (u - 1)u^{1/2} du = \int (u^{3/2} - u^{1/2}) du = \frac{u^{3/2+1}}{3/2+1} - \frac{u^{1/2+1}}{1/2+1} = \frac{u^{5/2}}{5/2} - \frac{u^{3/2}}{3/2} = \frac{2}{5} U^{5/2} - \frac{2}{3} U^{3/2} = \frac{2}{5} (1+x)^{5/2} - \frac{2}{3} (1+x)^{3/2}$$

$$\text{Also in } \int \frac{x}{(1+x^2)^{3/2}} dx$$

$$\text{where } U = 1 + x^2$$

(i. e item raised to fractional power)

$$\therefore du = (0 + 2x) dx, du = 2x dx, \frac{du}{2x} = dx$$

$$\therefore \int \frac{x}{(1+x^2)^{3/2}} dx = \int \frac{x}{U^{3/2}} \cdot \frac{du}{2x} =$$

$$\int \frac{1}{2U^{3/2}} du = \frac{1}{2} \int U^{-3/2} du =$$

$$\frac{1}{2} \left| \frac{U^{-3/2+1}}{-3/2+1} \right| = \frac{1}{2} \left(\frac{U^{-1/2}}{-1/2} \right) =$$

$$\frac{1}{2} \cdot \frac{-2}{1} (U^{-1/2}) = -U^{-1/2} \text{ i. e. -}$$

$$(1+x^2)^{-1/2}$$

Combination of powered numbers: - This deals with product or division of variables with integers or whole numbers as the power. Substitution is done for the term with even power or highest power where all are even or odd. e.g

$$(a) \int (x+1)(2-x)^4 dx,$$

$$\text{where } u = 2 - x$$

(the term with even power)

$$du = (0 - 1) dx, du = -dx \text{ or } dx = -du.$$

$$\text{Also, from } u = 2 - x, x = 2 - u$$

$$\int (x+1)(2-x)^4 dx = \int (2-u+1)u^4 \cdot (-du) = -\int (3-u)u^4 du = -$$

$$\int 3u^4 - u^5 = -\left(\frac{3u^5}{5} - \frac{u^6}{6}\right) = -\frac{3u^5}{5} +$$

$$\frac{u^6}{6} = \frac{u^6}{6} - \frac{3u^5}{5} = \frac{(2-x)^6}{6} - \frac{3(2-x)^5}{5}$$

$$(b) \int \frac{x^2}{(1+x^3)^2} dx$$

(both powers are even,

thus the complex part is taken)

$$u = 1 + x^3, du = (0 + 3x^2) dx, du = 3x^2 dx,$$

$$\frac{du}{3x^2} = dx$$

$$\therefore \int \frac{x^2}{(1+x^3)^2} dx =$$

$$\int \frac{x^2}{u^2} \cdot \frac{du}{3x^2} = \int \frac{1}{3u^2} du = \frac{1}{3} \int \frac{1}{u^2} du =$$

$$\frac{1}{3} \int (u^{-2}) du = \frac{1}{3} \left(\frac{u^{-2+1}}{-2+1} \right) = \frac{1}{3} \left(\frac{u^{-1}}{-1} \right) =$$

$$-\frac{u^{-1}}{3} = -\frac{(1+x^3)^{-1}}{3}$$

		<p>(c) $\int (x - 3)(x^2 - 6x + 5)^3 dx$</p> <p>(both powers are odd, thus the higher power is taken)</p> <p>i.e $u = x^2 - 6x + 5$, $du = (2x - 6)$ dx , $dx = \frac{du}{2x - 6} = \frac{du}{2(x - 3)}$ $\therefore \int (x - 3)(x^2 - 6x + 5)^3 dx = \int (x - 3) \cdot u^3 \cdot \frac{du}{2(x - 3)} = \frac{1}{2} \int u^3 du = \frac{1}{2} \left(\frac{u^4}{4} \right) = \frac{1}{8} u^4 = \frac{1}{8} (x^2 - 6x + 5)^4$</p> <p><u>Application of Integration</u></p> <p><u>Indefinite Integral</u> If $\frac{dA}{dx} = f(x)$, then $A = \int f(x) dx$; where A is the Area under a curve.</p> <p><u>Definite Integral</u> The area under a curve $y = f(x)$ between values of x from $x = b$ to $x = a$ is given by $\int_b^a y dx$.</p>	
<p>Step 6 Evaluation</p>	<p>15</p>	<p>Teacher evaluates the students by giving them class-works on differential and integral calculus. He marks and does corrections with them.</p> <p><u>Differential Calculus</u></p> <ol style="list-style-type: none"> 1. If $y = x^{-3/2}$ then $\frac{dy}{dx}$ is 2. If $y = x \sin x$, find $\frac{dy}{dx}$ when $x = \frac{\pi}{2}$ 3. Find the derivate of $(2 + 3x)(1 - x)$ with respect to x. 4. If $y = \frac{x}{(x^2 - 1)^{1/2}}$ find $\frac{dy}{dx}$ 5. Use the chain rule to find the derivative $y = \sqrt{1 - x^3}$ 6. If $f(x) = (2x + 1)^4$, then the $f''(x)$ of $f(x)$ at $x = 0$ is 7. Find $\frac{d^2y}{dx^2}$, given that $y = e^{x^4}$ 8. If $x^2 + xy + y^3 = 0$, then, in term of x and y, $\frac{dy}{dx} =$ 9. If $x = t^3 - t$, and $y = \sqrt{3t + 1}$, then $\frac{dy}{dx}$ at $t = 1$ is... 10. Find the derivate of the function 	<p>Students applied the rules and techniques to answer the given class-works and did their corrections after marking.</p>

	<p>$y = \log \sqrt{x}$ with respect to x</p> <p>11. The gradient of the curve $y = 3x^2 + 11x + 7$ at the point P (x, y) is -1. Find the co-ordinates of P.</p> <p>12. After t seconds a particle has travelled a distance s meters, where $s = -17t + 15t^2 - t^3$ find the acceleration after 6 seconds.</p> <p><u>Integral Calculus</u></p> <p>1. Simplify $\int \frac{x^2+3x+2}{x+1} dx$</p> <p>2. Evaluate $\int (\cos 3x + \sin 4x) dx$</p> <p>3. Evaluate $\int_2^5 (3x^2 - 4x + 2) dx$</p> <p>4. Evaluate $\int_2^\pi (\sec^2 x - \tan^2 x) dx$</p> <p>5. Evaluate $\int_{-2}^1 (x - 1)^2 dx$</p> <p>6. If $y = x(x^4 + x^2 + 1)$, evaluate $\int_{-1}^1 y dx$</p> <p>7. Evaluate $\int \frac{x}{\sqrt{3x^2 + 5}} dx$</p> <p>8. Evaluate the integral $\int_{\pi/12}^{\pi/4} 2\cos 2x dx$</p> <p>9. Evaluate $\int \frac{e^x}{(1+e^x)^2} dx$</p> <p>10. Evaluate $\int_2^3 \frac{3}{(x-1)(x+2)} dx$</p> <p>11. Ice forms on a refrigerator ice – box at the rate of $(4 - 0.6t)g$ per minute after t minutes. If initially there are 2g of ice in the box, find the mass of ice formed in 5 minutes.</p> <p>12. A student blows a balloon and its volume increases at a rate of $\pi(20 - t^2) \text{ cm}^3/\text{s}$ after t seconds. If the initial volume is 0 cm^3, find the Volume of the balloon after 2 seconds</p>	
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Primary School Leaving Certificate (Testimonial) 1997 – 2003

- Secondary Education
Army Barrack Grammar School, Iwo – Road, Ibadan 2003 – 2008
Senior Secondary Certificate Examination (SSCE)
 - Okebadan High School, Okebadan 2008
National Examination Council (NECO)
 - Tertiary Education
Wolex Polytechnic, Lagos 2011 – 2013
ND Computer Science
 - Lead City University, Ibadan 2017 – 2021
B.Sc. (Edu) Mathematics Education
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- D. Work Experience:**
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Class Teacher 2016 – 2018
 - Regina James Academy Olodo, Ibadan
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 - Scholar International Schools, Imokun-Epe, Lagos
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- E. Membership of Professional Organization:**
- Mathematics Association of Nigeria (MAN) 2024
- F. Publication:**
- **RAHEEM Tunde Rasheed & SAM-KAYODE** Christianah Olajumoke (Ph.D) (2024). The Use of Truth Table, Logical Reasoning and Logic Gate in Teaching and Learning Process. *International Journal of Latest Technology in Engineering, Management and Applied Science (IJLTEMAS)*, 13(6), Published June 28, 2024, Available online: DOI: <http://doi.org/10.51583/IJLTEMAS.2024.130601>, <https://www.ijltemas.in/> Pp 1-12, ISSN: 2278-2540 2024

- **RAHEEM Tunde Rasheed & YARA Philius Olatunde (Ph.D) (2024).** Effect of Inductive and Deductive Teaching Strategies on Senior Secondary School Students' Academic Achievement in Further Mathematics in Oyo State. *Journal of Capital Development in Behavioural Sciences (JACODEBS)*. (Under review) 2024

G. Published Refereed Conference Proceedings:

- Application of Mathematics Logical Reasoning and Computer Logic Gate Truth-values Coding System to Teaching and Learning Process in Ifá Religious Practice **Published in the Conference Proceedings of the:** 60th Annual National Conference of the Mathematical Association of Nigeria (MAN) held at National Teachers' Institute (NTI), Kaduna, Kaduna State, Nigeria, from 25th to 30th August, 2024

H. Conferences/ Seminars/ Workshops Attended/ Paper Read and Published in Book of Abstracts:

- One-Day International Seminar Jointly Organized by Post Graduate College, Lead City University, Ibadan, Nigeria and International Council for Education Research and Training (ICERT), India and USA on UN and UNESCO World Day for Cultural Diversity for Dialogue and Development held on May 21, 2024
- 60th Annual National Conference of The Mathematical Association of Nigeria (MAN) held at National Teachers' Institute (NTI), Kaduna, Kaduna State, Nigeria, from 25th to 30th August, 2024
Theme: Mathematics the Bedrock of Artificial Intelligence and Creative Thinking for National Development
Paper Read: Application of Mathematics Logical Reasoning and Computer Logic Gate Truth-values Coding System to Teaching and Learning Process in Ifá Religious Practice
- One-Day Training Workshop on Capacity Building for Teachers on Strengthening Mathematics and Science Education (SMASE): Principles of ASEI-PDSI Approach Organized by National Teachers' Institute (NTI), Kaduna in Collaboration with Mathematical Association of Nigeria (MAN) held at National Teachers' Institute (NTI), Kaduna, Kaduna State, Nigeria on 26th August, 2024
- DTW STEM Educators Workshop 5 on PhET Interactive

Simulations: Implementation of PhET Activities for STEM Education; an online non-credit course authorized by University of Colorado Boulder and offered through Coursera on 26th August,
Verify at: coursera.org/verify/7BV27DTNW8D7

2024

- DTW STEM Educators Workshop 5 on PhET Interactive Simulations: Whole Class with PhET for STEM Education; an online non-credit course authorized by University of Colorado Boulder and offered through Coursera on 17th September,
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The University Compliance Certification

This is to certify that this thesis by Tunde Rasheed RAHEEM with the matriculation number LCU/PG/003152 in the Department of Science Education, Faculty of Education, Lead City University, Ibadan, Oyo state is in full compliance with the approved University format and style.

Signature

Date

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