Chapter One

Introduction

1.1 Background to the Study

Mathematics holds an indispensable role across numerous domains. Providing foundational mathematical education to every child is not merely a luxury but an absolute imperative. Its significance extends beyond its own domain, as it equips individuals with skills applicable to various spheres including science, technology, business, medicine, humanities, and more. Diverse stakeholders such as researchers, educators, parents, social scientists, politicians, and others have consistently emphasized the value and necessity of mastering Mathematics. A variety of sources echo this sentiment, portraying Mathematics as a fundamental life skill. Its relevance traverses professions, fields without underscoring the importance of comprehending this subject thoroughly. Despite its perception as timeless, practical, and elegant, students are encouraged to actively engage in Mathematics classrooms. Notably, for the majority of non-science college graduates, proficiency beyond basic arithmetic is seldom essential for success. This reality prompts concern among educators who advocate for a shift in teaching methodology from rote procedures to conceptual understanding aligning with the notion that Mathematics should be approached as a cognitive endeavor. The pursuit of Mathematics for societal progress is readily apparent in national development strategies of both advanced and developing nations. The significance of Mathematics within the realms of science and technological advancement cannot be downplayed, particularly in uncovering fundamental truths, especially those pertaining to the natural world[1].

Mathematics stands as one of the most powerful tool for honing the intellect. Any nation's journey towards scientific and technological progress, as well as its expansion beyond its workforce capabilities, hinges upon a solid grasp in basic Mathematics. Serving as the cornerstone of all sciences, Mathematics is imperative for cultivating the intellectual potential of our youth and should undoubtedly be imparted with careful attention. Mathematics offers the framework and approach for delving into nearly all significant contemporary fields of study, serving as the essential tool for comprehending the world we inhabit[2].

In the context of the National Transformation agenda, progress is intrinsically linked to the effective utilization of Mathematics. Mathematics, often referred to as the cornerstone of sciences, assumes a pivotal role within the National Transformation agenda, serving as an indispensable instrument across diverse domains such as natural science, engineering, technology, medicine, and social science. The significance of Mathematics transcends its role as a mere academic pursuit; rather, it serves as a catalyst for honing an individual's capacity for logical reasoning and adept problem-solving. Functioning as a versatile tool, Mathematics, along with its associated knowledge and competencies, forms the very foundation upon which societal metamorphosis and the translation of concepts into tangible reality rest. This subject constitutes a fundamental component of our daily undertakings and assumes a central position in various spheres, particularly in the realm of numerical operations inherent in everyday calculations, measurements, computations, and notably, commercial transactions. In essence, Mathematics encapsulates a distinctive approach to cognition and numerical manipulation, necessitating methodical and dynamic cognitive engagement to discern patterns, correlations, and symbolic representations. Its scope extends to encompass not only the resolution of challenges but also the potential to facilitate effective communication[3].

Similar to other scientific disciplines, Mathematics embodies a collection of established truths that have been attained through a dependable methodology, affirmed through practical application, and ratified through the consensus of proficient authorities. At its core, Mathematics revolves around abstract notions and conceptual frameworks, entities that subsist solely within the collective cognizance of humankind. This characteristic endows Mathematics with a dual nature it assumes as the characteristics of both a science and a facet of human culture, attributable to its capacity for consistent replication. The bedrock of Mathematics rests upon deductive inference, even though humanity's initial interaction with Mathematics was characterized by an inductive approach. This signifies that the underpinnings of Mathematics emerge from the exploration of logical and philosophical concepts[4].

In the educational curriculum of Colleges of Education, the inclusion of Basic General Mathematics serves the purpose of enhancing the skills and competencies. This version of Basic General Mathematics corresponds to the mathematical content covered during their secondary school education. The scope of Basic General Mathematics encompasses students across all levels within Colleges of Education. Year I students engage with topics such as Binary numbers, conversion between base 2 and base 10, Set theory including definitions, notations, and diagrams, Fundamental operations involving fractions and whole numbers, as well as concepts like Fractions, decimals, and approximations, Indices and surds, Manipulation of formulae, Simplification and factoring of elementary algebraic expressions, Solving basic algebraic equations using different methods, Tackling straightforward word problems, Exploring Ratios, percentages, simple and compound interests, and various forms of Variation including direct, inverse, joint, and partial variations[5].

Upon progressing to Year II, students delve into subjects such as Rearranging formulae, Units of measurement pertaining to time, currency, length, mass, weight, area, and volume. They engage in computations related to the areas and volumes of 2 and 3-dimensional shapes, including triangles, squares, rectangles, cylinders, and more. The exploration extends to the properties and classifications of 2 and 3-dimensional shapes, as well as different types of angles, encompassing horizontal, vertical, parallel, and perpendicular lines. Data collection methodologies and sources are introduced, along with techniques for data representation through mediums like pictograms, bar charts, and pie charts[5].

Advancing to Year III, students encounter topics such as Frequency distribution, Histograms, and cumulative frequency distributions. They delve into measures of central tendency including Mode, Median, and Mean, as well as measures of dispersion like Range, Mean Deviation, and Standard Deviation. Lastly, the curriculum covers elementary probability theory and its applications. The structured progression through these mathematical topics aims to equip students with a comprehensive mathematical foundation, catering to their evolving cognitive capacities and academic growth[5].

The historical significance of Mathematics as one of the earliest academic disciplines cannot be disputed. Its indispensability for personal and societal advancement remains paramount. Mathematics permeates various aspects of daily existence, encompassing realms such as political dynamics, economic activities, scientific pursuits, and technological innovation. Regrettably, despite its paramount relevance, this venerable discipline often finds itself at the periphery of learners' preferences. Its identity as a vital monarch, ruler, and humble assistant is frequently overshadowed by a lack of enthusiasm from students. A disheartening trend of poor performance in Mathematics is observable across all educational tiers, spanning from primary education upwards. This trend is particularly a concern as students, even at an early stage, start expressing discontent with Mathematics, despite its foundational role in national progress. The pedagogical delivery and absorption of Mathematics knowledge encounters multifaceted challenges, culminating in consistent underachievement. Researchers, parents, and Mathematics educators are concerned by this issue, prompting a thorough exploration of the factors contributing to this distressing pattern of substandard mathematical proficiency[6].

The issue of concern on students' performance in Mathematics becomes evident in the insufficient number of Mathematics Educators. Without proficient and knowledgeable educators, students lack the opportunity to acquire the essential competencies that are vital for propelling Nigeria's technological advancement. A solid and well-informed instructional foundation is crucial to students' ability to grasp the intricacies of technological transformation via skilled guidance. In cases where the instructor's expertise merely surpasses that of the students by a small margin, they might struggle to provide a comprehensive elucidation of complex concepts that demand deeper comprehension. An educator whose grasp of the subject matter is constrained may struggle to effectively convey the content, leading to a disconnect between theoretical concepts and their practical application. Consequently, this shortfall in the teacher's understanding inadvertently widens the chasm between knowledge and its real-world utilization. This, in turn, detrimentally impacts students' grasp of the applicability of the subject matter[7].

A significant portion of Nigerian students harbor apprehension and aversion towards Mathematics, primarily due to the perceived abstract nature of its concepts. The immediate relevance and practical application of the subject often elude many students, leaving them questioning its pertinence to their daily lives and the professional landscape. Consequently, they grapple with the notion of why they should invest effort in studying Mathematics. For these youthful intellects, Mathematics persists as an enigmatic realm detached from tangible reality. In the realm of secondary education, Mathematics is frequently perceived as a prerequisite solely for securing admission into higher educational institutions. This viewpoint overlooks the subject's broader educational and cognitive merits, relegating it to the status of a mere stepping stone rather than recognizing its inherent value. It is disheartening to observe that Mathematics continues to hold its position as one of the subjects with the lowest pass rates in Nigerian schools, despite its significance and the amount of instructional time dedicated to it within the typical educational framework[8].

The curriculum stands as a pivotal tool within the educational framework, embodying profound importance. It serves as the very core and vital force propelling educational programs and practices forward. The failure to enact a functional curriculum carries detrimental consequences for any educational system. The Mathematics curriculum, from the moment modern Mathematics was introduced to Nigeria, has been a subject of ongoing debate among educators and practitioners in the field. This contention arises due to its foreign origins, rendering it ill-equipped to adequately address the unique needs of both the Nigerian populace and its educational landscape. Historically, the Mathematics curriculum in Nigerian secondary schools has been largely determined by the National Educational Research and Development Council (NERDC). It is an educational organization that develops and promotes curriculum materials and research for the Nigerian educational system. The National Educational Research and Development Council (NERDC) in Nigeria was established in 1973. It was created to coordinate and oversee educational research and curriculum development in the country. NERDC's primary goal is to ensure the development of a robust and relevant educational system in Nigeria. This ongoing clash over curriculum content predictably leads to a deficiency in effectively conveying Mathematics concepts to students within the system. As a consequence, it is clear that the effective transmission of Mathematics knowledge to students remains a consistent challenge. The amalgamation of external curriculum components and the inherent characteristics of Mathematics and its concepts instills a heightened sense of fear and aversion within the minds of learners[9].

The matter of financial support from governmental and pertinent entities has emerged as a significant obstacle in the realm of Mathematics education. The allocation of budgetary resources to the education sector has consistently fallen far short in comparison to funding dispensed by more advanced nations and certain developing economies[10.] Within Nigeria's context, the education sector has not commanded the paramount position in budgetary allocation that it rightfully merits, thus marking a prolonged period of underserved prioritization. Following instances of inadequate achievement, particularly evident in a subject like Mathematics, the repercussions often extend to closely related fields[11].

Class size is another issue of concern in relation to Mathematics performance. It is an instructional instrument characterized as the average count of students within a school classroom which signifies the ratio of students to teachers within a class, serving as a metric to evaluate the effectiveness of the education system[12]. The number of students in a classroom has a multifaceted impact on the learning experience. It can influence students interactions, potentially leading to disruptive behavior that constrains the types of instructional activities a teacher can facilitate. Moreover, it influences the extent to which a teacher can dedicate time to individual students and address their specific learning requirements, as opposed to focusing solely on the entire group. Smaller class sizes facilitate a more targeted and attentive approach to addressing individual needs. Additionally, class size affects how teachers apportion their time and, consequently, their overall effectiveness. This is reflected in considerations such as the amount of course outlines that can be covered comprehensively. Conversely, an overcrowded classroom involves a substantial number of students sharing one confined space. Such environments are more prone to inadequate or low-quality teaching resources, insufficient lighting, compromised safety measures, inadequate ventilation or air conditioning, shared learning materials, and students being compelled to sit on the floor[13].

Gender emerges as a factor highlighted in literature for its substantial influence on students' academic performance, particularly within scientific subjects. Gender encompasses a spectrum of physical, biological, mental, and behavioral attributes that distinguish and differentiate between the female and male populations. The significance of scrutinizing performance within the context of gender stems primarily from the socio-cultural distinctions existing between girls and boys. Certain occupations and fields have historically been labeled as male-dominated (such as engineering, arts and crafts, agriculture, etcetera), while others have been categorized as female-oriented (like catering, typing, nursing, etcetera)[14].

For a more comprehensive understanding of how to enhance Mathematics education within the classroom, delving into the diverse approaches to Mathematics instruction across various educational levels proves insightful. Each society harbours a unique teaching culture that profoundly influences students' encounters with Mathematics. Notably, instructional sessions often exhibit noteworthy variations from one society to another. While the prescribed Mathematics curriculum might remain consistent between any two societies, the methods employed to impart its content can differ significantly. Mathematics educators employ a diverse array of teaching methods and techniques in their daily interactions within the Mathematics classroom, aiming to foster greater interactivity and practicality in their instruction. The dynamic relationship between teachers and students serves as the bedrock of the educational environment. In order to foster positive interaction, educators employ strategic teaching approaches designed to render learning relevant and advantageous. Various teaching methods and techniques are at the disposal of Mathematics educators, offering a spectrum of options to choose from. Among the array of available options, several teaching methodologies can be harnessed, including the seminar method, lecture method, discovery method, deductive method, heuristic method, analytic method, synthetic method, cooperative method, laboratory method, and more. When it comes to Mathematics, instructors judiciously opt for the most suitable methods tailored to the subject's topics, content, and the specific requirements of the learners[15].

The Third International Mathematics and Science Study (TIMSS), conducted during 1994–1995, represented a substantial and all-encompassing exploration into the realm of Mathematics education and learning across various global regions[16]. This extensive study scrutinized Mathematics achievement across over forty nations. Remarkably high-ranking countries on the assessment encompassed Singapore, Korea, and Japan, with their eighth-grade average scores standing at 643, 607, and 605, respectively. Conversely, Canada, England, and the United States achieved notably lower scores, with eighth-grade mean scores of 527, 506, and 500, respectively. Subsequent iterations of the TIMSS in 1999, 2003, and 2007 revealed a consistent and enduring disparity in achievement between students in the United States and their peers in other advanced industrialized countries[17]. Conducted on a quadrennial basis, the study enrolls students from an expansive array of countries across varying grade levels. The most recent iteration took place in 2019, with the subsequent one scheduled for 2023, under the acronym TIMSS, which stands for Trends in International Mathematics and Science Study. Beyond solely assessing students' academic performance, the TIMSS investigations have also brought to light determinants that potentially elucidate disparities in achievement among different nations[18].

This analytical aspect proves particularly valuable in elucidating distinct methodologies employed in Mathematics instruction between the United States and Japan. Specifically, the study characterizes the Japanese pedagogical approach as one where educators assume a more passive role, allowing students to devise their own problem-solving procedures. Nevertheless, teachers meticulously structure and choreograph lessons to guide students toward employing recently introduced procedures. This approach could aptly be encapsulated by the term "structured problem solving". In contrast, the United States pedagogical approach does incorporate content, albeit at a less advanced level, necessitating considerably less mathematical reasoning. Instructors in the United States often present definitions of terms and showcase step-by-step procedures for solving specific problems. Students are then asked to memorize the definitions and practice the procedures[19].

In Indonesia, the learning of Mathematics within the High School Curriculum of 2013 is designed with a dual purpose. Beyond comprehending and attaining proficiency in a diverse array of mathematical concepts, students are also expected to apply this knowledge to address challenges encountered in their daily lives. Moreover, students are also anticipated to develop the capability to independently discover and grasp various mathematical concepts during their learning encounters[20]. School-based curriculum standards elucidate the necessity for students to cultivate a collection of mathematical competencies that become evident as a result of the learning process[21]. The enhancement of students' cognitive abilities is imperative to ensure a precise comprehension of Mathematics.

In Nigeria, one of the prominent organizations that conducts mathematics competitions and exams to promote mathematics improvement is the National Mathematical Centre (NMC). They organize various mathematics competitions and programs for students at different levels, including the Nigerian Mathematics & Sciences Olympiad, which is a nationwide competition designed to foster excellence in mathematics and the sciences.

Additionally, organizations like the Mathematical Association of Nigeria (MAN) also play a significant role in promoting mathematics education and organizing mathematics-related events and competitions. These organizations provide platforms for students to enhance their mathematical skills and knowledge in Nigeria. Nigeria has its own mathematics-related events and competitions that are organized by various institutions and bodies to promote mathematics education and identify talented individuals. Some of the notable ones in Nigeria include:

i. National Mathematics Competition (NMC): The National Mathematics Competition is organized by the National Mathematical Centre (NMC) in Nigeria. It is one of the most prestigious mathematics competitions in the country. The competition is open to students at both the junior and senior secondary school levels. NMC aims to promote interest in mathematics and identify and nurture young mathematical talents.

ii. Cowbellpedia Mathematics Competition: This is one of the largest mathematics competitions for students in Nigeria. Organized by Promasidor Nigeria, Cowbellpedia focuses on junior and senior secondary school students. The competition has gained popularity and is known for its challenging mathematics problems.

iii. Nigerian Mathematics and Sciences Olympiad: This competition is aimed at promoting the study of mathematics and sciences in Nigeria. It includes subjects like mathematics, physics, chemistry, biology, and computer studies. Winners often represent Nigeria at international competitions.

iv. Mathematics Without Borders (MWB) Nigeria: MWB is an international mathematics competition that also has a presence in Nigeria. It provides students with challenging mathematical problems and helps in promoting excellence in mathematics.

v. African Mathematics Millennium Science Initiative (AMMSI): Although not a competition in itself, AMMSI organizes workshops, conferences, and programs to support mathematics research and education in Nigeria and across Africa. These events bring together mathematicians and students to foster learning and research in mathematics.

vi. Regional Mathematics Olympiad (RMO): Nigeria also participates in the Regional Mathematics Olympiad, which serves as a qualifying competition for the International Mathematical Olympiad (IMO). Winners of the RMO represent Nigeria at the IMO, competing against students from around the world.

A prominent hurdle encountered in the teaching and learning process pertains to discerning the most effective teaching approaches and strategies that harmonize with students' individual learning styles. A teaching method encompasses the principles and techniques employed by educators to facilitate students' learning. These strategies are influenced both by the subject matter being taught and the inherent characteristics of the learners. In order for a specific teaching approach to be effective and fitting, it needs to align with the attributes of the learners and the desired outcomes of the learning process. Consequently, the design of instruction and the choice of teaching methods must consider not only the inherent nature of the subject matter but also the intricacies of how students engage in the learning process[21]. This study aims to determine the more effective teaching strategy using inductive and deductive teaching strategies.

The inductive approach involves presenting a mathematical context that includes the target rules, enabling students to deduce these rules through practical examples and contextual understanding. In essence, this approach progresses from setting up a scenario and offering illustrative instances to reaching a broader generalization. In this process, students either independently or with the guidance of the teacher, uncover such generalizations. In the inductive approach, educators present a series of examples to students, prompting them to recognize patterns and formulate generalizations or concept rules. This approach follows a trajectory from the specific to the general. Learners are initially presented with multiple examples showcasing a particular mathematical structure across diverse contexts. Their task is to deduce the underlying rules themselves. Subsequently, these rules are applied in various exercises and contexts to deepen their understanding of how they operate in practice.

The deductive approach to teaching Mathematics involves initially presenting students with the mathematical rules, which are subsequently employed in problem-solving. In this method, the teacher proceeds from the broader scope of general rules to the narrower realm of specific applications, resembling what can informally be termed a "top-down" approach.

Within the deductive approach, a mathematical rule is initially introduced explicitly by the teacher, followed by examples showcasing the application of the rule. Subsequently, students engage in practicing the rule through a variety of exercises. In essence, this method moves from providing general information to progressively delving into more specific details. The deductive approach serves to facilitate the learners' grasp by enabling them to discern patterns and trends that might otherwise remain unnoticed. This is accomplished by offering learners clear interpretations of rules and allowing them time to internalize these rules before being required to apply or generate structures that they may not yet fully comprehend. Additionally, this approach affords teachers a streamlined and efficient way to impart rules, creating more room for dedicated practice of the underlying concepts.

The academic performance of college students in Basic General Mathematics across three consecutive sessions (2019/2020, 2020/2021, and 2021/2022) was evaluated based on available records. A comprehensive analysis indicates a consistent decline and below-par achievement rate in the pass percentages within the three chosen Colleges located in Oyo State. Specifically, at Emmanuel Alayande College of Education, a total of two thousands one hundred and forty two (2,142),two thousands and fifty four (2,054), and one thousand five hundred and twenty six (1,526) students participated in the Basic General Mathematics examinations during the three consecutive sessions. The corresponding counts of students who successfully passed were one thousand nine hundred and seventy two (1,972), one thousand eight hundred and forty nine (1,849) and one thousand three hundred and forty three (1,343) respectively. A similar trend was observed in Federal College of Education (Special), Oyo, where three thousands and nineteen (3,019), two thousand five hundred and eighty four (2,584) and two thousands four hundred and seventy five (2,475) students took the examinations across the three sessions. Out of these, the counts of students who secured passing grades were two thousand eight hundred and thirty eight (2,838), two thousands three hundred and seventy seven (2,377) and two thousand and two hundred (2,200). Similarly, at Oyo State College of Education, Lanlate, the number of students who sat for Basic General Mathematics in the three sessions were six hundred and forty two (642), six hundred and twenty five (625) and four hundred and eighty nine (489). Among them, six hundred and ten (610), five hundred and seventy five (575) and four hundred and thirty five (435) students respectively achieved passing scores. Refer to Appendix 1 for detailed information[22]. This study will look into how inductive and deductive teaching strategies affect students' academic achievement in Oyo's Colleges of Education in Basic General Mathematics.

1.2 Statement of the Problem

The academic performance of students in Basic General Mathematics across Nigerian Colleges of Education has exhibited a noticeable decline over time. This discouraging trend has raised concerns among various education stakeholders. Multiple factors contribute to this issue of low academic achievement in Basic General Mathematics, these include the teaching methods employed by educators and the class sizes. In light of these challenges, this study aims to address this issue by implementing specific teaching strategies to intervene and rectify the problem. As such, the study focuses on investigating the effects of inductive and deductive teaching strategies on students' academic achievement in Basic General Mathematics within Colleges of Education located in Oyo State.

1.3 Aim and Objectives of the Study

The aim of this study is to investigate the effect of inductive and deductive teaching strategies on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State.

The objectives of the study are to:

i. determine the frequency distribution on students' academic achievement on Basic General Mathematics in Colleges of Education in Oyo State.

ii. examine the effect of :

   a. inductive teaching strategy,

   b. deductive teaching strategy and

   c. conventional teaching strategy

   on students' achievement in Basic General Mathematics in Colleges of Education in Oyo State.

iii. investigate the effect of :

   a. gender and

   b. class size

   on students' achievements in Basic General Mathematics in Colleges of Education in Oyo State.

iv. identify the interaction effect of treatment (inductive and deductive teaching strategies) and gender on students' achievements in Basic General Mathematics in Colleges of Education in Oyo State.

v. identify the interaction effect of treatment (inductive and deductive teaching strategies) and class size on students' achievements in Basic General Mathematics in Colleges of Education in Oyo State.

vi. identify the interaction effect of treatment (inductive and deductive teaching strategies), gender and class size on students' achievements in Basic General Mathematics in Colleges of Education in Oyo State.

1.4 Research Question

1. What are the frequency distribution of students' achievements for pre-test and post-test in Basic Mathematics Achievement Test (BMAT)?

1.5 Hypotheses

Based on the stated problems, the following hypotheses will be tested at a 0.05 level of significance

$H_0$1: There will be no significant main effect of:

i. Inductive teaching strategy
ii. Deductive teaching strategy
iii. Conventional teaching strategy

on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State.

$H_0$2: There will be no significant main effect of:

i. Gender
ii. Class size

on students' academic achievement in Basic General Mathematics in

Colleges of Education in Oyo State.

$H_0$3: There will be no significant interaction effects of treatment (inductive, deductive and conventional teaching strategies) and Gender on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State.

$H_0$4: There will be no significant interaction effects of treatment (inductive, deductive and conventional teaching strategies) and Class Size on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State.

$H_0$5: There will be no significant interactions effects of gender and class size on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State.

$H_0$6: There will be no significant interactions effects of treatment (inductive, deductive and conventional teaching strategies), Gender and Class Size on Student Academic Achievement.

1.6 Significance of the Study

The current study aims to delve into the effectiveness of inductive and deductive teaching approaches in enhancing students' academic performance in Basic General Mathematics at the NCE (Nigeria Certificate in Education) levels of education. By conducting this research, Mathematics educators, instructors, and researchers will gain a deeper understanding of which teaching strategy aligns best with the students' level of achievement. Furthermore, the study will facilitate the cultivation of a constructive perspective among teachers toward students' achievements. This study holds the potential to inform teaching practices and strategies that optimize students' learning outcomes and overall engagement in Mathematics education.

Furthermore, it is expected that the outcomes of this study will offer empirical insights into the influence of these variables on students' academic achievements. Educators stand to benefit from the results of this research, as the findings will provide them with valuable information regarding the significance of employing both inductive and deductive teaching methods. This enhanced understanding can guide teachers in making informed choices about instructional approaches, ultimately contributing to improved teaching practices and student learning outcomes.

In addition, this study holds relevance for policymakers within the education sector, aiding them in formulating effective and efficient decisions concerning educational practices within the country. Furthermore, the study could serve as a foundational resource for future research endeavors, paving the way for continued exploration and advancement in the field of Mathematics education. The insights gained from this study have the potential to inform policy directions and scholarly investigations aimed at enhancing the quality of education and student achievements in the long term.

1.7 Scope of the Study

The study encompasses the entire population of Year Two students within Colleges of Education situated in Oyo State. The content scope focuses specifically on the topic of expansion and factorization of algebraic expressions in the context of Basic General Mathematics as taught in Colleges of Education in Oyo State. Geographically, the study's purview is confined to Oyo State, located in the Southwestern region of Nigeria. The institutions under examination comprise Emmanuel Alayande College of Education, Oyo and Oyo State College of Education, Lanlate which are state owned government and Federal College of Education (Special), Oyo, which are all located in Oyo State.

1.8 Limitation of the Study

The study's primary objective centers around investigating the effects of inductive and deductive teaching strategies on students' academic achievements in the realm of Basic General Mathematics. This exploration is specifically conducted within the context of three Colleges of Education located in Oyo State, namely Emmanuel Alayande College of Education, Oyo, Oyo State College of Education, Lanlate and Federal College of Education (Special), Oyo.

1.9 Operational Definition of Terms

The following terms were operationally defined as they were used in the study:

Students' Academic Achievement: Students' academic achievement refers to the extent to which a learner has attained in Basic General Mathematics.

Inductive Teaching Strategy: This is an umbrella term that encompasses a range of instructional methods, including inquiry learning, problem-based learning, case-based teaching, discovery learning, and just-in-time teaching of Basic General Mathematics.

Deductive Teaching Strategy: This is a teaching method which leads us from particular to general, and unknown to known in Basic General Mathematics.

Conventional Teaching Method: This refers to the traditional method of teaching where teachers and learners meet in a classroom setup for teaching-learning process to take place. This often includes whole-class lectures, teacher-led instruction, pre-planned units, plenty of structures, objective modes of assessment such as grades in Basic General Mathematics.

Colleges of Education: The College of Education is one of the tripods of tertiary education in Nigeria with the primary roles of training teachers who will be awarded the minimum teaching qualification of Nigerian Certificate of Education (NCE). In this study, NCE II students will be considered.

Basic General Mathematics: This is one of the courses offered at all levels in Colleges of education. In this study, Year two students are used and algebra was considered (Expansion and Factorizing of Algebraic Expression) which was done in their year one second semester.

Experimental Group: The group that will be taught Basic General Mathematics by the researchers through inductive and deductive teaching strategies.

Control Group: The control group is the group that taught Basic General Mathematics by the researcher using conventional teaching strategy.

Gender: It refers to the categorization of students as either male or female. It is a moderating variable that is included to investigate whether the effect of inductive and deductive teaching strategies on students' academic achievement in Basic General Mathematics varies between male and female students. This variable will be recorded as "male" or "female" to distinguish between the two categories of students.

Class Size: Class size, as used in this research, represents the number of students present in a classroom during the experiment. It is a moderating variable included to explore whether the influence of inductive and deductive teaching strategies on students' academic achievement in Basic General Mathematics differs based on class size. Class size will be quantified as the actual number of students in each classroom under investigation. The small class size is less than forty (40) while large class size is above forty (40).

Endnotes

1. S. B. A. Muhammad, Y. Razia & M. Zeeshan, *The Impact of Technology Integration on Student Engagement and Achievement in Mathematics Education: A Systematic Review,* **International Journal of Computer Integrated Manufacturing** 6(3), March 2023, 222-2322, Available online: https://www.researchgate.net/publication/370446167

2. E. O. Onoshakpokaiye, *Functional Mathematics Skills: An Essential Tool for Functional Education and Development in Nigeria*, **Education Research Highlights in Mathematics, Science and Technology**, 2020, 105-119.

3. A. F. Crăciun, A. M. Țăran, G. G. Noja, M. G. Pirtea, & R. I. Răcătăian, *Advanced Model Public Governance and Digital Transformation: New Empirical Evidence from Structural Gaussian and Mixed-Markov Graphical Models*. **Mathematics**, *11*(5), 2023, 1168.

4. C. De Lima, D. Belot, R. Berkvens, A. Bourdoux, D. Dardari, M. Guillaud, & H. Wymeersch, *Convergent Communication, Sensing and Localization in 6G Systems: An Overview of Technologies, Opportunities and Challenges*. **IEEE Access**, 9, 2021, 26902-26925.

5. C. L. Protin, *Ancient Natural Deduction*, 2022, arXiv preprint arXiv:2209.03388.

6. NCCE, Federal Republic of Nigerial. National Commission for Colleges of Education, Nigeria Certificate in Education Minimum Standards for NCE Teachers 2020 Edition.

7. D. H. Tong, T. T. Nguyen, B. P. Uyen, L. K. Ngan, L. T. Khanh, & P. T. Tinh, *Realistic Mathematics Education's Effect on Students' Performance and Attitudes: A Case of Ellipse Topics Learning*. **European Journal of Educational Research**, 11(1), 2022, 403-421.

8. O. N. Jacob & H .Onoge, *Administration of Mathematics Programme in Nigerian Higher Institutions: Issues, Challenges and Ways Forwards*, **Central Asian Journal of Mathematical Theory And Computer Sciences,** 2(3), 2021, 27-36. https://cajmtcs.centralasianstudies.org/index.php/CAJMTCS/article/view/67

9. S. G. Ojo.,*Generating and Sustaining Interest of Students in Math ematics in Secondary School*, **The Journal of Mathematics Association of Nigeria: Abacus (Mathematics Education Series)** 47(1), 2022, 99-114.

10. F. C. Nworah & C. D. Oragade, *Prospect and Challenges of Mathematics Education in the Modern Globalized Curriculum in Globalized Curriculum Methods for Modern Mathematics Education*, **IGI Global**, 2019, 93-106.

11. S. Okwelogu Izunna, & O. N. Jacob, *Science Education in Nigerian Public Universities: Challenges and Way Forward.* **International Journal on Economics, Finance and Sustainable Development,** 3(9), 2021, 38-45.

12. S. F. Paulino, *Mathematical Language in the Modeling Learning Process in the Technologic Course in Fashion Design: A Case Study at a Private College in Recife-PE*. **Revista de Ensino em Artes, Moda e Design,** 4(2), 2020, 252-270, Available Online: https://www.revistas.udesc.br/index.php/ Ensinarmode/article/download/17748/11511.

13. M. I. Obiakor & N. Chidumebi, *Impact of Classroom Size on Academic Performance of Secondary School Students in Enugu North Local Government Area of Enugu State, **Nigeria*** **African Journal of Educational Management, Teaching and Entrepreneurship Studies**. 1(1), 2020,

14. M. A. Mustapha, M. Kachallah and F. A. Abulfathi, *Relationship Between Class Size and Students` Academic Performance in English Language,* **Journal of Curriculum and Media Technology Research (J-CUDIMAC),** 9 (1), 2021, 1-9.

15. K. L. W. Roberts, "*The Experiences of Male Early Childhood Teachers: Navigating Suitability to Teach",* (**Doctoral dissertation, Edgewood College**), 2021.

16. M. J. Cardino Jr., & A. R. Ortega-DelaCraiz, *Understanding of Learning Styles and Teaching Strategies Towards Improving the Teaching and Learning of Mathematic,* **LUMAT: International Journal on Math, Science and Technology Education**. Issue 8(1), 2020, 19-43. Published by the University of Helsinki, Finland / LUMA Centre Finland | CC BY 4.0.

17. B. Boman, *Educational Achievement Among East Asian Schoolchildren 1967–2020: A Thematic Review of the Literature*. **International Journal of Educational Research Open,** 3, 2022, 100168. Available Online: https://www.sciencedirect.com/science/article/pii/S2666374022000462.

18. P. McDermott, & A. Harris, *Teacher Professional Development for Pedagogical Change: A Systematic Review of the Literature*. **Teaching and Teacher Education**, 104, 2021, 103-413.

19. J. Jerrim, S., Sims & M. Oliver, *Teacher Self-Efficacy and Pupil Achievement: Much Ado About Nothing? International Evidence From TIMSS,* **Teachers and Teaching,** 29(2), 2023, 220-240.

20. K. Melhuish, T. Fukawa-Connelly, P. C. Dawkins, C. Woods, & K. Weber*, Collegiate Mathematics Teaching in Proof-Based Courses: What We Now Know and What We Have Yet To Learn,* **The Journal of Mathematical Behavior**, 67, 2022, 100986.

21. E. Zahara, A. Murni, & N. M. Hutapea, *Development of Mathematics Learning Tools by Implementing Numbered Head Together Type Cooperative Models to Improve*

Students' Mathematical Understanding Ability in Matrix Topic. **Journal of Educational Sciences**, 4(2), 2020, 250-260. P-ISSN 2581-1657, E-ISSN 2581-2203.
.

22. N. M. Hutapea, *Improving Senior High School Students Learning Autonomy Through Generative Learning*, **Journal of Educational Sciences**, 3(1), 2019, 84-95.

Chapter Two

Literature Review

The review of related literature is discussed under the following subheadings:

2.1 Conceptual Review

2.1.1 Students' Achievement

2.1.2 Concept of Class-Size

2.1.3Concept of Gender

2.1.4Concept of Basic General Mathematics

2.1.5 Inductive Teaching Strategy

2.1.6 Deductive Teaching Strategy

2.2 Theoretical Framework

2.2.1 Constructive Learning Theory

2.3 Review of Empirical Studies

2.3.1 Class size and Students' Achievement

2.3.2 Gender and Students' Achievement

2.4 Conceptual Model

2.5 Summary of Gap in Literature Reviewed

2.1 Conceptual Review

2.1.1 Students' Achievement

Academic achievement refers to a student's performance in educational settings, typically measured through grades, test scores, and other indicators of learning and knowledge acquisition. It is a critical aspect of a person's educational journey and can significantly impact future opportunities and success[1]. It encompasses a wide range of outcomes, including grades, test scores, class rankings, and overall knowledge acquisition. It can also extend beyond formal assessments to include critical thinking, problem-solving abilities, and practical application of knowledge[2]. Academic achievement is a complex and multifaceted concept influenced by various factors such as:

a. Individual factors which include a student's innate abilities, motivation, study habits, and attitude toward learning; growth mindset, where students believe in their ability to improve through effort, can positively impact their academic achievement in mathematics[3].

b. Socioeconomic factors which encompasses family income, parental education, and access to educational resources can significantly affect a student's academic success. Students from lower socioeconomic backgrounds may have limited access to resources, such as tutoring or educational materials, which can affect their mathematics achievement. Students from disadvantaged backgrounds may face more significant challenges[4].

c. Teacher Quality: effective teachers can inspire and guide students to excel academically; a supportive and skilled teaching environment is crucial[5].The teacher attitudes and biases, whether conscious or unconscious, can impact how they interact with students. This can affect a student's self-esteem and, consequently, their mathematics achievement.

d. The academic performance of peers can also influence students. Positive peer relationships and a culture of academic excellence can motivate students to achieve more in the subject while a negative social environment can have the opposite effect[6].

Students' academic achievement is promoted by regular assessment and constructive feedback the integration of technology into education[7]. Digital platforms, educational apps, and online courses offer opportunities for self-paced learning. Students' mental and emotional well-being must also be considered, high levels of stress and pressure can have adverse effects on academic performance[8]. Promoting a balanced approach to education is essential. Academic achievement in mathematics is achievable through a combination of effective teaching strategies, a supportive learning environment, and a focus on conceptual understanding[9]. Addressing math anxiety, providing differentiated instruction, and leveraging technology are some of the ways educators can help students excel in mathematics and develop essential problem-solving skills for the future[10].

The issue of academic achievement among students in Nigerian schools has garnered significant attention in the realm of education. When addressing this matter, it is crucial to delve into the root causes of the problem. Numerous factors have been examined as the underlying triggers for investigating the occurrences of both academic success and failure in mathematics within the educational system. These factors have been analyzed from various angles, encompassing elements such as students' attitudes, gender disparities, teachers' skill sets, pedagogical approaches employed by educators, parental and familial impact, school environment and location, inadequate educational funding, and more[11].

The focal point of the research revolves around students' academic achievement in

Basic General Mathematics, while variables such as gender and class size are considered moderating factors due to their potential influence on academic achievement. The research also considers inductive and deductive teaching strategies as the independent variables.

2.1.2 Concept of Class-Size

The term "class size" refers to the number of students enrolled in a particular class or learning environment, with variations spanning from small groups to larger cohorts. It is a multifaceted concept that intersects with various aspects of education, encompassing pedagogy, classroom management, resource allocation, and student outcomes[12]. Class size is an indispensable factor in the realm of education, wielding a profound influence on the teaching and learning process[13]. It is a variable that permeates every educational setting, from primary schools to higher education institutions, and plays a pivotal role in shaping the educational experience of both teachers and students.

Class size is often viewed through the lens of instructional effectiveness. Class size is measured as a student-teacher ratio, which indicates the number of students per teacher[15]. A lower student-teacher ratio generally allows for more individualized attention and support for students Smaller classes are believed to offer advantages such as increased individualized attention from teachers, enhanced opportunities for student engagement, and potentially improved academic outcomes. On the contrary, larger classes may present challenges in maintaining an optimal teacher-to-student ratio, potentially leading to reduced student-teacher interaction and a greater strain on educational resources. While smaller classes can provide more opportunities for teacher-student interaction and personalized instruction[16], the impact on student achievement may vary depending on various factors, including teacher quality, instructional methods, and grade level. Students with special needs, such as those with disabilities, may benefit from smaller class sizes, as it allows for more tailored support and accommodations[17]. Smaller classes can be easier to manage for teachers, as it may lead to fewer behavioral issues and disruptions[18]. This can create a more conducive learning environment.

Additionally, class size can intersect with social and demographic factors, impacting equity in education[19]. Class size can vary widely based on socioeconomic factors[20]. Schools in disadvantaged communities may have larger class sizes due to resource constraints, potentially exacerbating educational inequalities. Reducing class sizes can require additional resources, including hiring more teachers and building more classrooms. This can be a significant financial consideration for educational institutions Research has suggested that students from marginalized backgrounds may benefit more from smaller class sizes, as it can mitigate disparities in educational attainment. Class size is a critical factor in education and has significant implications for both students and teacher[21]. The COVID-19 pandemic has brought attention to class size as schools implemented remote and hybrid learning models[22]. Maintaining smaller in-person class sizes has been a challenge to ensure social distancing and safety[23]. Online classes can accommodate larger numbers of students, but effective online teaching strategies are crucial to maintaining engagement and learning outcomes[24]. Therefore, the implication of class size is crucial for ensuring that education remains accessible and equitable for all.

The relationship between class size and mathematics achievement is a topic that has been studied extensively. While the impact of class size on student achievement can vary depending on several factors, including grade level and teaching methods. Smaller class sizes often provide students with more individualized attention from teachers, allowing for better opportunities to ask questions, receive help, and engage in discussions. This can lead to improved mathematics achievement, especially in early grades. Research has shown that reducing class size in elementary schools, where foundational mathematics skills are taught, can have a positive impact on student performance. Students in smaller classes may benefit from increased teacher-student interaction. In some cases, the benefits of further reducing class size may diminish beyond a certain point. The relationship between class size and achievement tends to be more pronounced in very large classes, but the effects become less significant as class size decreases below a certain threshold. The effectiveness of a teacher plays a crucial role in student mathematics achievement. Smaller class sizes can be more effective when combined with high-quality teaching methods and well-prepared educators. Reducing class size significantly can be expensive, and education budgets often limit the feasibility of maintaining very small classes. Schools may need to balance the benefits of smaller class sizes with other educational priorities. Some students may benefit more from smaller classes, especially those who require additional support, have learning disabilities, or are struggling with mathematics. Smaller classes can allow for more targeted interventions. It is important to note that while smaller class sizes can have a positive impact, they are just one factor among many that influence mathematics achievement. Effective teaching methods, curriculum design, and addressing other social and individual factors are also critical in improving mathematics outcomes.

2.1.3 Concept of Gender

Gender, as a multifaceted and intricate aspect of human identity, has permeated every corner of society[24]. It is an integral part of the social fabric, influencing behavior, expectations, and opportunities[25]. Understanding gender is not just a matter of acknowledging the binary distinction between male and female; rather, it entails recognizing the complex interplay of biological, social, cultural, and psychological factors that shape an individual's sense of self and their role in society[26]. Gender, a fundamental aspect of human identity, transcends mere biological distinctions. It is a complex social construct that encompasses a spectrum of roles, behaviors, and expectations assigned to individuals based on their perceived masculinity or femininity. Gender is deeply intertwined with culture, history, and societal norms, shaping how people perceive themselves and interact with the world[27].

In its essence, gender transcends the mere classification of individuals as male or female. It encompasses a spectrum of identities and expressions, from masculinity to femininity and everything in between[28]. These identities can be fluid, evolving, and unique to each person. The study of gender goes beyond the surface, delving into the intricate web of norms, stereotypes, and expectations that society has woven around these identities. In conclusion, gender is a multifaceted concept that permeates every aspect of society, including education. Recognizing its intricate nature and its potential impact on teaching and academic achievement is crucial for creating an equitable educational system. Some key aspects of the concept of gender are:

i Gender identity is an individual's deeply held sense of their own gender, which may or may not align with the sex assigned to them at birth[29]. Some people identify as cisgender, where their gender identity aligns with their assigned sex, while others identify as transgender, where there is a disconnect between their gender identity and assigned sex.

ii Gender expression refers to the way individuals outwardly express their gender identity, which can include clothing, mannerisms, speech patterns, and more[30]. It can be diverse and is not necessarily tied to one's biological sex.

iii Gender roles are societal expectations and norms regarding how individuals of different genders should behave and the roles they should fulfill[31]. These roles can vary significantly across cultures and time periods.

iv Gender stereotypes are preconceived notions and beliefs about what is considered typical or appropriate for individuals of different genders[32]. These stereotypes can be limiting and contribute to inequality and discrimination.

v Traditionally, many societies have adhered to a binary understanding of gender, recognizing only male and female. However, a more inclusive perspective acknowledges that gender exists on a spectrum, with a wide range of gender identities beyond just male and female[33].

vi Gender intersects with other aspects of identity, such as race, ethnicity, class, sexual orientation, and disability. This intersectionality can lead to unique experiences and challenges for individuals[34].

vii Legal and social recognition of gender identity varies around the world[35]. Many countries have made efforts to acknowledge and protect the rights of transgender and non-binary individuals, including legal recognition of gender changes and protections against discrimination.

viii Gender equity advocates work to address inequalities and discrimination based on gender[36]. Feminism is a movement that seeks to promote the rights and equality of women but has evolved to encompass a broader range of gender-related issues.

It's important to note that discussions about gender are evolving, and there is increasing recognition that gender is not solely determined by biological factors but is shaped by social and cultural influences. Respect for diverse gender identities and expressions is a fundamental aspect of promoting inclusivity and equality in society.

Gender and mathematics achievement have been a subject of study and discussion for many years. There have been gender differences in mathematics achievement, with some studies showing that, on average, boys have outperformed girls in mathematics. However, these differences have been diminishing over the years and have become much less pronounced in recent research. Stereotype threat can impact gender differences in math achievement. When individuals believe in gender stereotypes suggesting that one gender is superior in mathematics, it can create anxiety and hinder performance, particularly for girls. Addressing and dispelling such stereotypes is important[36]. Cultural and societal norms can influence gender differences in mathematics achievement. In some cultures, girls have been discouraged or faced barriers in pursuing mathematics-related fields, affecting their achievement. Promoting gender equality in education can help mitigate these issues. There is significant individual variation within genders. While there may be average differences in mathematics achievement between boys and girls, many girls excel in mathematics, and many boys may struggle with the subject. Recognizing and supporting individual abilities and interests is crucial.

The effective teaching methods and curriculum design can impact the achievement of both genders in mathematics. This ensures that mathematic instruction is engaging and accessible to all students can help close achievement gaps. The teacher attitudes and biases can also play a role in gender differences in mathematics achievement. It's important for educators to provide equal opportunities and encouragement to all students, regardless of their gender.

2.1.4 Concept of Basic General Mathematics

Basic general mathematics is an essential set of skills that empowers individuals to navigate and make informed decisions in a numerically driven world. It forms the foundation for more advanced mathematical learning and is integral to many aspects of daily life and professional development. It encompasses a wide range of mathematical topics and principles that are relevant to various aspects of daily living, problem-solving, and decision-making. Here are some key aspects of the concept of basic general mathematics:

1. Arithmetic: Arithmetic is the foundation of basic mathematics and includes operations such as addition, subtraction, multiplication, and division. These operations are used in everyday tasks like budgeting, shopping, and cooking.

2. Numeracy: Numeracy is the ability to work with numbers effectively. This includes understanding number relationships, estimating quantities, and interpreting numerical information, such as percentages and fractions.
3. Measurement: Measurement involves concepts related to length, area, volume, weight, time, and temperature. Understanding measurement is crucial for tasks like construction, cooking, and understanding weather reports.
4. Geometry: Basic geometry includes concepts such as shapes, angles, and properties of two- and three-dimensional figures. It's relevant for activities like home improvement, navigation, and understanding spatial relationships.
5. Data Interpretation: Basic mathematics includes the ability to interpret and analyze data, including reading and creating simple graphs and charts. This skill is essential for making informed decisions based on data.
6. Algebraic Concepts: While basic mathematics may not delve deeply into algebra, understanding basic algebraic concepts like equations, inequalities, and variables can be valuable for solving real-world problems.
7. Financial Literacy: Basic mathematics plays a crucial role in financial literacy, including budgeting, saving, understanding interest rates, and making informed financial decisions.
8. Problem Solving: Basic mathematics is a key tool for problem-solving in various domains, from everyday challenges to workplace tasks

9. Practical Applications: Basic mathematics is used in a wide range of professions and industries, including science, engineering, healthcare, finance, and more. It provides a common language for solving problems and communicating ideas.
10. Life-Long Learning: Basic general mathematics is not limited to formal education; it is a skill set that individuals can continue to develop and apply throughout their lives to meet evolving needs and challenges.

2.1.5 Inductive Teaching Strategy

The inductive method centers around the principle of induction, which involves establishing a universal truth by demonstrating that if a specific case holds true and remains true across a sufficiently representative range of cases, then it holds true for all instances of its kind. Utilizing an inductive teaching strategy can prove highly effective in facilitating students' acquisition of mathematical knowledge. This pedagogical approach prioritizes student engagement and participation, fostering an environment where learners take an active role in their educational journey. Such a method aids in the cultivation of critical thinking skills and problem-solving abilities among students. Within this approach, the initial stage entails resolving a problem based on the learner's existing knowledge, thought processes, reasoning, and insights. It is also known as a 'bottom up approach[37]. During this phase, the student lacks familiarity with any specific formula, principle, or technique for addressing the given problem. Presented with a substantial collection of comparable examples, facts, or entities, learners undertake the task of independently deducing a generalized solution for all instances. Hence, they attain a broad conclusion or formulate an equation by employing a persuasive method of logical deduction and resolving numerous analogous challenges[38].

Within this approach, instructors refrain from furnishing students with predefined rules and equations. Instead, learners are exposed to a range of facts and instances. From these instances, they are tasked with deducing rules or devising overarching formulas. This process thus involves formulating a formula through the examination of a sufficient quantity of specific examples. Consequently, the inductive teaching method guides us from the familiar to the unfamiliar, specific to general, and from instances to comprehensive principles. Once a multitude of specific scenarios have been comprehended, the learner gains the capability to venture into generalizations independently. Various manifestations of inductive teaching strategies exist, encompassing approaches such as discovery learning, inquiry-based learning, problem-based learning, project-based learning, case-based instruction, and just-in-time teaching[37].

A comprehensive examination of the conceptual framework and foundational research for inductive teaching has extended to exploring its application within Engineering education. Additionally, the role of other student-centered methodologies, such as active and cooperative learning, in the context of inductive teaching has been subject to investigation. The shared characteristic among various inductive methods is the presentation of a challenge to students, prompting them to acquire the necessary knowledge to tackle the challenge. These methods diverge in terms of the complexity and extent of the challenge, as well as the level of guidance provided by instructors as students strive to overcome the challenge. Inductive approaches manifest in numerous forms, each of which can be executed with varying degrees of instructor participation, and may involve formal facilitation of teamwork or not, with tasks completed predominantly within or outside the classroom, and so forth. The subsequent sections provide a synopsis of findings from such meta-analyses.

i. Inquiry-based learning, also referred to as inquiry-guided learning or guided inquiry, involves presenting students with a specific challenge. This challenge could take the form of a question requiring an answer, an observation or dataset necessitating interpretation, or a hypothesis demanding testing. Through the act of addressing this challenge, students attain the intended learning outcomes. Like other inductive techniques, the information essential for addressing the challenge isn't directly conveyed in prior lectures or readings; however, it often draws upon pre-existing knowledge. Research has consistently shown that inquiry-based learning tends to outperform traditional science instruction in enhancing academic achievement and fostering the growth of critical thinking, problem-solving, and laboratory skills[40].

ii. Problem-based learning, often abbreviated as PBL, initiates by presenting students with an open-ended, complex, real-world problem. Collaborating in teams, students ascertain their learning requirements and formulate a viable solution. Instructors assume the role of facilitators, prioritizing guidance over being the main dispensers of information. The range of problems in problem-based learning can vary widely in terms of their extent, encompassing single-topic, single-discipline issues solvable within a few days, as well as multidisciplinary challenges that might require an entire semester for resolution [41].

iii. Project-based learning and its hybrid forms: Project-based learning commences by assigning one or more tasks that culminate in the creation of a final product a design, model, device, or computer simulation. The project concludes with a written and or oral report that outlines the procedure employed in crafting the product and presents the resultant outcome. Notably, the abbreviation PBL is commonly used to signify both project-based learning and problem-based learning. An inherent trade-off emerges between instructors adopting a relatively directive approach in selecting projects, ensuring alignment with course and curriculum objectives, and providing students the liberty to independently determine their project concepts and strategies, which can enhance their motivation[42].

iv. Case-based teaching: Within case-based teaching, students engage with the analysis of case studies that pertain to historical or hypothetical scenarios involving problem-solving and/or decision-making. These cases ought to authentically represent situations anticipated in real professional contexts and can be sourced from narratives in newspapers, magazines, or constructed through interviews with individuals directly involved in the depicted situations[43].

v. Discovery learning: Discovery learning represents an inquiry-based strategy wherein students receive a question to address, a problem to solve, or a collection of observations to elucidate. Subsequently, they operate in a largely self-directed manner to fulfill their assigned tasks and deduce appropriate inferences from the results, effectively "discovering" the essential factual and conceptual knowledge throughout the process. In this method, students are presented with a challenge and left to navigate the solution independently. While the instructor may offer feedback in response to student endeavors, minimal to no guidance is provided before or during these endeavors. The distinct characteristics of discovery learning, compared to other inductive approaches, encompass the absence of structured instruction and guidance from the instructor, and the consequential reliance on trial and error by students. This particularly rigorous form of inductive teaching was developed primarily for pre-college education and has been seldom employed in undergraduate courses, with limited empirical support for its effectiveness within that context[44].

vi. Just-in-time teaching: Just-in-time teaching, commonly known as J.I.T.T., integrates web-based technology with active learning strategies in the classroom environment. Students independently engage with web-based assignments a few hours before the class, providing answers to specific questions. The instructor evaluates their responses ahead of the class and adapts the lesson plan accordingly, guaranteeing its immediacy and pertinence. This cyclical process is repeated several times each week. The incorporation of questions to guide the learning trajectory defines the inherently inductive nature of this approach[45].

In summary, the traditional approach to science and engineering education is deductive, commencing with the introduction of fundamental principles in lectures and progressing towards students practicing and applying the lecture material. In contrast, the teaching methodologies addressed in this document namely inquiry learning, problem-based learning, project-based learning, case-based teaching, discovery learning, and just-in-time teaching take an inductive route. They commence with observations requiring interpretation, queries seeking answers, issues necessitating resolution, or case studies demanding analysis.

The knowledge, techniques, and proficiencies that the course aims to impart are acquired by students, with varying levels of instructor guidance, through engagement with these exercises.

Steps in Inductive Teaching Strategy

By using inductive method following steps are used:

a. Presentation of Examples: As the initial phase, the teacher showcases numerous instances of a similar nature, and the solutions to these particular examples are collaboratively obtained with the involvement of the students.

b. Observation/Reflection: Following the resolution of numerous specific examples, students engage in discerning and reflecting upon these instances, striving to derive certain conclusions.

c. Generalization (Simplification): At this juncture, both the educator and students pool their collective observations, systematically extracting common rules, laws, formulae, or principles through reasoned collaborative discussions.

d. Testing and verification (authentication): In the fourth step, students assess and validate the identified law, rule, or principle by subjecting it to examination using other suitable specific examples. This meticulous process enables students to logically attain proficiency in the inductive method, following the aforementioned steps.

Advantages and Disadvantages of Inductive Teachings Strategy

In general the advantages and disadvantages of inductive strategy to teaching are summarized below:

Advantages of an Inductive Teaching strategy

i. Enhanced Cognitive Depth and Memory Ability: The involvement of mental effort leads to heightened cognitive depth, subsequently facilitating greater memory capacity[46].

ii. Fosters Pattern Recognition and Problem-Solving: This approach particularly supports learners with an inclination towards pattern recognition and problem-solving, making it suitable for those who enjoy such challenges[47].

iii. Active Involvement and Increased Motivation: Students become active participants in the learning process, transcending the role of passive recipients. This heightened involvement results in improved attentiveness and motivation.[37].

iv. Meaningful and Memorable Rules: Rules that students discover on their own tend to align more effectively with their existing cognitive frameworks compared to rules presented to them. This alignment enhances the meaningfulness, memorability and practical utility of the acquired rules[48].

v. Cultivates Self-Reliance and Autonomy: Encouraging students to deduce solutions for themselves prepares them for greater self-reliance and autonomy, contributing to their overall development[49].

Disadvantages of an Inductive Teaching Strategy

i. Considerable time and effort are expended in collaboratively deriving rules alongside students.[50].

ii. The duration spent on formulating a rule might detract from the time available for implementing the rule in a productive manner[50].

iii. Teachers might be required to develop a lesson plan that involves the careful selection and organization of data. This process aims to lead students towards a precise understanding of a rule, all the while guaranteeing that the data remains comprehensible[51].

iv. An inductive approach can be frustrating for students who prefer straightforward rule presentation[52].

v. Students might hypothesize an incorrect rule, or their interpretation of the rule could be either overly general or excessively restricted in its application[53].

2.1.6 Deductive Teaching Strategy

Deductive teaching strategy is a method of teaching in which students are introduced to a broad principle, regulation, or idea at the start of a lesson. Subsequently, particular instances and uses of this principle are furnished to aid students in comprehending and employing the overarching concept. Essentially, it entails transitioning from a comprehensive statement to distinct occurrences or deductions. This approach is frequently utilized in disciplines such as Mathematics, logic, and linguistics. The deductive method involves presenting the content initially and then providing clarifications and illustrations thereafter[54]. Thus, in the deductive teaching approach, the learner moves from the broader concept to the specific, from theoretical to practical, and from formulas to instances. Here, learners are provided with a predefined rule or formula and are tasked with solving associated problems using that particular formula. Therefore, in this approach, the learner is primarily engaged in performing calculations or simplifying the substituted known values within the provided formula in order to derive the solution for the problem.

Deductive teaching secures first the learning of definition or law or rule, then carefully explains its meaning and lastly illustrates it fully by applying to fact. This approach is primarily employed in subjects such as Algebra, Geometry, Arithmetic, and Trigonometry[55]. This strategy involves utilizing assumptions and conjectures based on mathematical axioms. It finds application in teaching Mathematics at secondary, higher secondary, and higher educational levels. Deductive reasoning, also known as logical deduction or "top-down" logic, involves drawing logically definite conclusions from one or more statements. The deductive teaching approach stands in contrast to the inductive method. The deductive approach is more instructor-centered, wherein the teacher introduces a novel concept, elucidates it, and subsequently guides students through its application via practice[56].

Steps in Deductive Teaching Strategy

Deductive teaching strategy follows the following steps given below for effective teaching:

i. Introduction of the General Concept: Start by introducing the overarching concept, principle, or rule that you want to teach. This should be a broad statement that encapsulates the main idea you want students to understand.

ii. Explanation of the Concept: Provide a clear and concise explanation of the general concept. Use simple language and examples that are relatable to the students' level of understanding.

iii. Statement of the Specific Rule or Application: After explaining the general concept, present a specific rule, theorem, or application that is derived from the general concept. This specific application is what students will be focusing on in the deductive process.

iv. Clarification of the Specific Rule: Make sure the specific rule or application is well-defined. Break it down into its components and explain any terminology or notation that might be unfamiliar to students.

v. Presentation of Examples: Provide a series of examples that demonstrate how the specific rule or application is used. These examples should be carefully chosen to illustrate different aspects of the rule and to show its various applications.

vi. Guided Practice: Walk the students through solving problems or exercises that require them to apply the specific rule to new situations. Provide step-by-step guidance, explaining each step's connection to the general concept and the specific rule.

vii. Independent Practice: Assign exercises or problems for students to solve on their own. These should be similar to the guided practice problems but without as much hand-holding. This allows students to solidify their understanding and practice applying the rule independently.

viii. Review and Feedback: After students have completed the independent practice, review their work and provide feedback. Address any mistakes or misconceptions and encourage questions and discussion.

ix. Extension and Application: Introduce more complex examples or scenarios that require students to combine the specific rule with other concepts they've learned. This helps students see how the deductive reasoning process can be applied in a broader context.

x. Assessment: Administer quizzes, tests, or assignments that assess students' understanding of the general concept and their ability to apply the specific rule. This helps gauge their mastery of the material.

xi. Reinforcement and Recap: Periodically revisit the general concept and specific rule in subsequent lessons to reinforce learning and provide opportunities for students to apply their knowledge.

xii. Integration and Synthesis: Encourage students to connect the specific rule they've learned with other concepts they've studied. This helps deepen their understanding and demonstrates the interconnectedness of different ideas.

Advantages and Disadvantages of Deductive Teaching Strategy

Advantages of Deductive Teaching Strategy:

i. Clarity and Structure: Deductive teaching provides a clear structure to lessons. It starts with a clear statement of the main concept or principle, followed by specific examples. This structure helps students understand the logical progression of ideas and concepts[57].

ii. Efficiency: Deductive teaching can be efficient, especially when dealing with complex or abstract topics[58]. By presenting the main principle first, students have a framework to understand the subsequent examples. This approach can save time by avoiding unnecessary confusion that might arise from starting with examples before understanding the overarching concept[59].

iii. Critical Thinking: Deductive teaching encourages students to engage in critical thinking and problem-solving[60]. As they are presented with examples that illustrate a principle, they need to analyze and evaluate the relationships between the examples and the principle itself.

iv. Generalization: By starting with a general principle and then providing specific examples, students are encouraged to generalize their understanding. They learn to apply the principle to various scenarios and contexts, which can enhance their ability to transfer knowledge to different situations[61].

v. Higher-Order Skills: Deductive teaching promotes higher-order thinking skills such as analysis, synthesis, and evaluation[62]. Students are not just memorizing facts; they are actively processing information, making connections, and drawing conclusions based on the given information.

vi. Logical Reasoning: This strategy helps students develop their logical reasoning abilities. As they work through examples that support a given principle, they learn to follow logical steps and deduce conclusions based on the information provided[63].

vii. Preparation for Real-world Situations: In many real-world scenarios, we are presented with general rules or principles that guide our decision-making. Deductive teaching helps students become accustomed to this way of thinking, preparing them for situations where they need to apply general concepts to specific cases[64].

viii. Conceptual Understanding: By presenting the main principle before diving into examples, students have the opportunity to grasp the fundamental concept before getting caught up in the details. This can lead to a deeper and more comprehensive understanding of the subject matter[54].

ix. Orderly Progression: Deductive teaching follows a logical and orderly progression from the general to the specific. This progression aligns with how our brains naturally organize information, making it easier for students to follow and retain the content[65].

x. Effective for Foundations: Deductive teaching is particularly effective when introducing foundational concepts or theories[66]. It lays the groundwork for subsequent learning, making it easier for students to build upon their understanding in later lessons.

The disadvantages of a deductive strategy:

i. Starting the lesson with a rule presentation may be not understandable for some students, especially at young ages. They may not be able to understand the rules involved.

ii. It taxes the students' mind.

iii. Such an approach encourages the belief that learning a language is simply a case of knowing the rules.

iv. Students are only passive learners.

v. It does not impart any training in scientific method.

vi. It encourages cramming[67].

2.2 Theoretical Framework

There are two conflicting theories of learning: constructivism and behaviorism. Teachers hold a favorable outlook on both constructivism and behaviorism, blending these approaches in their instructional methods within their classrooms. For instance, they frequently employ inquiry-driven learning tasks to facilitate students in building their personal understanding, while also utilizing reinforcement methods to assist students in acquiring particular skills.

2.2.1 Constructive Learning Theory

Constructivism serves as an epistemological viewpoint, offering an explanation for how individuals attain their knowledge. At its core, constructivism posits that individuals formulate their own comprehension and awareness of the world by engaging with experiences and contemplating upon them. This theory emphasizes that learning is a personalized process intrinsic to each learner. This theory postulates that individuals will endeavor to comprehend all the information they encounter, resulting in each person uniquely "constructing" significance from the given information[68]. The concept of constructivism is commonly associated with Jean Piaget, who detailed how learners internalize knowledge. Piaget proposed that by using accommodation and assimilation, individuals create fresh knowledge based on their experiences. Constructivism proves advantageous in Mathematics education as it fosters a more profound comprehension of mathematical concepts and motivates students to formulate their own approaches to solving problems. To effectively employ constructivist methods, meticulous forethought and groundwork are essential. Several elements impact the efficacy of constructivist methodologies, encompassing variables such as the students' age and skill levels, the duration of the intervention, and the employment of suitable assessment metricsd[69]. Furthermore, in cases where an individual's experiences run counter to their internal conceptions, they might adjust their perceptions of those experiences to align with their internal frameworks.

Constructivist Assessment

Traditionally, classroom evaluation relies on tests. In this approach, the emphasis is on students providing accurate responses. Nevertheless, in constructivist education, the acquisition of knowledge is seen as equally significant as the end result. Hence, evaluation involves not solely exams, but also the observation of the student, their assignments, and their perspectives[70]. Several assessment approaches encompass the following methods:

i Verbal exchanges: The teacher introduces a "focus" question to students, fostering an open dialogue about the subject.

ii KWL (H) Chart: This method involves documenting "What we know," "What we want to know," "What we have learned," and "How we know it." It serves as a continual assessment tool for monitoring student progress throughout the topic's study period.

iii Concept Mapping: Students compile and categorize concepts and notions associated with a given topic.

iv Hands-on tasks: Using manipulatives and hands-on activities like geometric shapes, number lines, and other concrete materials can help students develop a deep understanding of mathematical concepts. For example, using physical objects to explore concepts like fractions or geometry can make abstract ideas more tangible. These activities prompt students to interact with their surroundings or specific educational materials. Teachers can employ checklists and observations to gauge students' proficiency with the designated materials.

v Pre-testing: This assessment aids educators in gauging students' existing knowledge about a new topic, offering guidance for the subsequent course of study.

Within the realm of cognitive constructivism, an individual's responses to experiences result in either the attainment or lack of attainment of learning outcomes[71]. Constructivist methodologies involve furnishing activities that leverage children's existing comprehension while aligning with their developmental stage. These activities should also present challenges, which, in turn, facilitate ongoing advancement through the mechanism of accommodation[72]. Both individual and collaborative tasks centered on problem-solving and project-based endeavors are deemed suitable in this context. Concrete activities are prioritized for younger children, whereas activities requiring symbolic and abstract thinking are reserved for older students[73]. As per the model, the instructor's role is to impart this knowledge to the students, often accomplished through lecturing as the inherent approach. Conversely, the students' responsibility is to assimilate this knowledge.

Guiding Principles of Constructivism

Proponents of constructivism offer variations of the following principles for effective instruction:

i. Prior Knowledge and Schema Theory: In mathematics, it's important to acknowledge and build upon students' prior mathematical knowledge and experiences. Teachers can use students' existing understanding of numbers, operations, and patterns as a foundation for new mathematical concepts. Schema theory proposes that individuals organize and categorize knowledge into mental frameworks or schemas. New information is assimilated into existing schemas or can lead to the creation of new ones[74].

ii. Active Learning: Learning is most effective when learners actively engage with the material. This can involve problem-solving, critical thinking, hands-on activities, discussions, and collaborative projects. Active participation helps learners make connections and adapt their mental frameworks to accommodate new information[75].

iii. Social Interaction: Social interactions play a crucial role in the construction of knowledge. Collaborative learning, group discussions, and interactions with peers and teachers help learners exchange ideas, challenge assumptions, and negotiate meaning. Vygotsky's socio-cultural theory is closely related to this aspect of constructivism[76]. Zone of Proximal Development (ZPD): Vygotsky's concept of the ZPD refers to the range of tasks that a learner can perform with the help of a more knowledgeable individual, such as a teacher or a peer. It's the gap between what a learner can do on their own and what they can achieve with guidance. Effective learning occurs when instruction is tailored to a learner's ZPD[77].

iv. Scaffolding: Just as in general constructivist education, scaffolding is used in mathematics instruction. Teachers provide guidance and support to students as they work through mathematical problems, gradually reducing the support as students become more independent[78].

v. Student-Centered and Individualized Learning: Constructivist learning environments are student-centered, focusing on the learner's interests, needs, and pace[79]. Instruction is adapted to accommodate different learning styles and abilities, promoting a more personalized learning experience.

vi. Reflection and Meta-cognition: Encouraging students to reflect on their problem-solving processes and discuss their thinking helps them develop meta-cognition, or awareness of their own thought processes. This can lead to a deeper understanding of mathematical concepts. Meta-cognition, or thinking about one's thinking, is essential for self-directed learning and continuous improvement[80].

vii. Real-World Contexts: Learning is more meaningful when it occurs within authentic, real-world contexts. Showing students how mathematics is used in real-world situations can make the subject more relevant and meaningful. This can enhance students' motivation to learn mathematics[81].

viii. Ownership and Motivation: When learners have ownership of their learning and can actively shape their educational experiences, they become more motivated and engaged. Constructivist approaches foster a sense of ownership and empowerment, leading to increased intrinsic motivatio[n82].

ix. Assessment as Understanding: Assessment in constructivist settings focuses on understanding and application rather than rote memorization. Performance-based assessments, portfolios, and projects that require learners to demonstrate their understanding in practical ways are preferred over traditional exams[83].

These guiding principles of constructivism collectively contribute to a holistic and dynamic approach to learning, where learners are active participants in the process of constructing their knowledge and understanding of the world.

Constructivist teaching encourages the development of critical reasoning and cultivates enthusiastic and self-reliant learners. This theoretical approach asserts that the process of learning consistently builds upon a student's existing knowledge, referred to as a schema. Because all learning is perceived through pre-existing mental frameworks, proponents of constructivism propose that active engagement in the learning process, as opposed to passive reception of information, enhances the effectiveness of learning. Numerous methodologies lay claim to being grounded in constructivist learning theory. The majority of these techniques involve some variant of guided exploration, wherein the teacher minimizes direct instruction and instead guides the student through questioning and activities, enabling them to uncover, discuss, value, and articulate new knowledge. Constructivist learning theory asserts that all knowledge is constructed on a foundation of prior understanding. Children aren't blank slates, and knowledge cannot be simply imparted; rather, it must align with the child's current conceptualizations for comprehension to take place. Hence, optimal child learning occurs when they are given the opportunity to create an individualized comprehension through direct encounters and subsequent contemplation of those experiences[84].

The conventional method of teaching through lectures contradicts each of these principles. Assuming the constructivist learning model is embraced, and considering the substantial supporting research, effective instruction must orchestrate situations that prompt students to independently formulate knowledge. This could involve modifying or discarding their existing beliefs and misunderstandings based on the evidence derived from these experiences. This depiction could essentially be regarded as a characterization of inductive learning. The philosophy of learning known as constructivism is rooted in the idea that our personal comprehension of the world develops when we contemplate our encounters.

Individually, we establish our unique "guidelines" and "cognitive frameworks" that we employ to comprehend our experiences. Consequently, learning entails the straightforward procedure of adapting our cognitive frameworks to incorporate novel experiences.

Constructivist learning operates on inductive principles. According to constructivist learning, actions drive the development of concepts rather than concepts guiding actions. Activities pave the way for the emergence of concepts; it's not the concepts that pave the way for the activities. Essentially, in constructivist learning, the conventional classroom approach is reversed – no lectures, no demonstrations, and no presentations. From the beginning, students engage in activities through which they develop skills and acquire concepts[85].

Constructivism as an Instructional Strategy: The Teacher's Role

Constructivism entails a cooperative dynamic involving educators, students, and other members of the community, and is customized to address the unique needs and objectives of each individual learner. This approach facilitates ongoing learning experiences. In a constructivist classroom, the teacher's role extends beyond mere lecturing to that of an adept learner, capable of steering students towards adopting cognitive techniques like self-assessment, articulating comprehension, posing probing inquiries, and reflecting. Within constructivist classrooms, the teacher's responsibility is to structure information around overarching concepts that captivate the students' curiosity, aid students in cultivating fresh perspectives, and bridge these with their earlier learning. The activities are centered around the students, encouraging them to pose their own inquiries, conduct their own experiments, establish their own parallels, and formulate their own conclusions. During typical constructivist sessions, as students tackle a problem, the instructor intervenes only when necessary to channel students in the appropriate direction. Essentially, the instructor presents the challenge and empowers the students to take the lead. Numerous educators and cognitive psychologists have applied constructivist principles to the design of learning environments. From these applications, they have distilled a set of design principles which encompass:

i. Develop authentic settings that mirror the real-life contexts where learning holds significance.
ii. Emphasize practical methods to address authentic real-world challenges.
iii. The instructor functions as a mentor and evaluator of the strategies applied to resolve these challenges.
iv. Highlight the interconnected nature of concepts, offering diverse representations or viewpoints of the subject matter.
v. Educational objectives and goals should be collaboratively established, rather than imposed.
vi. Assessment should function as a tool for learners to self-assess their progress.
vii. Supply tools and environments that aid learners in interpreting the myriad perspectives of the world.
viii. Learning should be driven by the learner's internal control and mediation.

Constructivism empowers educators. In constructivist teaching, instructors motivate students to consistently evaluate the efficacy of activities in fostering comprehension. Through introspection and analysis of their strategies, students within the constructivist framework ideally evolve into "proficient learners," progressively equipping themselves for ongoing learning. With a carefully designed classroom setting, students acquire the skills of learning itself, akin to a spiral progression. As they continually introspect on their experiences, students witness the growth of their ideas in complexity and potency, thereby enhancing their capacity to assimilate novel information. The central responsibility of the teacher shifts towards nurturing this cycle of learning and reflection.

Within the framework of constructivist learning, instructors offer a diverse range of learning scenarios to learners, resulting in a shift for students from the role of "acquiring knowledge" to "constructing knowledge." Learning transforms into a process of actively building knowledge. Learners play an active role in shaping their own understanding by linking novel concepts to preexisting ideas, drawing from the materials or activities presented to them. For instance, the utilization of text, a collection of images, or visual aids concerning a phenomenon or object is followed by group discussions or interactions[86].

Active involvement of learners in pertinent activities contributes significantly to the organization and reorganization of ideas. Collaborative learning fosters opportunities for the exchange of diverse viewpoints and the negotiation of meaning. Each individual learner, both independently and collectively, constructs meaning pertaining to a phenomenon, object, or event as they engage in the learning process. Teachers facilitate an environment where children can pose questions related to their school learning, and they encourage children to respond in their own words, drawing from their personal experiences. The encouragement of "intelligent guessing" is embraced as a valid teaching technique. Students question not only their teachers' ideas but also those of their peers, make predictions about phenomena, design experiments to test their hypotheses, and discuss their findings. They compare their results with those of others, arrive at autonomous conclusions, apply new concepts to familiar scenarios, and familiar concepts to novel situations. This process enables learners to validate their beliefs and notions, showcase solutions and methodologies, and elaborate on and interpret textual information. A habit of self-directed learning is cultivated in the learner. Moreover, constructivism empowers students to pursue their individual interests and objectives. Within this approach, learners harness and enhance their own abilities.

The implications of constructivism for teaching and learning are highlighted as follows:

i. Teachers function as facilitators, supporters, guides, and exemplars of the learning process.
ii. Learning involves adapting our mental frameworks to accommodate new encounters.
iii. Learning revolves around establishing connections between various pieces of information.
iv. Instruction should revolve around intricate problems that lack straightforward, definitive answers.
v. Context and personal knowledge hold significant importance.
vi. Student engagement and dedication outweigh the importance of textbook content.
vii. Learners excel in the process of discovering and generating their own knowledge.
viii. Emphasis is placed on discovery and guided discovery learning.

Behaviorism Approach to Learning

The deductive strategy, as promoted by behaviorists, serves as a clear and direct illustration of conventional teaching, involving the following steps:

1. Presenting overarching principles or generalizations.

2. Reinforcement through methods such as:
    a. Providing examples
    b. Addressing students' inquiries
    c. Clarifying and restating the principle.
3. Utilizing tangible manipulation when applicable.
4. Seeking feedback from students through questioning.
5. Implementing drill exercises.

The inductive discovery strategy aimed to uncover principles or generalizations. The instructional sequence was structured as follows:

1. Concretely manipulating the facts intended for correlation.
2. Introducing the facts intended for correlation.
3. Facilitating discovery through discussion by:
    a. Offering specific examples
    b. Addressing students' queries
    c. Proposing guiding questions if steps a. and b. didn't result in discovery.
4. Reinforcing the identified generalization.
5. Incorporating a drill phase.

The theory of behaviorism originated from the contributions of Thorndike, Pavlov, and Skinner to the field of learning[88]. The established principles of stimulus-response, along with classical and operant conditioning, have been employed to elucidate the process of learning by utilizing rewards, penalties, and trial-and-error mechanisms. This perspective is rooted in biological drives and is considered a means of adapting to the environment. In this framework, learners are positively reinforced in a consistent manner for incremental strides in learning and accomplishments. On a broader level, behaviorism advocates for teacher-controlled or teacher-centered methodologies where the educator holds the primary authoritative role. Knowledge is distributed across distinct segments of a segregated curriculum, perceived by students as separate subjects, and conveyed from teacher to student in predetermined sequences, with limited room for student choice or interaction. Behaviorism theory centers on the analysis of observable and quantifiable behavior, underscoring that behavior is largely acquired through conditioning and reinforcement, encompassing rewards and punishments. From the behaviorist perspective, the objective of educational psychology is to equip educators with the ability to anticipate, regulate, and modify classroom behavior. This outlook contrasts with the approach that regards educational psychology as a comprehensive area of content, emphasizing information over skill development. From the forgoing the principles derived from Thorndike's postulates can be summarized as follows:

i. Law of Effect: Behaviors leading to satisfying outcomes are more likely to be repeated, while behaviors leading to unsatisfying outcomes are less likely to be repeated.
ii. Law of Exercise: Connections between stimuli and responses are strengthened through repetition and practice.
iii. Law of Readiness: Learning is most effective when the learner is motivated and ready to engage in the task.
iv. Law of Multiple Responses: In a situation, an organism may exhibit multiple responses, but only one is likely to be correct or successful.

v. Law of Prepotency of Elements: Some elements in a situation are more noticeable and elicit stronger responses.

vi. Law of Belongingness: Connections between stimuli and responses are more effective if they logically belong together.

vii. Law of Analogy: Learning involves making analogies between new and previously learned situations.

viii. Law of Imitation: Learning can occur through observing and imitating the behaviors of others[89].

Behaviorism and the Construction of Knowledge

Behaviorists posit that learning emerges through the observation of cultural influences[90]. Instruction grounded in behaviorism can serve as an efficacious method for imparting mathematical concepts, especially beneficial for students encountering challenges with the subject. This approach aids in fostering a more favorable outlook towards Mathematics, potentially resulting in heightened motivation and increased involvement among students. Instruction rooted in behaviorism can serve as a valuable pedagogical resource for educators aiming to enhance both student learning achievements and their attitudes toward Mathematics[91]. On the flip side, the behaviorist-oriented teaching approach falls short in addressing the cognitive processes intrinsic to the acquisition of mathematical knowledge[92].

Basic Tenets of Behaviorist Approach

The following principles illustrate the operating principles of behaviorism:

i. Empiricism: Behaviorists believe that knowledge comes from empirical observation and measurement. They emphasize the importance of studying behaviors that can be objectively observed, measured, and analyzed.

ii. Focus on Observable Behavior: Behaviorists primarily focus on studying and analyzing behaviors that are directly observable and measurable. This allows for a more scientific and objective approach to psychology.

iii. Stimulus-Response (S-R) Relationships: Behaviorists often describe behavior in terms of stimulus-response relationships. A stimulus is something in the environment that triggers a response, which is a behavior. This approach emphasizes the role of the environment in shaping and controlling behavior.

iv. Classical Conditioning: This is a form of learning in which an initially neutral stimulus becomes associated with a meaningful stimulus, leading to a learned response. Ivan Pavlov's famous experiments with dogs are an example of classical conditioning.

v. Operant Conditioning: Operant conditioning involves learning through the consequences of one's actions. Behaviors that are followed by rewards (reinforcements) are more likely to be repeated, while behaviors followed by punishments are less likely to be repeated. B.F. Skinner is a key figure associated with operant conditioning.

vi. Reinforcement and Punishment: Reinforcement is a process that increases the likelihood of a behavior being repeated, while punishment decreases the likelihood of a behavior being repeated. Positive reinforcement involves adding a rewarding stimulus, while negative reinforcement involves removing an aversive stimulus.

vii. Behavior Modification: Behaviorists believe that behavior can be modified or changed through appropriate techniques. By manipulating the environment and providing the right reinforcements, undesirable behaviors can be replaced with desirable ones.

viii. Environmental Determinism: The behaviorist approach leans towards the idea of environmental determinism, suggesting that behavior is largely determined by external factors rather than internal thoughts or emotions. This is in contrast to approaches like cognitive psychology, which give more weight to internal mental processes.

ix. Observational Learning: While the behaviorist approach primarily focuses on direct experiences and conditioning, some behaviorists also acknowledge the role of observational learning. This is learning by observing others' behaviors and their consequences. Albert Bandura's work on social learning theory is relevant here.

x. Scientific Method: Behaviorists emphasize the importance of using the scientific method to study behavior. This includes formulating hypotheses, conducting experiments, collecting data, and analyzing results to draw conclusions about behavior and its underlying principles[93].

Criticisms of the behaviorist approach

The Behaviorist approach encounters the subsequent criticisms: (a) it is contended that Behaviorist methodologies are tailored exclusively to address aberrant conduct; (b) the contention is that pinpointing distinct teacher behaviors conducive to specific student outcomes is unfeasible; and (c) the accusation persists that Behaviorists exclusively impart Skinnerian and operant techniques. Furthermore, there are misapprehensions surrounding courses in educational psychology. Such courses ought to exclude subject areas that do not contribute to expediting behavioral transformation.. Instead of attempting to encompass all topics, educators should focus on instructing students in skills that will prove valuable to them in their future roles as teachers[94]. Behaviorist proponents do not recognize the internal composition of the learner or the methods by which they assimilate incoming information. Consequently, Behaviorism falls short of elucidating the cognitive mechanisms engaged in language acquisition. This divergence becomes evident when compared to the socio-cultural standpoint, which comprehensively considers both external stimuli and internal cognitive frameworks. Additionally, it is improbable that learning unfolds uniformly for every individual. In other words, each person cannot attain identical proficiency under identical learning circumstances due to the distinct backgrounds and experiences that shape individual learning paths. Furthermore, as posited by Chomsky, there exists a necessity for innate capacities within human beings that incline them towards seeking fundamental patterns within language[95]. The behaviorist model encountered opposition from the social learning theory, which observed that children acquire knowledge through observing and imitating adults in an apprenticeship-style framework. In a more comprehensive sense, behaviorism aligns with teacher-controlled or teacher-centered methodologies, positioning the teacher as the primary authoritative figure. Knowledge is parceled across various segments of a segregated curriculum, presenting children with distinct subjects. This knowledge is then transmitted from the teacher to the students in predetermined sequences, characterized by limited student autonomy or engagement. Assessment is often exam-oriented and high stake, without teachers' direct involvement[96].

Pedagogical methods that can be broadly categorized as having roots in behaviorism might lead to practices like delivering lectures, providing demonstrations, employing rote learning, memorization techniques, collective repetition, imitation or copying, and conducting specialized instructional sessions, such as master classes (for instance, in learning music or dance). The practice of 'structured' or 'direct/explicit instruction' diverges by being led by the teacher instead of being centered solely on the teacher[97]. This strategy denotes that educators follow a particular sequence, frequently employing scripted and occasionally prescriptive techniques, which is particularly noticeable in the context of initial reading education[98]. Nevertheless, this methodology has the potential to transition into more activities centered around the students as the lesson advances.

2.3 Review of Empirical Studies

The teaching of Mathematics has long been a subject of educational research, with a continuous exploration of teaching strategies that promote effective learning outcomes. Two prominent teaching strategies, inductive and deductive, have gained substantial attention. This review aims to critically assess empirical studies comparing the efficacy of these strategies in the context of teaching Mathematics. Inductive teaching emphasizes learning through discovery. Students are presented with specific examples or observations and are encouraged to derive general principles or concepts from these examples. Proponents argue that this approach promotes critical thinking, problem-solving skills, and a deeper understanding of mathematical concepts. Several empirical studies support the benefits of inductive teaching. For example, in a research study, an investigator examined the impact of both inductive and deductive approaches on students' academic achievement concerning various grammatical topics covered in a textbook used for teaching Grammar 2 within the Department of English Language and Literature. The findings indicated notable disparities, with the inductive approach proving to be more effective[99]. Inductive instruction led to higher engagement and better conceptual understanding compared to traditional deductive methods[100].

Deductive teaching, on the other hand, involves presenting students with general principles or concepts followed by specific examples and applications[101]. This approach is often associated with more structured and formal learning. Advocates suggest that deductive teaching helps students grasp abstract concepts and develop logical reasoning skills. Numerous empirical studies have examined the effectiveness of deductive teaching. For example, A study conducted to explore the impacts of employing deductive and inductive methods for instructing grammar at both a university and two chosen schools revealed a noteworthy statistical contrast between the two approaches, with a preference observed for the deductive method[102]. Deductive instruction is particularly effective in enhancing procedural knowledge and preparing students for standardized tests.

Several empirical studies have directly compared inductive and deductive teaching strategies, both strategies led to significant learning gains, inductive teaching fostered a stronger ability to apply mathematical concepts in novel scenarios. However, it's important to note that the effectiveness of each strategy can be influenced by factors such as the students' prior knowledge, learning styles, and the specific mathematical topic being taught[103]. Inductive and deductive teaching strategies in Mathematics continue to spark interest among educators and researchers. Both approaches offer unique advantages and disadvantages, and their effectiveness can vary depending on the context and the learning objectives. Empirical studies have consistently demonstrated that both strategies can yield positive learning outcomes, suggesting that a balanced approach that integrates elements of both methods might be most beneficial. Further research should focus on identifying the conditions under which each strategy is most effective and tailoring instructional approaches to meet the diverse needs of students.

2.3.1 Class size and Students' Academic Achievement

Class size pertains to the number of students present within a particular course or classroom setting. This measurement encompasses either the number of students under the instruction of individual teachers within a specific course or classroom or the average count of students taught by educators within a school or educational framework. Additionally, the term may also denote the number of students engaged in a learning process. Notably, class size primarily constitutes an administrative determination, often outside the realm of direct influence for teachers. It serves as an educational metric to describe the typical number of students within a given class across a school. UNESCO's estimations indicate that approximately 84 percent of classrooms feature a student-teacher ratio of fewer than 40 students per teacher[104]. The majority of nations surpassing a student-teacher ratio of 40:1 are concentrated in Sub-Saharan Africa and Asia. Notably, Sub-Saharan Africa registers the highest median Pupil-Teacher Ratio (PTR), with countries such as Congo, Ethiopia, and

Malawi displaying PTRs hovering around 70:1. Likewise, South and East Asia also report elevated PTRs, with Afghanistan and Cambodia surpassing a ratio of 55:1[105]. Within Nigeria, there exists a recurring issue of considerable class sizes, marked by ratios ranging from 40:1, 50:1, and occasionally even reaching an alarming ratio of 100:1. This prevalent trend has been notably impeding the progress of the education system, acting as a significant hindrance[106]. The National Policy on Education (NPE) advocates for specific class size guidelines of twenty (20) pupils for pre-primary levels, thirty (30) students for primary levels, and thirty-five (35) students for secondary school levels[107]. An appropriate class size for the secondary level is generally considered to be around forty (40) students per teacher.

On average, in many educational institutions worldwide, including colleges and universities, class sizes of 20 to 30 students per lecturer are often considered reasonable for effective teaching and learning[108]. However, this number can be higher or lower depending on the specific circumstances and resources available at a particular institution. The ideal class size for effective teaching and learning in Colleges of Education in Nigeria should take into account the institution's specific goals, resources, and the nature of the programs being offered[109]. Smaller class sizes are generally preferred, but practical constraints may influence the actual class size. It's essential for educational institutions to strike a balance between maintaining manageable class sizes and ensuring access to education for a broad range of students. However, there are some general guidelines that can be considered. In higher education institutions like Colleges of Education, smaller class sizes are often preferred for more effective teaching and learning[108]. Smaller classes can facilitate better student-teacher interactions, more personalized instruction, and a more conducive learning environment[110].

The size of a class has a direct impact on classroom instruction, as larger classes necessitate teachers to allocate time towards management duties instead of focusing solely on teaching and facilitating learning. The size of classes differs across different educational levels. A high student-teacher ratio poses challenges for educators in delivering high-quality instruction, consequently resulting in diminished student achievements.

The number of students in a classroom can impact the learning process in various manners. One notable effect is on students interactions. A larger class size might lead to disruptive behavior, influencing the types of activities the teacher can implement. Moreover, it influences the extent of individualized attention a teacher can offer to each student, as opposed to focusing solely on the entire group. Smaller class sizes allow for greater focus and tailored attention based on individual needs. Furthermore, class size also influences how effectively a teacher manages their time and resources, affecting factors such as the amount of material that can be covered. In classrooms with high occupancy, the prevalent issues includes; inadequate or substandard teaching materials, inadequate lighting, compromised safety measures, insufficient ventilation or air conditioning, low-quality flooring and foundations, book sharing, students sitting on bare floor due to inadequate furniture and lack of enough spaces for teachers and students to move freely in the classroom[111]. Students enrolled in smaller classes tend to exhibit better academic performance compared to their counterparts in larger classes. The average student-teacher ratio within the Nigerian government schools system fluctuates from one state to another, although it typically remains relatively high. The elevated student-teacher ratio stands as a significant obstacle to maintaining the quality of education in Nigeria[112]. Moreover, smaller class sizes have been found to be associated with higher students achievement, especially for younger students and students from low income families. Smaller class sizes also grant teachers the opportunity to offer greater individual attention to students, a factor that often contributes to elevated academic accomplishments[113]. Several crucial factors, including the caliber of the teacher, the attributes of the students, motivation levels, and the quality of interaction between students and teachers, hold significance in shaping academic achievements in Mathematics[114].

Even highly experienced teachers encounter challenges in managing large class sizes. These challenges encompass constraints on the time available for curriculum-related activities and extended periods required for grading assessments. In the face of sizable class sizes, educators often resort to employing direct teaching methods to cope with the situation. Substantial class sizes serve as a formidable barrier to achieving optimal classroom integration, thereby underscoring the notion that smaller classes are more likely to foster heightened academic achievement[115].

2.3.2 Gender and Students' Academic Achievement

Gender stands out as one of the factors frequently discussed in literature for its considerable influence on students' academic achievement, particularly in science subjects. Gender refers to the spectrum of physical, biological, mental, and behavioral attributes distinguishing between the female and male populations. The exploration of achievement in relation to gender is primarily rooted in the socio-cultural disparities between girls and boys.

Certain careers and fields have traditionally been deemed suitable for men (such as engineering, arts and crafts, and agriculture), while others are associated with women (like catering, typing, nursing). This division has even permeated into household responsibilities, where tasks like car maintenance, gardening, and manual tasks are often assigned to boys, whereas girls are often designated with duties like cooking, cleaning, and household chores. This pattern of thinking has led society to perceive boys as capable of tackling complex and demanding tasks, while viewing girls as more suited for less challenging responsibilities. In essence, this societal mindset has contributed to the perception of girls as the "weaker sex." As a result, the average Nigerian girl enters the educational system burdened with these ingrained stereotypes[116]. The exploration of gender disparities in academic achievement has been a longstanding focus of research, resulting in the accumulation of a significant body of literature. Within this realm of studies, certain researchers contend that no substantial gender differences exist in students' academic achievement and continuity across diverse subjects. In contrast, alternative studies reveal noteworthy disparities, wherein either boys or girls exhibit superior academic performance and persistence. Studies have delved into the intersection of gender and motivation in the context of explaining students' achievements in Mathematics. An example of such is a sample of Korean middle and high school students, where the authors investigated the interplay between gender, motivation, and Mathematics achievement[117]. Findings from the study revealed that, on average, male students exhibited higher Mathematics achievement compared to their female counterparts. The disparity in Mathematics achievement between genders was found to be partially attributed to variations in students' motivational aspects. Notably, the authors discovered that female students displayed lower levels of Mathematics self-efficacy and intrinsic motivation in comparison to male students. These motivational factors were found to play a role in mediating the connection between gender and Mathematics achievement. Furthermore, it was noted that the gender discrepancies in Mathematics achievement demonstrated variability contingent on the specific level of Mathematics being studied. In the realm of Mathematics, female students generally exhibited comparatively lower performance than their male counterparts in subjects like algebra, geometry, and statistics. However, their performance was on par with male students' achievements in the field of calculus[118].

The belief that men possess a natural advantage in Mathematics compared to women has persisted throughout history. This belief has also manifested in the education system, where girls were frequently dissuaded from pursuing studies in Mathematics and science. It's worth noting that gender differences in Mathematics are generally marginal and subject to variations depending on the particular task or measurement being considered. Several factors contribute to these gender differences in Mathematics, including:

i Teacher expectations: teachers often have lower expectation for girls' mathematical ability than boys[119]. This can lead to girls receiving less challenging Mathematics instruction leading to girls having less confidence in their mathematical abilities.

ii Parental involvement: Parent often encourages their sons to pursue Mathematics more than their daughter[120]. This can lead to boys having more opportunities to learn Mathematics outside of school and to boys having more positive attitude towards Mathematics.

iii Peer pressure: peer pressure can also influence gender difference in Mathematics[121]. For example, girls may be less likely to participate in Mathematics activities if their friends are not interested in Mathematics.

iv Cultural factors: In some cultures, Mathematics is seen as a masculine domain which can discourage girls from pursuing Mathematics and Mathematics related disciplines[122].

A study conducted on a sample of Chinese middle school students utilized data from the Trends in International Mathematics and Science Study (TIMSS) to explore the gender gap in Mathematics achievement and its potential contributing factors to this gap. The findings indicated that, on the average, male students achieved higher Mathematics scores compared to their female counterparts. However, the observed gender gap in Mathematics achievement was found to be partially attributed to differences in students' attitudes toward Mathematics and their approach to learning. Specifically, female students demonstrated lower levels of confidence in their mathematical abilities and were less inclined to employ advanced learning strategies like planning and monitoring, in comparison to their male counterparts[123]. Furthermore, the gender disparities in Mathematics achievement exhibited variations based on the specific type of Mathematics being studied. Male students tended to perform better than female students in geometry and data analysis[124]. Female students tended to outperform male students in the domains of number and algebra[125].

Teaching Strategies and Students' Academic Achievement

Two methodologies considered for Mathematics instructions in this study are deductive approach and inductive approach. In the deductive method of teaching, the instructor directly introduces the mathematical framework right at the beginning of the lesson. The instruction usually involves a detailed explanation of the rules, forms, and contexts[126]. Mathematicians employ various techniques to uncover novel concepts, and one such approach involves experimentation. Referred to as the "experimental method" or "inductive reasoning," this technique entails the scientist conducting a multitude of meticulous observations and subsequently drawing likely conclusions. Likewise, the scientist might replicate experiments numerous times and derive probable outcomes from the amassed data, thereby engaging in inductive reasoning. In essence, this entails drawing a broad inference from an extensive array of specific instances. In contrast, another method hinges on logical analysis rather than experimental or observational data. This is denoted as "deductive reasoning." When a mathematician commences with a collection of accepted conditions, termed the hypothesis, and then employs a sequence of logical implications to arrive at a valid conclusion, they are employing deductive reasoning[127].

The primary contrast between these two methodologies becomes evident through the specific terms they incorporate: "probable," which characterizes inductive reasoning, and "valid," which pertains to deductive reasoning. In certain research contexts, these two strategies are alternatively labeled as qualitative (inductive) and quantitative (deductive), signifying their ongoing rivalry and competition over the course of time. Various adjectives have been employed to characterize the distinct concepts of induction and deduction. These include terms such as inductive/deductive research, inductive/deductive thinkers, inductive/deductive approaches, instructive/deductive pedagogy, inductive/deductive teaching, inductive/deductive learning strategies, and inductive/deductive reasoning. These two approaches are frequently encountered in written works. Although the methodologies themselves diverge, their objectives remain consistent. Both strategies present strengths and weaknesses[128].

2.4 Conceptual Model

Conceptual model of this study shows the relationship between the independent variables (inductive teaching strategy, deductive teaching strategy and conventional teaching strategy) and dependent variables (students' achievement in Basic General Mathematics). The moderating variables are Gender (male and female) and Class size (large and small). This is illustrated in the Figure below

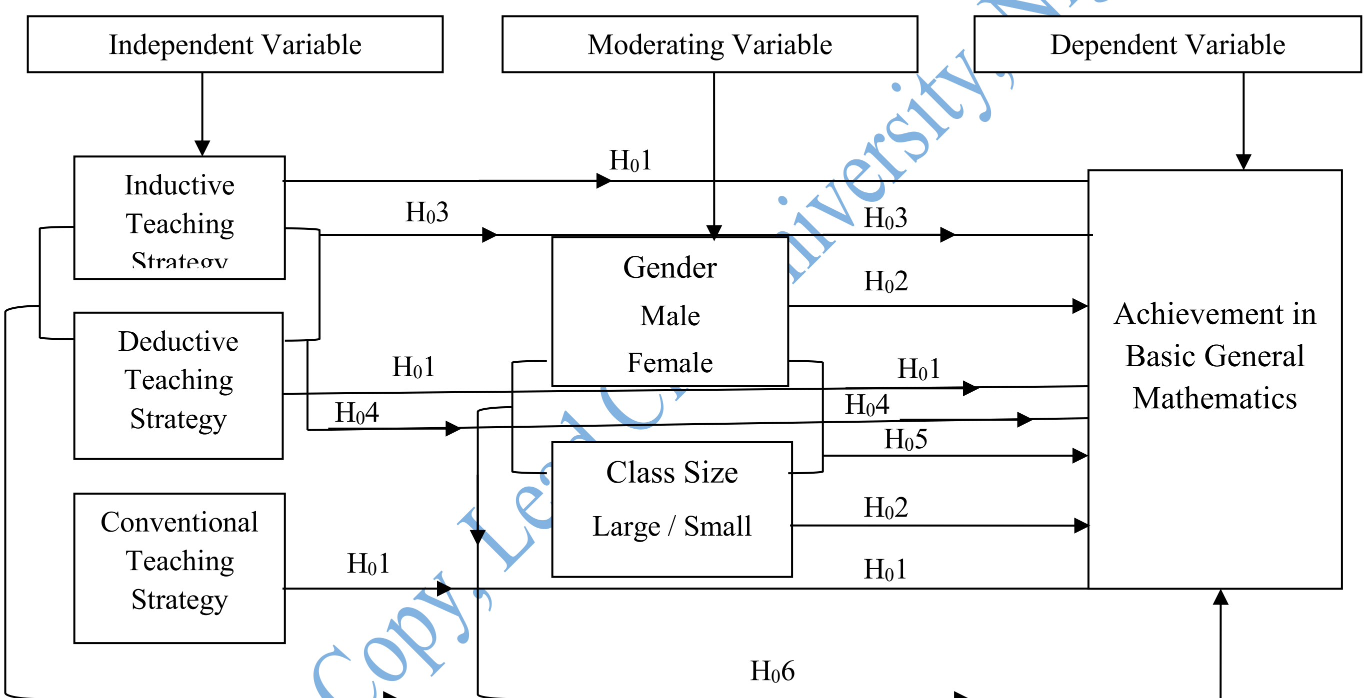

Fig 2.1: **Conceptual Framework of the Study**

Source: Field work 2023

Dependent and Independent Variables

The fundamental aspect of crafting an experiment involves identifying the research variables that could potentially influence the final results. These variables encompass various types, but the most pivotal ones in the context of most research methodologies are the independent and dependent variables. The independent variable, also referred to as the manipulated variable, serves as the core element in quantitative experimental design. It is meticulously isolated and controlled by the researcher. In the framework outlined above, the independent variables that influence the academic achievement among College students are the inductive teaching strategy, deductive teaching strategy and conventional teaching strategy.

The dependent variable, on the other hand, represents the quantifiable outcome resulting from this manipulation, which in this case is the academic achievement of the students. In this particular study, there exist two distinct groups: (i) the Control group and (ii) the Experimental groups. The Experimental groups will receive instruction through inductive and deductive teaching strategies, while the Control group will be taught using conventional teaching methods. Additionally, this research takes into account gender and class size as moderating variables.

One of the factors frequently discussed in academic literature as having a significant effect on the academic achievements of students, particularly in the field of science subjects, is gender. Gender encompasses a spectrum of physical, biological, mental, and behavioral traits that distinguish and differentiate between the female and male populations. The significance of investigating students' academic performance in connection with gender primarily arises from disparities in academic achievement between girls and boys, known as the gender gap. It's worth noting that the gender gap in Mathematics achievement varies depending on the specific level of Mathematics under consideration, and it may be particularly pronounced in certain mathematical topics[130]. Considering the notion that students' gender might influence their academic performance, this research explores any potential relationship between the two.

Research evidences indicate that class size has a notable adverse impact on students' academic performance. Specifically, the research revealed that students in smaller class settings outperformed their counterparts in larger classes. Furthermore, it was observed that the detrimental impact of class size on academic performance was particularly notable in science subjects compared to non-science subjects[131].

Mathematics learning encompasses more than just thinking and reasoning; it is closely tied to the learners' attitudes towards both learning and Mathematics itself. Attitudes comprise cognitive, affective, and behavioral responses that individuals exhibit towards an object or their surroundings based on their emotions or interests. In the context of attitudes towards Mathematics, the cognitive component pertains to an individual's thoughts or beliefs about the subject, while the affective component involves the emotions and feelings associated with learning Mathematics. Negative attitudes, such as laziness/procrastination, tardiness, absenteeism, apathy/lack of interest, and low self-esteem, can exert adverse effects on students' academic performance. Conversely, positive attitudes like self-motivation can significantly enhance students' academic achievement[132].

2.5 Summary of Gaps in Literature Reviewed

Research have demonstrated that a critical factor contributing to success in Mathematics is the selection of efficient problem-solving strategies. Mastery of calculations alone is insufficient; instead, it is vital to cultivate meta-cognitive skills, including control and elaboration strategies. Several research findings indicate that students can enhance their mathematical achievements significantly when they make intensive use of elaboration strategies. Therefore, the present research centers on assessing the impacts of inductive and deductive teaching methods in Mathematics education. Although these methods may differ, their ultimate objectives align, and both approaches come with their respective advantages and disadvantages.

There are two basic schools of thought in the theory of learning. These are behaviorism and constructivism. Behaviorists define the role of educational psychology as equipping educators with the ability to anticipate, manage, and modify classroom behavior. This viewpoint stands in contrast to an approach that emphasizes educational psychology as a comprehensive field centered on information rather than skills. A core divergence between behaviorists and non-behaviorists centers on whether the purpose of education and teaching is primarily to impart and cultivate skills (as viewed by behaviorists) or to prioritize the development of interpersonal relationships and positive self-concepts (as seen in the non-behaviorist perspective). In contrast, constructivism serves as an epistemological theory that elucidates how individuals acquire knowledge. Essentially, constructivism posits that people construct their own understanding and knowledge of the world through firsthand experiences and reflective processes. It asserts that learning is a highly individualized activity, suggesting that individuals endeavour to make sense of all the information they encounter, thus "constructing" their own meaning from it.

Both behaviorism and constructivism offer distinct advantages and drawbacks as theoretical frameworks in the context of Mathematics education. Behaviorism underscores the significance of practice, repetition, and feedback in the learning process. Nevertheless, it has faced criticism for its heavy reliance on rote memorization and its tendency to overlook students' active engagement in knowledge construction. On the contrary, constructivism places importance on students' active involvement in learning, emphasizing their role in constructing meaning and understanding through experiences and interactions with their environment. However, constructivism has also been criticized for its limited emphasis on explicit instruction and foundational knowledge and skills. Exploring the application of behaviorism in Mathematics teaching, it's essential to understand behaviorism as a psychological theory that highlights observable behaviors and their reinforcement in the learning process. This perspective can be valuable in addressing challenges students encounter in Mathematics learning. One significant application of behaviorism in Mathematics teaching involves employing positive reinforcement to encourage desired behaviors among students. Teachers can utilize various forms of reinforcement, such as praise, rewards, and grades, to reinforce correct responses and promote desirable behaviors. Furthermore, behaviorism can be harnessed to teach mathematical concepts and skills by emphasizing repetition and practice, allowing students ample opportunities to solve mathematical problems and tasks, thus aiding in the development of automaticity and fluency in Mathematics. Another practical use of behaviorism in Mathematics education is the implementation of behavior contracts to establish clear expectations for student behavior and offer incentives for meeting these expectations.

The researchers arrived at the conclusion that a blended approach, combining elements of behaviorism and constructivism, could prove to be the most efficient strategy for Mathematics education. They recommended that educators should offer students the chance for regular practice and repetition. Simultaneously, they should foster an environment where students actively engage in constructing their own comprehension of mathematical concepts through problem-solving and exploration. Additionally, the researchers stressed the significance of delivering prompt and insightful feedback. They also highlighted the advantages of leveraging technology to enrich the learning experience and offer personalized feedback and practice opportunities.

When designing an experiment, it is crucial to consider the research variables that might have an impact on the results. Various types of variables exist, but for most research methods, the primary ones are the independent and dependent variables. The independent variable serves as the central element of the experiment, controlled and manipulated by the researcher. In the context of this research, the specific independent variables under scrutiny are the inductive and deductive teaching methods. Meanwhile, the dependent variable in this study is the academic achievement of the students. Additionally, gender and class size are considered moderating variables in relation to Mathematics.

Endnotes

1. S. F. A. Hossain, Z. Xi, M. Nurunnabi, & B, Anwar, *Sustainable Academic Performance in Higher Education: A Mixed Method Approach*, **Interactive Learning Environments**, 30(4), 2022, 707-720.

2. J. O'Flaherty, & M. Costabile, *Using a Science Simulation-Based Learning Tool to Develop Students' Active Learning, Self-Confidence and Critical Thinking in Academic Writing,* **Nurse Education in Practice**, 47, 2020. 102839.

3. A. Alhadabi, & A. C. Karpinski, *Grit, Self-Efficacy, Achievement Orientation Goals, and Academic Performance in University Student,* **International Journal of Adolescence and Youth**, 25(1), 2020, 519-535.

4. C. F. Rodríguez-Hernández, E. Cascallar, & E. Kyndt, *Socio-economic Status and Academic Performance in Higher Education: A Systematic Review,* **Educational Research Review**, *29*, 2020, 100305.

5. A. E. Clark, H. Nong, H. Zhu, & R. Zhu, *Compensating for Academic Loss: Online Learning and Student Performance during the COVID-19 pandemic,* **China Economic Review**, 68, 2021, 101629.

6. A. A. Hayat, K. Shateri, M. Amini, & N. Shokrpour, *Relationships Between Academic Self-Efficacy, Learning-Related Emotions, and Metacognitive Learning Strategies with Academic Performance in Medical Students: A Structural Equation Model,* **BMC medical education**, 20(1), 2020, 1-11.

7. S. Felszeghy, S. Pasonen-Seppänen, A. Koskela, P. Nieminen, K. Härkönen, K. M. Paldanius, & A. Mahonen, *Using Online Game-Based Platforms to Improve Student Performance and Engagement in Histology Teaching,* **BMC Medical Education**, 19, 2019, 1-11.

8. J. Gustems-Carnicer, C. Calderón, & D. Calderón-Garrido, *Stress, Coping Strategies and Academic Achievement in Teacher Education Students,* **European Journal of Teacher Education**, 42(3), 2019, 375-390.

9. H. Franklin, & I. Harrington, *A Review Into Effective Classroom Management and Strategies For Student Engagement: Teacher and Student Roles in Today's Classrooms,* **Journal of Education and Training Studies**, 7(12), 2019, 1-12.

10. A. Wanjiku Wang'ang'a,, *Dyscalculia in Kenyan Schools: Implications for Transition to Higher Education and Employment, Literature Review*, **East African Journal of Education Studies**, 6(2), 2023, 121-138.

11. Mehmet Ozcan, *Factors Affecting Students' Academic Achievement According to the Teachers' Opinion,* **Education Reform Journal**, 6(1), 2021, 1 -18.

12. R. A. Cruz, A. R. Firestone & M. Love, *Beyond a Seat at the Table: Imagining Educational Equity Through Critical Inclusion*, **Educational Review**, 2023, 1-27.

13. A. Al-Abdullah & L. Hassan, *Factors Determining the Success and Failure of EdTech Initiatives in Rural Academic Institutions*, **AI, IoT and the Fourth Industrial Revolution Review**, 13(7), 2023, 47-60.

14. J. Kim, H. Lee & Y. H. Cho, *Learning Design to Support Student-AI Collaboration: Perspectives of Leading Teachers for AI in Education*, **Education and Information Technologies,** 27(5), 2022, 6069-6104.

15. T. Shen & S. Konstantopoulos, *Are Class Size and Teacher Characteristics Associated with Cognitive Outcomes in Early Grades?*, **School Effectiveness and School Improvement**, 33(3), 2022, 333-359.

16. A. Alshuraiaan, *Exploring the Relationship between Teacher-student Interaction Patterns and Language Learning Outcomes in TESOL Classrooms*, **Journal of English Language Teaching and Applied Linguistics**, 5(3), 2023, 25-34.

17. X. Qu, *Structural Barriers to Inclusive Education for Children with Special Educational Needs and Disabilities in China*, **Journal of Educational Change**, 23(2), 2022, 253-276.

18. A. B. Radjiev, I. A. Gapparovich, K. A. Yuldoshevich & M. I. Turdiboevich, *Does the Quality of Education Today Depend on the Number of Students?*, **International Journal on Integrated Education**, 5(6), 2022, 109-114.

19. T. R. Jones & S. Burrell, *Present in Class Yet Absent in Science: The Individual and Societal Impact of Inequitable Science Instruction and Challenge to Improve Science Instruction*, **Science Education**, 106(5), 2022, 1032-1053.

20. A. B. Kamiza, S. M. Toure, M. Vujkovic, T. Machipisa, O. S. Soremekun, C. Kintu & S. Fatumo, *Transferability of Genetic Risk Scores in African Populations*, **Nature Medicine**, 28(6), 2022, 1163-1166.

21. M. A. Almaiah, R. Alfaisal, S. A. Salloum, S. Al-Otaibi, R. Shishakly, A. Lutfi & R. S. Al-Maroof, *Integrating Teachers' TPACK Levels and Students' Learning Motivation, Technology Innovativeness, and Optimism in an IoT Acceptance Model*, **Electronics,** 11(19), 2022, 3197.

22. E. Acosta-Gonzaga & E. F. Ruiz-Ledesma, *Students' Emotions and Engagement in the Emerging Hybrid Learning Environment During the COVID-19 Pandemic*, **Sustainability,** 14(16), 2022, 10236.

23. D. Ahwireng, *Confronting COVID-19 Whilst Elementary School Students Resume In-Person Learning*, **Journal of Education and Learning**, 11(3), 2022, 64-76.

24. N. Dsouza, *Analyzing the Transformative and Multifaceted Impact of Social Media Platforms*, **GPH-International Journal of Social Science and Humanities Research**, 6(07), 2023, 56-65.

25. S. Lundberg, Gender Economics: *Dead-ends and New Opportunities*, In 50th Celebratory 50, 2023, 151-189, Emerald Publishing Limited.

26. C. Rioux, A. Paré, K. London-Nadeau, R. P. Juster, S. Weedon, S. Levasseur-Puhach, & L. M. Tomfohr-Madsen, *Sex and Gender Terminology: A Glossary for Gender-Inclusive Epidemiology,* **J Epidemiol Community Health**, 76(8), 2022, 764-768.

27. I. GHipólito, K. Winkle & M. Lie, *Enactive Artificial Intelligence: Subverting Gender Norms in Human-Robot Interaction*, **Frontiers in Neurorobotics**, 17, 2023, 1149303.

28. K. Clary, J. Goffnett, M. King, T. Hubbard & R. Kitchen, *"It's the Environment, Not Me": Experiences Shared By Transgender and Gender Diverse Adults Living in Texas*, **Journal of Community Psychology**, 51(3), 2023, 906-923.

29. M .Lundin, & S. Bombaci, *Making Outdoor Field Experiences More Inclusive for the LGBTQ+ Community*, **Ecological Applications**, 33(5), 2023, e2771.

30. D. Harding, S. Marsh & Y. Lennie, *Perioperative Considerations for Transgender and Gender Diverse Adults*, **BJA education**, 23(4), 2023, 136-143.

31. M. Eisend & A. Rößner, *Breaking Gender Binaries*, **Journal of Advertising**, 51(5), 2022, 557-573.

32. J. Strübel & S. Goswami, *Clothing and Self Concept in Cisgender and Transgender Individuals,* **Gender Issues**, 39(4), 2022, 387-408.

33. J. D. Haug, *Gender Identities and Intersectional Violence Within Forensi C Anthropology*, In The Marginalized in Death: A Forensic Anthropology of Intersectional Identity in the Modern Era, 2022, 175-201, Lexington Books Washington, DC.

34. A. E. Goldberg, *LGBTQ-Parent Families: Diversity, Intersectionality, and Social Context*. **Current Opinion in Psychology**, 2022, 101517.

35. M. Salvati Y. & Koc, *Advancing Research Into the Social Psychology of Sexual Orientations and Gender Identities: Current Research and Future Directions*, **European Journal of Social Psychology**, 52(2), 2022, 225-232.

36. C. T. Kulik, *Gender (in) Equality in Australia: Good Intentions and Unintended Consequences,* **Asia Pacific Journal of Human Resources**, 60(1), 2022, 97-115

37. R. P. Samanta, *Inductive Approach: Its Pros & Cons*. **Scholars International Journal of Linguistics and Literature,** 2021, 351-353.

38. M. Tohir, M. Maswar, M. Atikurrahman, S. Saiful & D. A. R. Pradita, *Prospective Teachers' Expectations of Students' Mathematical Thinking Processes in Solving Problems*, **European Journal of Educational Research**, 9(4), 2020, 1735-1748.

39. M. Kusmin, *Inquiry-based Learning and Trialogical Knowledge-Creation Approach in Smart Schoolhouse Supported by IoT Devices*. **Global Engineering Education Conference (EDUCON)**, April, 2019, 571-575.

40. M. L. Kovarik, J. K. Robinson & T. J. Wenzel, *Why Use Active Learning?. In Active Learning in the Analytical Chemistry Curriculum*. **American Chemical Society**, 2022, 1-12.

41. J. G. Hardy, S. Sdepanian, A. F. Stowell, A. D. Aljohani, M. J. Allen, A. Anwar, & K. L. Wright, *Potential for chemistry in multidisciplinary, interdisciplinary, and transdisciplinary teaching activities in higher education*, **Journal of Chemical Education**, 98(4), 2021, 1124-1145.

42. B. Lasamahu, E. Siregar, & M. Sukardjo, *Online Learning with Project Based Learning Approach in the Human Performance Technology Course*, **Journal of Education Research and Evaluation**, 5(2), 2021, 208-215.

43. E. R. Hoffer, *Case-Based Teaching: Using Stories for Engagement and Inclusion*. **International Journal on Social and Education Sciences**, 2(2), 2020, 75-80.

44. R. E. Simamora, & S. Saragih, *Improving Students' Mathematical Problem Solving Ability and Self-Efficacy through Guided Discovery Learning in Local Culture Context,* **International Electronic Journal of Mathematics Education**, 14(1), 2019, 61-72.

45. D. A. Miranda, A. R. Lizcano-Dallos, & E. F. Pinzón, *Improving the Physics Learning Outcomes of Engineering Students Through Just in Time Teaching (JiTT),* **IEEE Revista Iberoamericana de Tecnologias del Aprendizaje**, 2023.

46. Y. Shi, & S. Qu, *Cognitive Ability and Self-Control's Influence on High School Students' Comprehensive Academic Performance*, **Frontiers in psychology**, 12, 2021, 783673.

47. M. M. Rahman, *21st Century Skill 'Problem Solving': Defining the Concept*, **Asian Journal of Interdisciplinary Research**, 2(1), 2019, 64-74.

37. R. P. Samanta, *Inductive Approach: Its Pros & Cons*, **Scholars International Journal of Linguistics and Literature,** 4(11) 2021,351-353.

48. I. A. Khan, M. Iftikhar, S. S. Hussain, A. Rehman, N. Gul, W. Jadoon & B. Nazir, *Redesign and Validation of a Computer Programming Course Using Inductive Teaching Method,* **PloS one**, 15(6), 2020, e0233716.

49. A. H. Abdullah, N. S. Misrom, U. H. A. Kohar, M. H. Hamzah, Z. M. Ashari, D. F. Ali, & S. N. S. Abd Rahman, *The Effects of an Inductive Reasoning Learning Strategy Assisted by the GeoGebra Software on Students' Motivation for the Functional Graph II topic*, **IEEE Access**, 8, 2020, 143848-143861.

50. U. Dustova, *Inductive and Deductive Grammar Teaching*, *Евразийский журнал социальных наук, философии и культуры*, 2(12), 2022, 247-251.

51. N. A. Abdukarimova, & N. N. Zubaydova, *Deductive and Inductive Approaches to Teaching Grammar*. **JournalNX,** 2021, 372-376.

52. A. Widyantoro, *Teaching Conditional Sentence Using Presentation, Practice, Production (PPP) Technique in Vocational School*, **CLLiENT (Culture, Literature, Linguistics, And English Teaching)**, 1(02), 2019, 147-164.

53. C. R. Muthmainnah, *The Effect of Deductive and Inductive Instruction on Students' Grammar Ability (A Comparative Study)* **(Doctoral dissertation, UIN Ar-Raniry),** 2019, 21.

54. S. Wardani & I. W. Kusuma, *Comparison of Learning in Inductive and Deductive Approach to Increase Studentâ€™s Conceptual Understanding Based on International Standard Curriculum*, **Jurnal Pendidikan IPA Indonesia**, 9(1), 2020, 70-78.

55. T. G. Campbell, J. D. Boyle & S. King, *Proof and argumentation in K-12 Mathematics: A Review of Conceptions, Content, and Support,* **International journal of Mathematical Education in Science and Technology**, 51(5), 2020, 754-774.

56. H. K. Sawhney, *Self-study Exploring Pedagogy to Engage Community College Students in Chemistry* ***(Doctoral dissertation, San Francisco State University)***, 2020

57 B. I. Ansari, T. Taufiq & S. Saminan, *The Use of Creative Problem Solving Model to Develop Students' Adaptive Reasoning Ability: Inductive, Deductive, and Intuitive,* **International Journal on Teaching and Learning Mathematics**, 3(1), 2020, 23-36.

58. D. Szyliowicz & T. G. Green, Making strategy "Real": *Using Reality Television for Innovating Teaching Approaches*, **The International Journal of Management Education,** 17(3), 2019, 100304.

59. P. Stilwell & K. Harman, *Phenomenological Research Needs to be Renewed: Time to Integrate Enactivism as a Flexible Resource*, **International Journal of Qualitative Methods**, 20, 2021, 1609406921995299.

60. S. Hieng, S. Thlang & S. Nget, *A Comparison of Concept-Based Instruction and a Deductive Approach in Teaching English Grammar*, **Cambodian Journal**, 20. 2023

61. T. R. Souisa, & L. Yanuarius, *Teachers' Strategies on Teaching Grammar: Facts and Expectations of Senior High School Teachers at Ambon*, **International Journal of Evaluation and Research in Education,** 9(4), 2020, 1121-1127.

62. N. H. Acharya, *Mathematics Teachers' Perceptions on Higher Order Thinking Skill,* **International Journal of Multidisciplinary Perspectives in Higher Education**, 6(2), 2021, 105-125.

63. S. F. Jreisat, *The Effectiveness of a Proposed Training Program Based on the Technological Approach to Improve the Deductive Thinking Skills of Students*, **Science and Education**, 62(2), 2023, 141-157.

64. O. R. Mahdi, I. A. Nassar & H. A. I. Almuslamani, *The Role of Using Case Studies Method in Improving Students' Critical Thinking Skills in Higher Education*, **International Journal of Higher Education,** 9(2), 2020, 297-308.

54. S. Wardani & I. W. Kusuma, *Comparison of Learning in Inductive and Deductive Approach to Increase Studentâ€™s Conceptual Understanding based on International Standard Curriculum,* **Jurnal Pendidikan IPA Indonesia**, 9(1), 2020, 70-78.

65. E. Barroga, & G. J. Matanguihan, *Creating logical flow when Writing Scientific Articles*, **Journal of Korean Medical Science**, 36(40), 2021. Available Online: https://synapse.koreamed.org/articles/1147950.

66. S. Rivard, *Theory Building is Neither an Art Nor a Science. It is a Craft*, **Journal of Information Technology,** 36(3), 2021, 316-328.

67. I. Ahmad, A. Farid, & M. Hussain, *Teacher Cognition and English as a Foreign Language Context: Potential Challenges.* **Psychology and Education**, 58(5), 2021, 1553-6939.

68. K. Umida, A. Farida, B. Dilnoza & X. Lenie*, Development Stages of the Concept to Constructivism*, **湖南大学学报 (自然科学版)**, 49(07). 2022.

69. M. Männistö, K. Mikkonen, H. M. Kuivila, M. Virtanen, H. Kyngäs & M. Kääriäinen, *Digital Collaborative Learning in Nursing Education: A Systematic Review*. **Scandinavian Journal of Caring Sciences**, 34(2), 2020, 280-292.

70. M. Y. Adjei, *Assessment Practices of Christian Religious Studies Teachers in Senior High Schools in Ghana: A Survey,* **Doctoral Dissertation, University of Cape Coast**, 2021.

71. B. J. Ngereja, & B. Hussein, *An Examination of the Preconditions of Learning to Facilitate Innovation in Digitalization Projects: A Project Team Members' Perspective*, **International Journal of Information Systems and Project Management**, 9(2), 2021, 23-41.

72. Y. Ozdem-Yilmaz & K. Bilican, *Discovery Learning Jerome Bruner Science Education in Theory and Practice:* **An Introductory Guide to Learning Theory**, 2020.177-190.

73. T. Lynch, *Theories, Models and Approaches: Physical Education and Wellbeing.* ***Global and Holistic Approaches to Child Health***, 2019, 15-34. DOI10.1007/978-3-030-22266-6_2

74. T. Sulistyowati, *Bottom-up and Top-down Listening Processes Within Cognitive Constructivist Learning Theory,* **Prominent Journal**, 2(1), 2019, 92-100.

75. I. W. Santyasa, N. K. Rapi & I. Sara, *Project Based Learning and Academic Procrastination of Students in Learning Physics,* **International Journal of Instruction**, 13(1), 2020, 489-508.

76. I. F. F. A. T. Basit, K. H. U. D. A. Bakhsh, & M. Hafeez, *Adult Learning Theories and their Role in Instructional Design, Curriculum Development and Educational Technology*, **Wseas Transactions on Environment and Development**, 17, 2021,1149-1159. Available Online: https://wseas.com/journals/articles.php?id=698.

77. E. Rassaei, *The Effects of Text-Based and Audio-based Dynamic Glosses on L2 Vocabulary Learning: A Dynamic Assessment Approach,* **The Language Learning Journal**, 2023, 1-14.

78. N. K. A. Suwastini, N. P. D. Ersani, N. N. Padmadewi & L. P. Artini, *Schemes of Scaffolding in Online Education,* **Retorika: Jurnal Ilmu Bahasa**, 7(1), 2021,10-18.

79. S. Hoidn, & K. Reusser, *Foundations of Student-Centered Learning and Teaching,* In *The Routledge International Handbook of Student-Centered Learning and Teaching in Higher Education* 2020, 17-46, Routledge.

80. D. Nadim, *Interplay Between Constructivism and Metacognitive Regulation: An Experimental Study on Mathematics Student,* **Towards Excellence**, 14(4). December 2022, 24 – 33.

81. R. Rufii, & D. Rochmawati, *Evaluation of Universal Design for Constructivist-based Statistics Learning Module for Students' Increased Motivation*, **Journal of Education and Learning (EduLearn)**, 13(3), 2019, 431-440.

82. M. Pande, & S. V. Bharathi, *Theoretical Foundations of Design Thinking–A Constructivism Learning Approach to Design Thinking.* **Thinking Skills and Creativity**, 36, 100637. 2020. Available Online: https://www.sciencedirect.com/science/article/abs/pii/S1871187119 303104

83. A. G. Rillo, B. E. Martínez-Carrillo, J. A. Castillo-Cardiel, & J. M. Rementería-Salinas, *Constructivism: An Interpretation From Medical Education*. **IOSR J Res Method Educ**, 10, 2020, 1-12.

84. S. Papavlasopoulou, M. N. Giannakos, & L. Jaccheri, *Exploring Children's Learning Experience in Constructionism-Based Coding Activities Through Design-Based Research,* **Computers in Human Behavior***, 99*, 2019, 415-427.

85. A. Alam, *Educational Robotics and Computer Programming in Early Childhood Education: A Conceptual Framework for Assessing Elementary School Students' Computational Thinking for Designing Powerful Educational Scenarios*, **International Conference on Smart Technologies and Systems for Next Generation Computing (ICSTSN),** 2022, 1-7.

86. Y. Mohibu, & H. Ismail, *The Application of the Cooperative Learning Model (Picture and Picture) to Improve the Students' Reading Skill,* **Langua: Journal of Linguistics, Literature, and Language Education**, 4(2), 2021, 6-17.

87. J. W. Kusuma, *Constructivism from Philosophy to Mathematics Learning,* **International Journal of Economy, Education, and Enterpreneurship**, 1(2), 2021.

88. N. R. S. M. Dali, H. A. Hamid, W. R. W. Nawang, & W. N. F. W. M. Nazarie, *Post Pandemic Consumer Behavior: Conceptual Framework*, **The Journal of Muamalat and Islamic Finance Research**, 17(Special), 2020, 13-24 ISSN: 1823-075X, e-ISSN: 0126-5954.

89. J. Lemantara, B. Hariadi, D. Sunarto, T. Amelia, & T. Sagirani, *An Innovative Strategy to Anticipate Students' Cheating: The Development of Automatic Essay Assessment on The "MoLearn" Learning Management System,* **IEEE Transactions on Learning Technologies,** 2023.

90. M. S. Kirby, T. D. Spencer & S. T. Spiker, *Humble Behaviorism Redu.* **Behavior and Social Issues**, 31(1), 2022, 133-158.

91. Y. Pan, F. Ke, & X. Xu, *A Systematic Review of the Role of Learning Games in Fostering Mathematics Education in K-12 Settings*, **Educational Research Review,** 36, 2022, 100448.78.

92. G. Aly, *Benny, Barbara, and the Ethics of EdTech*, **Journal of Humanistic Mathematics**, 12(2), 2022,98-127.

93. L. W. Daffin Jr, *Principles of Learning and Behavior*, 2021. Available Online: https://opentext.wsu.edu/principles-of-learning-and-behavior/wp-content/uploads/sites/93/2019/04/Principles-of-Learning-and-Behavior-2nd-Edition.pdf

94. B. S. Haug & S. M. Mork, *Taking 21st Century Skills from Vision to Classroom: What Teachers Highlight as Supportive Professional Development in the Light of New Demands from Educational Reforms,* **Teaching and Teacher Education**, 100, 2021, 103286. Available Online: https://www.sciencedirect.com/science/article/pii/S0742051X2100010X

95. N. Ezenwa-Ohaeto, & E. N. Ugochukwu, *Language Learning Theories: Behaviourism, Mentalism and Affectivism*, **Awka Journal of English Language and Literary Studies**, 8(1), 2021.

96. A. F. M. Marzaini, W. N. E. H. Sharil, K. Supramaniam, & S. M. Yusoff, *Evaluating Teachers' Assessment Literacy in Enacting Cefr-Aligned Classroom-Based Assessment in Malaysian Secondary Schools ESL Classroom*, **International Journal of Academic Research in Progressive Education and Development,** 12(1), 2023, 661-675.

97. D. K. Abdieva, *Acquisition Of Pedagogy Via E-Learning,* **Theoretical & Applied Science**, 95(3), 2021, 126-128.

98. S. Hennessy, S. D'Angelo, N. McIntyre, S. Koomar, A. Kreimeia, L. Cao, & A. Zubairi, *Technology Use for Teacher Professional Development in Low-And Middle-Income Countries: A Systematic Review,* **Computers and Education Open**, 3, 2022, 100080.

99. M. M. Obeidat, & M. D. A. Alomari, *The Effect of Inductive and Deductive Teaching on EFL Undergraduates' Achievement in Grammar at the Hashemite University in Jordan*, **International Journal of Higher Education**, 9(2), 2020, 280-288.

100. Dhiorbháin Ni, *A Sociocultural Rationale for an ExplicitInductive Approach to Grammar Teaching in L2 Teacher Education,* **Teaching Education**, 34:3, 2023, 319-334, Available Online: https://doi.org/10.1080/10476210.2022.2118703.

101. L. Radford, *Introducing Equations in Early Algebra,* **ZDM–Mathematics Education**, 54 (6), 2022, 1151-1167. Available Online: https://rdcu.be/cU5SG.

102. A. M. M. Navaz, & M. F. Hanaan Khaathoon, *Teaching Grammar: A Comparison Between Schools and University.KALAM,* **International Research Journal Faculty of Arts and Culture, South Eastern University of Sri Lanka**, 13 (4), 2020, 58-70.

103. N. O'Meara, & F. Faulkner, *Professional Development for Out-Of-Field Post-Primary Teachers of Mathematics: An Analysis of the Impact of Mathematics Specific Pedagogy Trainin,* **Irish Educational Studies,** 41(2), 2022, 389-408.

104. J. Benbow, A. Mizrachi, D. Oliver, & L. Said-Moshiro, *Large Class Sizes in the Developing World: What Do We Know and What Can We Do?* **American Institutes for Research under the EQUIP1 LWA**, October 2007, 1 – 14. Available Onliine: https://www.edu-links.org/sites/default/files/media/file/Large_Class_Sizes_in_the_Developing_World__What_Do_We_Know_and_What_Can_We_Do_.pdf

105. F. T. Fubile, & J. Sawe, *The Impact of Pupil-Teacher Ratio on Performance in Mastering Reading, Writing and Arithmetic Competencies in Morogoro Municipality. A*

Case Study of Standard Four Pupils in Primary School, **East African Journal of Education Studies**, 5(3), 2022, 250-258.

106. M. A. Mustapha, M. Kachallah & F. A. Abulfathi, *Relationship between Class Size and Students Academic Performance in English Language*. **Editorial Board**, 10, 2021, SSN 0794 – 4764 (PRINT) ISSN 2651 – 6063 Available Online: https://cudimac.unn.edu.ng/wp-content/uploads/sites/52/2021/12/Muhammad-et-al-10-18.pdf.

107. I. A. Mohammed, S. A. Uche, & M. S. Kasim, *Effect of Class Size on the Academic Achievement of Students in Basic Science and Technology in Gwagwalada Area Council FCT Abuja*, **CARD International Journal of Educational Research and Management Technology (IJERMT)**, 2(3), 2017, ISSN: 2545-5893 (Print) 2545-5877.

108. S. Iglesias-Pradas, Á. Hernández-García, J. Chaparro-Peláez, & J. L. Prieto, *Emergency Remote Teaching and Students' Academic Performance in Higher Education During The COVID-19 Pandemic: A Case Study,* **Computers in Human Behavior**, 119, 2021, 106713.

109. M. A. Adeoye, *Advanced Supervision in Educational Management: Differences Between Supervision, Accreditation, Inspection, Collaboration, Evaluation, and Quality Assurance*, **ASEAN Journal of Educational Research and Technology**, 1(2), 2022. 169-176.

110. S. Iglesias-Pradas, Á. Hernández-García, J. Chaparro-Peláez, & J. L. Prieto, *Emergency Remote Teaching and Students' Academic Performance in Higher Education During The COVID-19 pandemic: A Case Study,* **Computers in human behavior**, 119, 2021, 106713.

111. A. Alshuraiaan, *Exploring the Relationship Between Teacher-student Interaction Patterns and Language Learning Outcomes in TESOL Classrooms*, **Journal of English Language Teaching and Applied Linguistics**, 5(3), 2023, 25-34.

112. J. N. Okechukwu, & B. C. Oboshi, *Influence of Overcrowded Classroom on Pupils' Academic Achievement In Public Primary Schools In Idemili South Local Government Area Of Anambra State, Nigeria,* **Journal of Educational Research & Development**, 4(2), 2021.

113. M. T. Teibowei, *Challenges to The Implementations of Internal Quality Assurance Mechanisms in Bayelsa Medical University*, **British Journal of Multidisciplinary and Advanced Studies**, 4(2), 2023, 102-108.

114. K. Maloney, *The Effects of Class Size on Student Achievement*. 2020, Available Online: https://scholarworks.waldenu.edu/cgi/viewcontent.cgi?article=3404&context=dissertations&httpsredir=1&referer=

115. D. N. Nonyelum, K. Ogugua, & J. A. Abah, *Influence of Student-Teacher Relationship on the Academic Performance of Junior Secondary School Students in Mathematics in Makurdi Local Government Area of Benue State, Nigeria*, **VillageMath Educational Review (VER)**, 3(1), 2020.

116. M. I. Obiakor, & C. N. Oguejioffor, *Impact of Classroom size on Academic Performance of Secondary School Students in Enugu Local Government Are of Enugu State, Nigeria,* **African Journal of educational Management, Teaching and Entrepreneurship studies.** 1 (1), 2020, 51-59.

117. O. A. Gbeleyi & O. C. Potokri, *Gender Beliefs Framed on Culturo-Techno-Contextual Approach About Learning of Difficult Stem Concepts in African Secondary Schools*. **African Perspectives of Research in Teaching & Learning (APORTAL),** *7*(1). 2023.

118. S. Yeo, H. Shim, S. Hwang, & T. G. Campbell, *Relations Between Elementary Mathematics Growth Trajectories and Middle School Mathematics Achievement: Moderating Effects of Student Perception of Teaching Styles*, **International Journal of Science and Mathematics Education**, 21(6), 2023,1889-1912.

119. M. Vooren, C. Haelermans, W. Groot, & H. M. van den Brink, *Comparing Success of Female Students to their Male Counterparts in the STEM Fields: An Empirical Analysis From Enrollment Until Graduation Using Longitudinal Register Data,* **International Journal of STEM Education**, *9*(1), 2022, 1-17.

120. C. Brandmiller, H. Dumont & M. Becker, Teacher *perceptions of learning motivation and Classroom Behavior: The Role of Student Characteristic,* **Contemporary Educational Psychology**, 63, 2020, 101893.

121. M. Šimunović, & T. Babarović, The *Role of Parents' Beliefs in Students' Motivation, Achievement, and Choices in the STEM Domain: A Review and Directions for Future Research,* **Social Psychology of Education**, 23, 2020, 701-719.

122. K. A. Weeden, D. Gelbgiser, & S. L. Morgan, *Pipeline Dreams: Occupational Plans and Gender Differences in STEM Major Persistence and Completion*, **Sociology of Education**, 93(4), 2020, 297-314.

123. Z. Mkhize, *'They Are Just Women, What Do They Know?': The Lived Experiences of African Women Doctoral Students in the Mathematics Discipline in South African Universities*, **Transformation in Higher Education**, 7, 2022, 218.

124. M. Ekatushabe, D. Kwarikunda, C. M. Muwonge, J. Ssenyonga, & U. Schiefele, *Relations Between Perceived Teacher's Autonomy Support, Cognitive Appraisals and Boredom in Physics Learning Among Lower Secondary School Students*, **International Journal of STEM Education**, 8(1), 2021, 1-15.

125. A. Maharani, H. Sulaiman, N. Aminah, & C. D. Rosita, *Analyzing the Student's Cognitive Abilities Through the Thinking Levels of Geometry Van Hiele Reviewed from Gender Perspective*, **Journal of Physics: Conference Series,** 1188(1), March 2019, 012066. IOP Publishings .

126. J. T. Ajai & B. I. Imoko*, Gender Differences in Mathematics Achievement and Retention Scores: A Case of Problem-Based Learning Method*, **International Journal of research in Education and Science**, 1(1), 2015, 45-50.

127. U. M. Mashrabovna, *Using Inductive and Deductive Teaching to Improve Grammar*. **International Journal of Formal Education**, 2(7), 2023, 43-46, ISSN: 2720-6874.

128. A. Grami, *Discrete Mathematics: Essentials and Applications*, 2022, Academic Press.

129. A. Shirav, & E. Nagai, *The Effects of Deductive and Inductive Grammar Instructions in Communicative Teaching*. **English Language Teaching**, 15(6), 2022, 102-123.

130. S. Rodriguez, B. Regueiro, I. Piñeiro, I. Estévez & A. Valle, *Gender Differences in Mathematics Motivation: Differential Effects on Performance in Primary Education*, **Frontiers in psychology**, 10, 2020, 1-8. Available Online: https://doi.org/10.3389/fpsyg.2019.03050

131. S. Datta & G. G. Kingdon, *Class Size and Learning: Has India Spent Too Much On Reducing Class Size?*, 2021, 1-35.

132. R. T. Nair & U. K. Kulkarni, *Study Habits and it's Impact on Academic Performance in English of Secondary School Students in Kalaburgi Region*, **PalArch's Journal of Archaeology of Egypt/Egyptology**, 17(12), 2020, 670-682.

Chapter Three

Methodology

The research study is concerned with effects of inductive and deductive teaching strategies on students' achievement in Basic General Mathematics in Colleges of Education in Oyo State. This chapter deals with Research Design, Population of the Study, Sample and Sampling Techniques, Description of the Research Instruments, Validity of the Research Instruments, Reliability of the research Instrument, Data collection and Data analysis.

3.1 Research Design

The research design that was used for this study is quasi experimental design to examine the effect of inductive and deductive teaching strategies on students' achievement in Basic General Mathematics in Colleges of Education in Oyo State. The study was make use of 3 ×**2** × **2** factorial design. This design is chosen because it allows for the determination of the effect of each independent variable on the dependent variable. This is the main component of the design. It also provides an opportunity to determine the combined influence of the independent variable on the dependent variable.

Table 3.1: Factorial Design

	1		**2**		
GROUP	PRE	TREATMENT	POST-TEST	CLASS SIZE	GENDER
E_1	O_1	X_1	0_2	Large	Female
				Small	Male
E_2	O_3	X_2	O_4	Large	Female
				Small	Male
E_3	O_5	X_3	O_6	Large	Female
				Small	Male

Source: Field work 2023

Where

E_1 represents Experimental Group 1 (Inductive Teaching Strategy)

E_2 represents Experimental Group 2 (Deductive Teaching Strategy)

E_3 represents Experimental Group 3 (Conventional Teaching Strategy)

O_1 represents Pre-test score of Group 1

O_3 represents Pre-test score of Group 2

O_5 represents Pre-test score of control Group

O_2 represents Post-test score of Group 1

O_4 represents Post-test score of Group 2

O_6 represents Post-test score of control Group

X_1 = Treatment 1 (Inductive Teaching Strategy)

X_2 =Treatment 2 (Deductive Teaching Strategy)

X_3 =Treatment 3(Conventional Teaching Strategy)

Independent variables include

- ❖ Independent variables of three levels
  - ➢ Inductive teaching strategy
  - ➢ Deductive teaching strategy
  - ➢ Conventional teaching strategy

Dependent variables include

- ➢ Students' academic achievement in Basic General Mathematics

Moderating variables include

- ❖ Gender at two levels
  - ➢ Male
  - ➢ Female
- ❖ Class size at two levels
  - ➢ Small
  - ➢ Large

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

Treatment	Class Size	Gender
Inductive Teaching Strategy (X_1)	Large	Female
	Small	Male
Deductive Teaching Strategy (X_2)	Large	Female
	Small	Male
Conventional Teaching Strategy (X_3)	Large	Female
	Small	Male

The schematic representation of the (3 × 2 × 2) factorial matrix for the study is shown above

3.2 Population of the Study

The population for the study comprises of three thousand, six hundred and sixty three (3663) year Two Students in the government Colleges of Education in Oyo State: four hundred and seven (407) Year Two students in Oyo State College of Education, Lanlate; Two thousand and fifty-six (2056) year two students in Federal College of Education(Special), Oyo and one thousand two hundred(1200) students in Emmanuel Alayande College of Education, Oyo.

Table 3.3: Population of year two students

S/N	College of Education	Level	Population
1	Emmanuel Alayande Colleges of Education, Oyo	200	1,200
2	Federal College of Education (special), Akinmorin, Oyo	200	2,056
3	Oyo State College of Education, Lanlate, Oyo State	200	407
	TOTAL		3,663

Source: Field work 2023

3.3 Sample and Sampling Techniques

The study adopted a purposive sampling technique of three intact class of non-science Year Two students of Early Childhood Care School and Adult and non-formal education students from school of Education of Alayande College of Education, Oyo, Federal College of Education (Special), Oyo and Oyo State College of Education, Lanlate, Oyo. There are six (6) Schools in all Colleges of Education (School of Art &Social Science, School of Early Childhood Care, School of Education, School of Languages, School of Science and School of Vocational and Technical Education). The total number of Year Two students of School of Education and Early Childhood Care from the three Colleges of Education who is participated in the study is two hundred and thirty-five (235). One hundred and nine (109) students from Federal College of Education (Special), Oyo, sixty (60) students from Oyo State College of Education, Lanlate and sixty six (66) students from Emmanuel Alayande College of Education ,Oyo.

Table 3.4: Sample of year two students

S/N	College of Education	Level	Population	Sample
1	Emmanuel Alayande Colleges of Education, Oyo	200	1200	66
2	Federal College of Education (Special), Akinmorin, Oyo	200	2,056	109
3	Oyo State College of Education, Lanlate, Oyo State	200	407	60
	TOTAL		3,663	235

Source: Field work 2023

3.4 Description of the Research Instruments

The instruments used in this research work were:

i) Lesson Plan prepared by the researcher and

ii) Basic Mathematics Achievement Test (BMAT).

i. Lesson Plan: The lesson plan was developed by the investigator and specifically designed to align with the content in the Basic General Mathematics II curriculum, as outlined in the second-semester course for 100-level students. The topic selected for this plan is "Expansion and Factorization of Algebraic Expressions." Three separate lesson plans were created: one for the experimental group I, another for experimental group II, and a third for the control group. These lesson plans were employed as instructional tools, and you can find them in Appendix II, III, and IV.

ii. Basic Mathematics Achievement Test (BMAT): The BMAT was derived from previously administered 100-level examination questions. It comprehensively covers all subtopics related to the expansion and factorization of algebraic expressions. The Basic Mathematics Achievement Test (BMAT) consists of a set of 25 multiple-choice questions, each offering five answer choices labeled from A to E. Detailed question examples can be found in Appendix V.

3.5 Validity of Research Instruments

The face and content validity of the research instruments, was done by the researcher's supervisor and two experts in the Department of Science Education. All corrections and modifications were effected before the final drafts were produced.

3.6 Reliability of the Research Instruments

A pilot survey of Twenty (20) Year II students were chosen from School of Languages at Emmanuel Alayande Colleges of Education, Oyo was used to determine the reliability of the instruments and was carried on of the sample of the population who did not partake in the main study. Kuder-Richardson formula (KR-20) was used to calculate the reliability of the instrument (BMAT) with reliability value of 0.89.

3.7 Method of Data Collection

Prior to the commencement of the research, a letter of introduction was collected from the Department of Science Education, Lead City University, Ibadan to secure the consent of Heads of the various institutions. The researcher administered and conducted the Basic Mathematics Achievement Test (BMAT) with the help of two (2) trained research assistances both before and after the treatments. A total of nine (9) weeks was used to conduct the study. The first one (1) week was used for pre-test; the second stage of seven (7) weeks was used for lectures. The third stage of two (2) weeks was used for post-test. This was paper and pencil tests. The post-test results were obtained after the treatment, students from Emmanuel Alayande College of Education (Experimental group1), Oyo were exposed to inductive teaching strategy, while the students of Federal College of Education (Special) (Experimental group 2), Oyo were exposed to deductive teaching strategy and Oyo State College of Education Lanlate was only exposed to the regular conventional teaching strategy. The table of specification for Basic Mathematics Achievement Test (BMAT) was used for assessment, both before and after the treatment. see Appendix II.

3.8 Method of Data Analysis

Analysis of Co-variance (ANCOVA) was used to analyze the collected data. The data was tabulated and analyzed under the following headings: (i) Analysis of mean achievement scores of control group and experimental group for pre-test data (ii) Analysis of mean achievement scores of control group and experimental group for post-test data.

Out of six categories of cognitive domain which aims at the development of mental skills and the acquisition of knowledge of the individual, which include knowledge, comprehension, application, analysis, synthesis and evaluation, the items in Basic Mathematics Achievement Test (BMAT) was based on three cognitive levels which are Knowledge, Comprehension and Application. This measure the dependent variable, that is, Students' Academic Achievement in Basic General Mathematics. The table of specification for Basic Mathematics Achievement Test (BMAT) is presented in Appendix VI.

Endnote

1. List of Colleges of Education in Oyo State, https://samphina.com.ng/federalstate-private-colleges-education-oyo-state/

Chapter Four

Results and Discussion of Findings

4.1 Demographic Data Analysis

This chapter is based on presentation and analysis of data of the results. It also includes discussion of findings. The analysis is in line with the research objectives and hypothesis generated for the study. The study focused on students of Early Childhood Care School and Adult and non-formal education students from school of Education of Alayande College of Education, Oyo, Federal College of Education (Special), Oyo and Oyo State College of Education, Lanlate, Oyo offering Basic General Mathematics course. The total number of Year Two students of school of Education and Early Childhood Care from the three Colleges of Education is two hundred and thirty-five (235). One hundred and nine (109) from Federal College of Education (Special), Oyo, sixty (60) from Oyo State College of Education, Lanlate and sixty six (66) from Emmanuel Alayande College of Education, Oyo. The moderating variables include gender at two levels (Male and Female); and class size at two levels (Small and Large).The data were analyzed with different descriptive and inferential statistical method using the Statistical Package for Social Science (SPSS) IBM Version 26.0 in order to analyse data collected and test the hypotheses formulated for the study.

4.2 Presentation of Data

4.2.1 Research Question

1. What are the frequency distribution of students' achievements for pre-test and post-test in Basic Mathematics Achievement Test (BMAT)?

The frequency distribution of students' achievements in Basic Mathematics Achievement Test for pre-test and post-test are presented below:

Table 4.1: Basic Mathematics Achievement Test (Pre-Test score) at Emmanuel Alayande College of Education, Oyo

Score (Out of 25)	Male	Female	Total	Percentage (%)
2	2	2	4	6.06
3	3	3	6	9.09
4	2	6	8	12.12
5	4	2	6	9.09
6	2	6	8	12.12
7	1	3	4	6.06
8	1	4	5	7.58
9	1	5	6	9.09
10	3	3	6	9.09
11	2	4	6	9.09
12	0	3	3	4.55
17	0	3	3	4.55
19	1	0	1	1.52
Total	**21**	**44**	**66**	**100.00**

Source: Researcher Field Work 2023

The data collected from Emmanuel Alayande College of Education, Oyo, for pre-test score of Year 2 students on Basic General Mathematics. Out of sixty-six students, four (4) students scored 2 marks , two (2) female and two (2) male during the pre-test representing 6.06 %; six (6) scored 3 marks, three (3) female and three (3) male during the pre-test representing 9.09 %; eight (8) students scored four (4) marks, six (6) female and two (2) male representing 12.12%; six (6) students scored 5 marks, two (2) female, four (4) representing 9.09%; eight (8) students scored 6 marks, six (6) female, two (2) male representing 12.12%; four (4) students scored 7marks, three (3) female and one (1) male representing 6.06%; five (5) students scored 8 marks, four (4) female and one (1) male representing 7.58%; six (6) students scored 9 marks, five (5) female and one (1) male representing 9.09%; six(6) students score 10 marks, three (3) female and three (3) male representing 9.09%; six (6) students scored 11 marks, four (4) female and two (2) male representing 9.09%; three (3) students scored 12 marks which were female students representing 4.55%; three (3) students scored 17 marks which also were female students representing 4.55% and finally one (1) student scored 19 marks which was a male student representing 1.52% as shown in the table above.

Table 4.2: Basic Mathematics Achievement Test (Pre-Test score) at Federal College of Education (Special), Oyo

Score (Out of 25)	Male	Female	Total	Percentage (%)
0	1	0	1	0.92
1	2	1	3	2.75
2	0	1	1	0.92
3	4	6	10	9.97
4	5	4	9	8.26
5	2	8	10	9.17
6	8	10	18	16.51
7	7	15	22	20.18
8	3	11	14	12.84
9	5	1	6	5.50
10	1	3	4	3.67
11	1	2	3	2.75
12	0	3	3	2.75
13	3	1	4	3.67
15	1	0	1	0.92
Total	**43**	**66**	**109**	**100.00**

Source: Researcher Field Work 2023

The data collected from Federal College of Education (Special), Oyo, for pre-test score of Year 2 students on Basic General Mathematics. Out of One hundred and nine (109) students. One (1) student scored 0 mark which was male student representing 0.92%; three (3) students scored 1 mark, two (2) male and one (1) female representing 2.75%; One (1) student scored 2 marks, which was a female student representing 0.92%; ten (10) students scored 3 marks, four (4) male and six (6) female representing 9.17%; nine (9) students scored 4 marks. five (5) male and four (4) female students representing 8.26%, ten (10) students scored 5 marks, two (2) male and eight (8) female students representing 9.17%; eighteen (18) students scored 6 marks. eight males and ten (10) females students representing 16.51%; twenty-two (22) students scored 7 marks, seven (7) male and fifteen (15) female representing 20.18%; fourteen (14) students scored 8 marks. three (3) male and eleven (11) female students representing 12.84%; six (6) students scored 9 marks, five (5) male and one (1) female representing 5.50%; four (4) students scored 10 marks, one (1) male and three (3) female student representing 2.75%; three (3) students scored 12 marks which were female students representing 2.75%; four (4) students scored 13 marks, three (3) male and one (1) female representing 3.67%; and finally, one (1) student scored 15 marks which was a male student representing 0.92% as shown in the table above.

Table 4.3: Basic Mathematics Achievement Test (Pre-Test score) at Oyo State College of Education, Lanlate, Oyo State

Score (Out of 25)	Male	Female	Total	Percentage (%)
2	2	0	2	3.33
3	2	3	5	8.33
4	3	6	9	15.00
5	4	6	10	16.67
6	3	4	7	11.67
7	4	5	9	15.00
8	1	3	4	6.67
9	2	3	5	8.33
10	2	5	7	11.67
12	0	2	2	3.33
Total	**23**	**37**	**60**	**100.00**

Source: Researcher's Fieldwork 2023

The data collected from Oyo State College of Education, Lanlate for Pre-test score on Basic Mathematics Achievement Test for Year two students of Oyo State of College of Education, Lanlate. Out of sixty (60) students, two (2) students scored 2 marks which was male student representing 3.33%; five (5) students scored 3 marks, two (2) male and three (3) female representing 8.33%; nine (9) students scored 4 marks, three (3) male and six (6) female representing 15.00%, ten (10) students scored 5 marks, four (4) male and six (6) female representing 16.67%; seven (7) students scored 6 marks, three (3) male and four (4) female representing 11.67%; nine (9) students scored 7 marks, four (4) male and five (5) female representing 15.00%; four (4) student scored 8 marks one (1) male and three (3) female representing 6.67%; five (5) students scored 9 marks, two (2) male and three (3) female representing 8.33%; seven (7) students scored 10 marks. two (2) male five (5) female representing 11.67%; and finally two (2) students scored 12 marks which were female representing 3.33% as shown in the table above.

Table 4.4: Basic Mathematics Achievement Test (Post-Test Score) at Emmanuel Alayande College of Education

Score (Out of 25)	Male	Female	Total	Percentage (%)
3	1	2	3	4.55
4	2	3	5	7.58
5	3	6	9	13.64
6	1	6	7	10.61
7	3	6	8	13.64
8	1	6	7	10.61
9	2	2	4	6.06
10	0	2	2	3.03
11	2	2	4	6.06
12	2	1	3	4.55
13	2	2	4	6.06
14	1	2	3	4.55
15	1	1	2	3.03
17	1	1	2	3.03
19	0	1	1	1.52
21	0	1	1	1.52
Total	**22**	**44**	**66**	**100**

Source: Researcher's Fieldwork 2023

The post-test score of Year 2 students of Emmanuel Alayande College of Education, Oyo, Oyo State on Basic General Mathematics. Out of sixty-six (66) students, three (3) students scored 3 marks, one (1) male and two (2) female during the Post-test representing 4.55%; five (5) students scored 4 marks, two (2) male and three (3) female representing 7.58%; nine (9) students scored 5 marks, three (3) male and six (6) female representing 13.64%; seven (7) students scored 6 marks, one (1) male and six (6) female representing10.61%; nine (9) students scored 7 marks, three (3) male and six (6) female during post-test representing 13.64%; seven (7) students scored 8 marks, one (1) male and six (6) female representing 10.61% ; four (4) students scored 9 marks , two (2) male and two (2) female during the post test representing 6.06% ; two (2) students scored 10 marks which were female students representing 3.03% ; four (4) students scored 11 marks, two (2) male and two (2) female representing 6.06% ; three (3) students scored 12 marks, two (2) male and one (1) female representing 4.55%; four (4) students scored 13 marks ,two (2) male and two (2) female representing 6.06% ; three (3) students scored 14 marks ,one (1) male and two (2) female representing 4.55%; two (2) students scored 15 marks, one (1) male and one(1) female representing 3.03%, two (2) student scored 17 marks, one(1) male and one (1) female representing 3.03% ; one (1) student scored 19 marks, which was a female representing 1.52% and finally one (1) student scored 21 marks, which was a female representing 1.52% as shown in the table above.

Table 4.5: Basic Mathematics Achievement Test (Post-Test Score) at Federal College of Education (Special), Oyo

Score (Out of 25)	Male	Female	Total	Percentage (%)
4	4	1	5	4.59
5	3	4	7	6.42
6	2	2	4	3.67
7	2	5	7	6.42
8	5	7	12	11.01
9	3	7	10	9.17
10	2	12	14	12.84
11	3	3	6	5.50
12	5	14	19	17.43
13	2	2	4	3.67
14	3	1	4	3.67
15	3	4	7	6.42
16	4	2	6	5.50
17	2	0	2	1.83
20	0	2	2	1.83
Total	**43**	**66**	**109**	**100.00**

Source: Researcher's Fieldwork 2023

The post test data collected from Federal College of Education (Special), Oyo, Out of One hundred and nine (109) of the Year two students, five (5) students scored 4 marks, four (4) male and one (1) female during the post test representing 4.59%; Seven (7) students scored 5 mark, three (3) male and four (4) female, during the post text representing 6.42%; Four (4) students scored 6 marks two (2) male and two (2) female representing 3.67%; Seven (7) students scored 7 marks, two (2) male and five (5) female representing 6.42%, twelve (12) students Scored 8 marks five (5) male and Seven (7) female representing 11.01%;

ten (10) students scored 9 marks three (3) male and Seven (7) female representing 9.17%; fourteen (14) students scored 10 marks, two (2) male and twelve (12) female representing 12.84%; six (6) students scored 11 marks, three (3) male and three (3) female represent 5.50%; nineteen (19) students scored 12 marks, five (5) male and fourteen (14) female representing 17.43%; four (4) students scored 13 marks, two (2) male and two (2) female students representing 3.67%; four (4) students scored 14 marks, three (3) male and one (1) female representing 3.67%; Seven (7) students scored 15 marks, three (3) male and four (4) female representing 6.42%; Six (6) students scored 16 marks, four (4) male and two (2) female representing 5.50%; two (2) students scored 17 marks which were male representing 1.83%; and finally two (2) students scored 20 marks which were female representing 1.83% as shown in the table above.

Table 4.6: Basic Mathematics Achievement Test (Post-Test Score) at Oyo State College of Education, Lanlate, Oyo State

Score (Out of 25)	Male	Female	Total	Percentage (%)
3	1	0	1	1.67
4	2	2	4	6.67
5	3	1	4	6.67
6	1	2	3	5.00
7	2	0	2	3.33
8	5	1	6	10.00
9	2	3	5	8.33
10	5	6	11	18.33
12	0	12	12	20.00
13	2	0	2	3.33
14	0	6	6	10.00
15	0	4	4	6.67
Total	**23**	**37**	**60**	**100**

Source: Researcher's Fieldwork 2023

The post-test score collected from Oyo State college of Education, Lanlate. Out of Sixty (60) students, one (1) student scored 3 marks which was a male representing 1.67%; four (4) students scored 4 marks, two (2) male and two (2) female during the post-test representing 6.67%; four (4) students scored 5 marks three (3) male and one (1) female representing 6.67%; three (3) students scored 6 marks, one (1) male and two (2) female representing 5.00%; two (2) students scored 7 marks, two (2) students which were male students representing 3.33%; six (6) students scored 8 marks, five (5) male and one (1) female representing 10.00%; five (5) students scored 9 marks, two male and three (3) female representing 8.33%; eleven (11) students scored 10 marks. five (5) male and Six (6) female representing 18.33%; twelve students (12) scored 12 marks which were female representing 20.00%; two (2) students scored 13 marks which were male students representing 3.33%; six (6) students scored 14 marks which were female students representing 10.00%, and finally, four (4) students scored 15 marks of which were female representing 6.67% as shown in the table above.

The tables above show the performance of the students in Basic Mathematics Achievement Test (BMAT) conducted in the three (3) selected Colleges of Education in Oyo State for pre-test and post-test results. The result revealed that the female students performed better than the male students.

4.2.2 Hypotheses

The following hypotheses was tested at a 0.05 level of significance

$H_0$1: There will be no significant main effect of:

i. Inductive teaching strategy

ii. Deductive teaching strategy

iii. Conventional teaching strategy

on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State.

Hypothesis 1 is also re-written in this form: There will be no significant main effect of treatment (Inductive teaching strategy, Deductive teaching strategy and Conventional teaching strategy) on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State.

Table 4.7 :Analysis of covariance showing The Main Effect of Treatment (Inductive Teaching Strategy, Deductive Teaching Strategy and Conventional Teaching Strategy) Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2884.785[a]	3	961.595	574.187	0.000
Intercept	161.726	1	161.726	96.570	0.000
Pre-test	2757.851	1	2757.851	1646.765	0.000
Treatment	301.201	2	150.600	89.926	0.000
Error	386.858	231	1.675		
Total	25548.000	235			
Corrected Total	3271.643	234			

a. R Squared = 0.882 (Adjusted R Squared = 0.880)

From table 4.7, it was found that there was a significant main effect of treatment on students' academic achievement in Basic General Mathematics in Colleges of Education ($F_{(2;231)} = 89.93$; $p < 0.05$). Therefore, the $R^2 = 0.882$ which implies that 88.2% of the variance (in dependent variable) is accounted for by the treatment, the null hypothesis 1 is rejected. To explore the magnitude of the significant may effect across treatment groups, the estimated mean of the treatment was carried and the result is presented in Table 4.8.

Table 4.8: Estimated Marginal Means for Treatment

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Inductive Teaching Strategy	7.917[a]	0.160	7.602	8.233
Deductive Teaching Strategy	10.532[a]	0.124	10.288	10.776
Control Group (convectional teaching strategy)	10.291[a]	0.168	9.961	10.621

a. Covariates appearing in the model are evaluated at the following values: pre-test = 6.7915.

The estimated marginal mean in Table 4.8 shows that the students exposed to deductive teaching strategy had the highest academic achievement in BMAT with mean score of 10.53, followed by those exposed to control group with value of 10.29 while those exposed to inductive teaching strategy had the lowest value of 7.92.

H₀2: There will be no significant main effect of:

i. Gender
ii. Class size

on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State.

i There will be no significant effect of Gender on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State.

Table 4.9: Analysis of Covariance showing Effect of Gender on Students' Academic Achievement in Basic General Mathematics in Colleges of Education in Oyo State

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2583.600[a]	2	1291.800	435.580	0.000
Intercept	251.848	1	251.848	84.920	0.000
Pre-test	2565.249	1	2565.249	864.972	0.000
Gender	.016	1	.016	28.005	0.942
Error	688.043	232	2.966		
Total	25548.000	235			
Corrected Total	3271.643	234			

a. R Squared =0.790 (Adjusted R Squared = 0.788)

In line with the hypothesis 2.i in Table 4.9, which says there will be no significant effect of gender on students' academic achievement in Basic General Mathematics. It showed that there is no significant effect of gender on students' academic achievement in basic general Mathematics ($F_{(2;231)} = 28.01$; $p > 0.05$) that is, p-value was 0.942. The R^2=0.790 which implies that 79% of the variance is accounted for by the dependent variable (student's academic achievement). Therefore, the null hypothesis 2.i is not rejected. The estimated Marginal mean for gender is shown in Table 4.10.

Table 4.10: Estimated Marginal Means for Gender

		95% Confidence Interval	
Mean	Std. Error	Lower Bound	Upper Bound
9.738[a]	.116	9.510	9.967

a. Covariates appearing in the model are evaluated at the following values: pre-test = 6.7915.

The estimated marginal mean Table 4.10 shows that Gender has effects on students' academic achievement in Basic General Mathematics with mean score of 9.74 which is in agreement with Test of between subject effect Table.

ii: There will be no significant effect of Class size on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State.

Table 4.11: Analysis of Covariance showing the Effect of Class Size on Students' Academic Achievement in Basic General Mathematics in Colleges of Education in Oyo State

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2710.521[a]	2	1355.260	560.342	0.000
Intercept	249.087	1	249.087	102.987	0.000
Pre-test	2627.258	1	2627.258	1086.259	0.000
Class-size	126.937	1	126.937	52.483	0.000
Error	561.122	232	2.419		
Total	25548.000	235			
Corrected Total	3271.643	234			

a. R Squared = 0.828 (Adjusted R Squared = 0.827)

Table 4.11 shows the analysis of hypothesis 2.ii, which says there will be no significant effect of class size on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State. It revealed that there is significant effect of class size on students' academic achievement in Basic General Mathematics ($F_{(1;232)}$ = 52.48; $p < 0.05$). Therefore, the null hypothesis 2.ii is rejected.

Table 4.12: Estimated Marginal Means of Class-Size

		95% Confidence Interval	
Mean	Std. Error	Lower Bound	Upper Bound
9.790[a]	0.102	9.589	9.990

a. Covariates appearing in the model are evaluated at the following values: pre-test = 6.7915.

H_03: There will be no significant interaction effects of treatment (Inductive teaching strategy, Deductive teaching strategy) and gender on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State.

Table 4.13: Analysis of Covariance showing Interaction Effects of Treatment (Inductive teaching strategy, Deductive teaching strategy and Conventional teaching strategy) and Gender on Students' Academic Achievement in Basic General Mathematics in Colleges of Education in Oyo State

	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2997.857[a]	6	499.643	416.087	0.000
Intercept	163.587	1	163.587	136.230	0.000
Pre-test	2721.806	1	2721.806	2266.635	0.000
Treatment	209.960	2	104.980	87.424	0.000
Gender	1.294	1	1.294	1.077	0.300
treatment * gender	112.675	2	56.337	46.916	0.000
Error	273.785	228	1.201		
Total	25548.000	235			
Corrected Total	3271.643	234			

a. R Squared = 0.916 (Adjusted R Squared = 0.914)

Table 4.13 shows the analysis of hypothesis 3 that there will be no significant interaction effects of Treatment (Inductive teaching strategy and Deductive teaching strategy) and gender on students' academic achievement in Basic General Mathematics. There is significant interaction effect of treatment and gender on students' academic achievement in Basic General Mathematics ($F_{(1;228)} = 46.92; p< 0.05$). Therefore, the null hypothesis 3 is rejected

Table 4.14: The Estimated Marginal Means

		95% Confidence Interval	
Mean	Std. Error	Lower Bound	Upper Bound
9.589[a]	0.077	9.437	9.740

a. Covariates appearing in the model are evaluated at the following values: pre-test = 6.7915.

The interaction effects of treatments and gender on students' academic achievement in Basic General Mathematics when exposed to inductive teaching strategy and deductive teaching strategy is significant.

H_04: There will be no significant interaction effect of Treatment ((Inductive teaching strategy and Deductive teaching strategy) and Class Size on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State.

Table 4.13: Analysis of Covariance showing Interaction Effects of Treatment (Inductive teaching strategy, Deductive teaching strategy and Conventional teaching strategy) and Class-Size on Students' Academic Achievement in Basic General Mathematics in Colleges of Education in Oyo State

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2884.785[a]	3	961.595	574.187	0.000
Intercept	179.547	1	179.547	107.211	0.000
Pre-test	2757.851	1	2757.851	1646.765	0.000
Treatment	174.264	1	174.264	104.057	0.000
Class-size	0.000	0	.	.	.
treatment * class-size	0.000	0	.	.	.
Error	386.858	231	1.675		
Total	25548.000	235			
Corrected Total	3271.643	234			

a. R Squared = 0.882 (Adjusted R Squared = 0.880)

Based on the information given by the ANCOVA table 4.15 which shows the Analysis of hypothesis 4 that there will be no significant interaction effects of Treatment (Inductive teaching strategy, and Deductive Teaching Strategy) and class size on students' academic achievement in Basic General Mathematics. There is no significant interaction effect of treatment and class size on students' academic achievement in Basic General Mathematics because of inconclusive result represented as dot("."). Therefore, the null hypothesis is not rejected.

Table 4.16: The Estimated Marginal Means

		95% Confidence Interval	
Mean	Std. Error	Lower Bound	Upper Bound
9.580[a,b]	0.087	9.408	9.752

a. Covariates appearing in the model are evaluated at the following values: pre-test = 6.7915.

b. Based on modified population marginal mean.

$H_0$5: There will be no significant interaction effect of gender and class size on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State

Table 4.17: Analysis of Covariance showing Interaction Effect of Gender and Class-size on Students' Academic Achievement in Basic General Mathematics

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2711.688[a]	4	677.922	278.455	0.000
Intercept	249.698	1	249.698	102.563	0.000
Pre-test	2582.962	1	2582.962	1060.945	0.000
Gender	0.049	1	0.049	0.020	0.888
Class size	125.069	1	125.069	51.372	0.000
gender * class size	1.095	1	1.095	0.450	0.503
Error	559.955	230	2.435		
Total	25548.000	235			
Corrected Total	3271.643	234			

a. R Squared = 0.829 (Adjusted R Squared = 0.826)

Table 4.17 shows that the analysis of hypothesis 5 that there will be no significant interaction effects of gender and class size on students' academic achievement in Basic General Mathematics. It revealed that there is no significant interaction effect of gender and class size on students' academic achievement in Basic General Mathematics ($F_{(1; 230)}$ =0.45; $p > 0.05$).

Therefore, the null hypothesis is not rejected.

Table 4.18: Estimated Marginal Means

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
9.783[a]	0.105	9.575	9.991

a. Covariates appearing in the model are evaluated at the following values: pre-test = 6.7915.

The interaction effect of gender and class-size on students' academic achievement in Basic General Mathematics is not significant at ($\overline{x}$ = 9.78), ($F_{(1; 230)}$ =0.45; p> 0.05).

$H_0$6: There will be no significant interaction effect of Treatment (Inductive and deductive Teaching Strategies), Gender and Class Size on Students' Academic Achievement in Basic General Mathematics in Colleges of Education in Oyo State.

Table 4.19: Analysis of Covariance showing interaction effect of Treatment (Inductive and Deductive Teaching Strategy), Gender and Class Size on Students' Academic Achievement in Basic General Mathematics in Colleges of Education in Oyo State

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2997.857[a]	6	499.643	416.087	0.000
Intercept	181.451	1	181.451	151.107	0.000
Pre-test	2721.806	1	2721.806	2266.635	0.000
treatment	95.630	1	95.630	79.638	0.000
gender	0.941	1	0.941	0.784	0.377
Class-size	0.000	0	.	.	.
treatment * gender * class-size	0.000	0	.	.	.
Error	273.785	228	1.201		
Total	25548.000	235			
Corrected Total	3271.643	234			

a. R Squared = 0.916 (Adjusted R Squared = 0.914)

Table 4.19 Revealed that there is no significant interaction effect of treatment (Inductive and Deductive Teaching Strategies), Gender and Class Size on Students' Academic Achievement in Basic General Mathematics in Colleges of Education In Oyo States because of inconclusive result represented as (”.”). Therefore, the null hypothesis is not rejected.

4.3 Discussion of Findings

With respect to research hypothesis 1 which stated that there will be no significant main effects of Inductive teaching strategy, Deductive teaching strategy and Conventional teaching strategy on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State, result revealed that after introducing the treatment the experimental group 2 exposed to Deductive teaching strategy (Federal College of Education (Special), Oyo) had highest academic achievement in Basic Mathematics Achievement Test with mean score 10.53 followed by the control group (conventional teaching strategy) mean score was 10.29 and while the other experimental group 1 that was exposed Inductive teaching strategy (Emmanuel Alayande College of Education, Oyo) had the lowest mean score of 7.92.

The analysis revealed that Deductive teaching strategy has a significant effect on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State as indicated by the statistical analysis of (($F_{(2;231)} = 89.93$; $p < 0.05$). The statistical significance of the findings ($p < 0.05$) suggests that the utilization of the Deductive teaching strategy in teaching Algebra in Mathematics instruction is associated with improved academic achievement among students. Deductive teaching strategy is mainly used in teaching of Algebra, but certain topics in algebra may lend themselves more naturally to a deductive approach due to their reliance on established principles and logical relationships[1]. There are some algebra topics that are often better suited for deductive teaching strategy: Proofs of Algebraic Identities, Theorems and Properties of Exponents, Complex Numbers and Operations, Properties of Functions, Logical Implications in Algebra and Matrix Operations are often more effectively taught using a deductive teaching approach because it helps students understand the underlying principles and relationships that govern algebraic concepts[2,3]. Starting with the foundational principles and leading students through the logical steps of deduction, a deeper understanding of the subject matter can be developed.

This findings are in line with several previous studies that have demonstrated the efficacy of deductive teaching strategy in various educational contexts (Geometry, Arithmetic, Algebra, Trigonometry)[4]. This study showed that when deductive method is effectively implemented, it can leads to improved students' performance and engagement in Mathematics[5]. Deductive teaching and inductive teaching are both valuable methods whereby they both have positive effects on the academic achievement of students in BMAT[6]. It is important to strike a balance between presenting general principles and incorporating real-world context and active learning. Every teaching strategy has its place, and a thoughtful combination of deductive and inductive approaches can create a well-rounded learning experience for students.

The analysis revealed that gender has no significant effect on academic achievement of the student in Basic General Mathematics in Colleges of Education, Oyo State. The p Value was greater than significance level of 0.05 ($F_{(2.23)} = 28.01$; $p > 0.05$). The result of this study corroborates with the findings which revealed insignificant influence of gender on students' academic achievement with physical and mental issues[7]. However, the result of this study is not in line with another study which fund that gender has a significant main effect on academic performance[8]. Class Size has significant main effect on students' academic achievement. The p- value was less than the significance level ($F_{(1,232)} = 54.48$; $p < 0.05$). The class-size is one of the factors that affect the academic achievement of students due to teacher inability to attend to all cases in the class. The findings are in line with several previous studies that reported that substantial class-sizes serve as formable tool to achieving optimal classroom integration, thereby underscoring the notice that smaller classes are more likely to heightened academic achievement faster[10]. This indicates that Class size has definite impact on academic achievements of students[10].

There was a noteworthy interaction effect between treatment (Inductive teaching strategy and Deductive teaching strategy) and gender concerning students' academic achievement in Basic General Mathematics. This interaction effect was found to be statistically significant ($F_{(1;228)} = 46.92$; $p < 0.05$), as evidenced by the F-statistic of 46.92 with a p-value less than 0.05. This significant interaction effect implies that the influence of teaching strategies, specifically inductive and deductive approaches, on students' academic achievement in Basic General Mathematics is not consistent across different gender groups. The effect of these teaching strategies varies based on whether the students are male or female. This finding sheds light on the subtle relationship between the teaching strategies and gender-specific learning outcomes. These findings are in line with previous studies that reported that there is significant interaction effect of treatment and gender on students' achievement[11]. The result of this study however, is not in line with the findings that there was no notable interaction observed between deductive and inductive teaching methods and gender in relation to the average retention scores of students in the field of Basic Science and Technology[12]. These inconsistencies in findings may be due to variations in study design, sample characteristics, or the specific mathematics content being taught. It underscores the complexity of the relationship between teaching strategies, gender, and academic achievement and warrants further investigation to elucidate the underlying factors.

The interaction effect of treatment (inductive and deductive teaching strategies) and class-size on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo state was found non-significant, as indicated by the result "dot" (.) in the analysis output is. This suggested that there is no significant interaction between two variables in influencing the outcome. The implications of this non-significant interaction in the context can result to other potential factors that could be influencing the outcome of interest. This supports the findings of treatment has no connection to student performance and the class size does not appear to be a crucial factor[13].

There is no significant interaction effect of gender and class size on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State ($F_{(1; 230)} = p > 0.05$). This result implies that gender and class size, when considered alongside any covariates, do not appear to have a substantial combined effect on Students' academic achievement. This aligns with the study's conclusion, affirming that gender and Class Size do not significantly have an effect on Students Academic Achievement[14]. The result of this study however, is not in line with the findings of significant interaction of Gender and Class Size on Students' academic performance.

There is no significant interaction effect of treatment (Inductive, Deductive and Convectional Teaching Strategies'), Gender and Class Size on Students' Academic Achievement in Basic General Mathematics in Colleges of Education in Oyo State. It suggests that there is no significant relationship among the three variables (Treatment, gender and class Size) being studied. The treatment, gender and class size have no interaction effect on students academic achievement in Basic General Mathematics. This supports the findings of no Interaction effects of Treatment, Gender and Class Size on Students' academic Achievement[15].

Endnotes

1 N. Jumayeva, G. Abdurakhmonov & S. Shopulotova, *Innovations in Teaching of Mathematics*, ***Academic research in educational sciences***, **Scientific Journal Impact Factor (SJIF),** 2(1), 2021. 1142-1147, ISSN: 2181-1385 021: 5.723.

2. H. H. Wu & Wu, H, *Algebra and geometry*, **American Mathematical Society, Providence, Rhode Island**, 132, 2020.

3. H. N. Kamau, *Selected Teaching Strategies and Performance of Students in Mathematics in Public Secondary Schools of Bahati Subcounty, Nakuru County, KENYA,* **Doctoral Dissertation, The Catholic University of Eastern Africa**, 2022 Available Online: http://ir.cuea.edu/jspui/handle/1/12153

4. T. G. Campbell, J. D. Boyle & S. King, *Proof and argumentation in K-12 Mathematics: A review of conceptions, content, and support*, **International Journal of Mathematical Education in Science and Technology**, 51(5), 2020, 754-774.

5. K. Maass, P. Cobb, K. Kraine & D. Potari, *Different ways to implement innovative teaching approaches at scale,* **Educational Studies in Mathematics**, 102, 2019, 303-318.

6. O. Krey, *What is learned about the roles of Mathematics in physics while learning physics concepts? A Mathematics sensitive look at physics teaching and learning,* **Mathematics in Physics Education**, 2019, 103-123.

7. J. Li & W. Che, *Challenges and coping strategies of online learning for college students in the context of COVID-19: A survey of Chinese universities,* **Sustainable Cities and Society**, *83*, 2022, 103958.

8. R. C. Chan, *A social cognitive perspective on gender disparities in self-efficacy, interest, and aspirations in science, technology, engineering, and Mathematics (STEM),* the Influence of Cultural and Gender Norms, **International Journal of STEM Education**, 9(1), 2022, 1-13.

9. M. I. Obiakor & C. N. Oguejioffor, *Impact of Classroom size on Academic performance of Secondary School Students in Enugu local Government Are of Enugu State, Nigeria,* **African Journal of educational Management, Teaching and Entepreneurship Studies,** 1 (1), 2020, 51-59.

10. M. Förster, A. Maur, C. Weiser & K. Winkel, *Pre-class video watching fosters achievement and knowledge retention in a flipped classroom*, **Computers & Education**, 179, 2022, 104399.

11. S. S. Imam, H. M. Adamu, & R. Haruna, *Effects of Kolb's Experiential Learning Model and Gardner's Multiple Intelligence Learning Model on Students' Psychomotor*

Achievement in Electrical Installation and Maintenance Wor, **Bije-bichi Journal of Education**, 17(1), 2023, 40-51.

12. J. Paul & F. Jefferson, *A Comparative Analysis of Student Performance In An Online vs. Face-to-Face Environmental Science Course from 2009 to 2016*, **Frontiers in Computer Science**, 1, 2019, 7.

13. E. E Achor, G. U. Jack & C Jack., *"Towards Scaling Up Students' Interest In Carbohydrate Using Jigsaw, Think-Pair-Share and Coop-Coop Cooperative Strategies*", **Journal of the International Centre for Science, Humanities & Education Research (ICSHER Journal)**, 5(2), 2022, 1-18.

14. I. Mupfudze, & T. Mapolisa, *Variables Affecting Learners' Performance at Ordinary Level in Zimbabwean Secondary Schools*, **Indiana Journal of Humanities and Social Sciences**, 2(2), 2021, 25-40. Available Online; https://indianapublications.com/articles/IJHSS_2(2)_25-40_604331e1a4ba71.98905801.pdf

15. E. Namaziandost, & F. Çakmak, *An account of EFL learners' self-efficacy and gender in the Flipped Classroom Model*. **Education and Information Technologies**, 25(5), 2020, 4041-4055.

16. S. Park, & W. Weng, *The relationship between ICT-related factors and student academic achievement and the moderating effect of country economic index across 39 countries*. **Educational Technology & Society**, 23(3), 2020, 1-15.

Chapter Five

Conclusion

This chapter deals with the Summary of Findings, Conclusion, Recommendations based on the finding of the study, Contribution to Knowledge and Suggestion for further research.

5.1 Summary of Findings

The findings showed the minimum and maximum score for the students of Emmanuel Alayande College of Education, Oyo (Experimental group I), Federal College of Education (Special), Oyo (Experimental group II) and Oyo State College of Education, Lanlate (Control Group), Oyo State. For student of Emmanuel Alayande College of Education, Oyo and Oyo State College of Education, Lanlate, Oyo State, minimum score in the pre-test of the Basic Mathematics Achievement Test was 2 out of 25, while the minimum score in pre-test of Basic Mathematics Achievement for students of Federal College of Education (Special), Oyo was also 0 mark. The maximum score for pre – test for Emmanuel Alayande College of Education, Oyo was 19 marks; Federal College of Education (Special), Oyo was 15 marks and Oyo State College of Education, Lanlate, Oyo State was 12 marks.

There is a significant main effect of treatment (inductive teaching strategy, Deductive teaching strategy and conventional teaching strategy) on students' Academic Achievement in Basic General Mathematics in Colleges of Education in Oyo State. The P-value was less than significance level which is 0.000. ($F_{(2;231)} = 89.93$; $p < 0.05$).

Gender does not have a significant main effect on the academic achievement of students in Basic General Mathematics in Colleges of Education, Oyo State ($F_{(2;231)} = 28.01$;

$p > 0.05$). However, it was found that class size does have a significant main effect on students' academic achievement ($F_{(1;232)} = 52.48$; $p < 0.05$).

The interaction effects of treatment and gender is significant. This indicates that the choice of teaching strategy has significant impact on academic achievement based on gender ($F_{(1;228)} = 46.92$; $p < 0.05$).

There is non-significant interaction effect between treatment (inductive and deductive teaching strategies) and class size on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State.

There is no significant interaction effect between gender and class size on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State. This means that the combination of gender and class size does not significantly impact on students' academic performance in this context ($F_{(1;230)} =$; $p > 0.05$).

There is non-significant interaction effects of treatment (inductive and deductive teaching strategies), gender and class size on students' academic achievement in Basic General Mathematics in Colleges of Education in Oyo State.

5.2 Conclusion

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

This study was carried out as one of such efforts to improved students' performance in Basic General Mathematics in Colleges of Education, thus improving students' academic achievement in Mathematics. To achieve this, the study determined the Effect of Inductive and Deductive Teaching Strategies on Students' Academic Achievement in Basic General Mathematics in Colleges of Education in Oyo State. The two teaching strategies were found to be effective. However, the deductive teaching strategy was found more effective in students' academic achievement for treating Algebra concept.

5.3 Recommendations

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

i. Teachers should employ the use of Deductive and Conventional Teaching Strategies in teaching Basic General Mathematics especially at the Colleges of Education in Oyo State.

ii. School Management and teachers should device a means of grouping students to sizable and Manageable groups for effective teaching and learning of Basic General Mathematics at the Colleges of Education in Oyo State.

iii. Male and Female gender should be encouraged and assisted for better achievement in Basic General Mathematics at the Colleges of Education in Oyo State.

iv. Teachers and School Administrators should work together to address the challenges posed by class size and ensure that resources are allocated effectively to support students learning, this might include the use of teaching assistants or other support staff to manage larger classes.

v. Teachers should be mindful of the significant interaction effect between teaching strategies (Inductive and Deductive) and gender on academic achievement. This suggests that teachers may need to tailor their teaching methods to suit the diverse learning needs of male and female students. It's important to foster an inclusive learning environment that accommodates various learning styles.

vi. Teachers and school administrators should work together to address the challenges posed by class size and ensure that resources are allocated effectively to support student learning. This might include the use of teaching assistants or other support staff to manage larger classes.

vii. Regular assessment and monitoring of students' academic performance can help identify areas where specific groups (e.g., male or female students) may need additional support. This can guide targeted interventions to improve overall achievement.

5.4 Contribution to Knowledge

1. Conceptual Contribution

    Conceptually, this study has enhanced the conceptual definitions of the following terms, such as the "effect of teaching strategy," "students' academic achievement," and "Basic General Mathematics."

2. Theoretical Contribution

    In contrast to previous studies that have supported the link between independent variables (Inductive teaching strategy and Deductive teaching strategy) and the dependent variable (Students' academic achievement in Basic General Mathematics), this study makes a theoretical contribution by discovering additional theories.

3. Experimental Contribution

    This research significantly contributes to the growing body of evidence supporting the effectiveness of Deductive teaching in Mathematics Education.

4. Implications for Education and Policy Makers

    Education and policy makers are encouraged to consider the integration of Deductive reasoning into Mathematics instruction as a means to foster improved learning outcomes.

5.5 Suggested Areas for Further Research

It is essential to acknowledge the limitations of this study. The research was conducted in Colleges of Education in Oyo State, and the findings may not be directly generalized to other regions or educational settings. Additionally, other unexamined factors, such as student motivation, teacher expertise, and classroom dynamics, could have influenced the results.

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

1. Multicenter Study: Conducting a broader, multicenter study could provide a more comprehensive understanding of the effects of the deductive teaching strategy across diverse educational environments, such as universities and polytechnics. This approach would allow for further research in varied contexts.
2. Long-term Effects: Exploring the long-term effects of the Deductive teaching strategy on students' mathematical proficiency and retention could also be a valuable avenue for further investigation. This would provide insights into the lasting impact of this teaching approach on students' learning outcomes.
3. This Study could also be conducted in other states in Nigeria with at least three Colleges of Education.
4. More investigations need to be carried out on the two teaching strategies using other moderating variables like attitude and school location.
5. This study can be replicated in other science subjects such as chemistry, physics and biology.
6. It can be extended to other concepts in Mathematics not examined.

Bibliography

Book

Daffin L. W. Jr., " *Principles of Learning and Behavior"*, Discovery Psychological Series, 2021.

Grami A., "*Discrete Mathematics: Essentials and Applications*", Academic Press , 2022.

Hartman H. J., "*Holistic Faculty Development: A Learner-Centered Approach In Developing and Supporting Multiculturalism and Leadership Development*", International Perspectives on Humanizing Higher Education**,** 30, 2020, 103-125. Emerald Publishing Limited.

Hoidn, S., & Reusser, K., *Foundations of Student-Centered Learning and Teaching,* In *The Routledge International Handbook of Student-Centered Learning and Teaching in Higher Education* 2020, 17-46, Routledge.

Goldberg A. E., *LGBTQ-parent families: Diversity, intersectionality, and social context*. Current Opinion in Psychology, 2022, 101517.

Haug J. D., *Gender identities and intersectional violence within forensi c anthropology*, In The Marginalized in Death: A Forensic Anthropology of Intersectional Identity in the Modern Era, Lexington Books Washington, DC.,2022, 175-201,

Krey O., "*What is Learned about the Roles of Mathematics in Physics while Learning Physics Concepts? A Mathematics Sensitive look at Physics Teaching and Learning"*, Mathematics in Physics Education, 2019, 103-123.

Lundberg S., *Gender economics: Dead-ends and new opportunities*, In 50th Celebratory Emerald Publishing Limited, Volume , 2023, 151-189.

Mustapha M. A., Kachallah M. & Abulfathi F. A., " *Relationship between Class Size and Students Academic Performance in English Language",* Editorial Board, 10, 2021.

NCCE, Federal Republic of Nigeria," "*National Commission for Colleges of Education, Minimum Standards for NCE Teachers*", Edition, 2020.

Nworah F. C. & Oragade C. D., "*Prospect and Challenges of Mathematics Education in the Modern Globalized Curriculum In Globalized Curriculum Methods for Modern Mathematics Education*", IGI Global, 2019, 93-106.

Onoshakpokaiye E. O., "*Functional Mathematics Skills: An Essential Tool for Functional Education and Development in Nigeria"*, Education Research Highlights in Mathematics, Science and Technology, 2020, 105-119.

Ozdem-Yilmaz Y. & Bilican K., "Discovery Learning Jerome Bruner", Science education in theory and practice: An introductory guide to learning theory, 2020, 177-190.

Protin, C. L., *Ancient Natural Deduction*, 2022, arXiv preprint arXiv:2209.03388.

Wu H. H. & Wu, H., "*Algebra and geometry"*, American Mathematical Society, Providence, Rhode Island**,** 132, 2020**.**

Conference Proceeding

Kusmin M.*" Inquiry-based learning and trialogical knowledge-creation approach in smart schoolhouse supported by IoT devices*". 2019 IEEE Global Engineering Education Conference (EDUCON). April, 2019, 571-575, IEEE, Available Online: https://www.researchgate.net/publication/333492642

Journal

Abdieva D. K., "*Acquisition Of Pedagogy Via E-Learning"*, **Theoretical & Applied Science**, (3), 2021, 126-128.

Abdukarimova N. A., & Zubaydova N. N., " *Deductive and inductive approaches to teaching grammar*". **JournalNX**, 2021, 372-376, ISSN: 2531 4230.

Abdullah A. H., Misrom N. S., Kohar U. H. A., Hamzah M. H., Ashari Z. M., Ali D. F., & Abd Rahman S. N. S., "*The effects of an inductive reasoning learning strategy assisted by the GeoGebra software on students' motivation for the functional graph II topic"*, **IEEE Access**, 8, 2020, 143848-143861.

Acharya N. H. "*Mathematics Teachers' Perceptions on Higher Order Thinking Skills*". **International Journal of Multidisciplinary Perspectives in Higher Education**, 6(2), 2021, 105-125.

Achor E. E, Jack G. U. & Jack C., *"Towards Scaling Up Students' Interest in Carbohydrate Using Jigsaw, Think-Pair-Share and Coop-Coop Cooperative Strategies*", **Journal of the International Centre for Science, Humanities & Education Research (ICSHER Journal)**, 5(2), 2022, 1-18.

Acosta-Gonzaga E. & Ruiz-Ledesma E. F., *Students' Emotions and Engagement in the Emerging Hybrid Learning Environment during the COVID-19 Pandemic*, **Sustainability,** 14(16), 2022, 10236.

Adeoye, M. A., "*Advanced supervision in educational management: Differences between supervision, accreditation, inspection, collaboration, evaluation, and quality assurance*", **ASEAN Journal of Educational Research and Technology**, 1(2), 2022, 169-176.

Ahmad I., Farid A. & Hussain M., "*Teacher cognition and English as a foreign language context: potential challenges"*. **Psychology and Education**, 58(5), 2021, 1553-6939.

Ahwireng D., "*Confronting COVID-19 Whilst Elementary School Students Resume In-Person Learning"*, **Journal of Education and Learning**, 11(3), 2022, 64-76.

Ajai J. T & Imoko B. I., "*Gender Differences in Mathematics Achievement and Retention Scores: A Case of Problem-Based Learning Method*", **International Journal of research in Education and Science**, 1(1), 2015, 45-50.

Al-Abdullah A. & Hassan L., "*Factors Determining the Success and Failure of EdTech Initiatives in Rural Academic Institutions"*, **AI, IoT and the Fourth Industrial Revolution Review**, 13(7), 2023, 47-60.

Almaiah M. A., Alfaisal R., Salloum S. A., Al-Otaibi S., Shishakly R., Lutfi A. & Al-Maroof, "*Integrating teachers' TPACK levels and students' learning motivation, technology innovativeness, and optimism in an IoT acceptance model"*, **Electronics,** 11(19), 2022, 3197.

Alhadabi, A., & Karpinski, A. C., "*Grit, self-efficacy, achievement orientation goals, and academic performance in University student*", **International Journal of Adolescence and Youth**, 25(1), 2020, 519-535.

Alshuraiaan, A., "*Exploring the Relationship between Teacher-student Interaction Patterns and Language Learning Outcomes in TESOL Classrooms*", **Journal of English Language Teaching and Applied Linguistics**, 5(3), 2023, 25-34.

Barroga E. & Matanguihan G. J.," *Creating logical flow when writing scientific articles*", **Journal of Korean medical science**, 36(40), 2021, 1-14.

Boman, B., "*Educational achievement among East Asian schoolchildren 1967–2020: A thematic review of the literature*", **International Journal of Educational Research Open,** 3, 2022, 100168.

Brandmiller C., Dumont H. & Becker M., "*Teacher perceptions of learning motivation and classroom behavior: The role of student characteristics*", **Contemporary Educational Psychology**, 63, 2020, 101893.

Cai J., Wen, Q. Qi, Z. & Lombaerts K., "*Identifying core features and barriers in the actualization of growth mindset pedagogy in classrooms"*, **Social Psychology of Education**, 26(2), 2023, 485-507.

Campbell T. G, Boyle J. D & King S., *"Proof and argumentation in K-12 mathematics: A review of conceptions, content, and support*", **International Journal of Mathematical Education in Science and Technology**, 51(5), 2020, 754-774.

Cardino Jr. J. M. & Ortega-Dela Cruz R. A., "*Understanding of learning styles and teaching strategies towards improving the teaching and learning of mathematic, LUMAT*", **International Journal on Math, Science and Technology Education**, 8(1), 2020, 19-43 .

Chan R. C., "*A social cognitive perspective on gender disparities in self-efficacy, interest, and aspirations in science, technology, engineering, and mathematics (STEM): the influence of cultural and gender norms*", **International Journal of STEM Education**, 9(1), 2022, 1-13.

Clark, A. E., Nong H., Zhu H., & Zhu R. "*Compensating for academic loss: Online learning and student performance during the COVID-19 pandemic*", **China Economic Review**, 68, 2021, 101629.

Clary K., Goffnett J., King M., Hubbard T. & Kitchen R., *"It's the Environment, Not Me": Experiences shared by transgender and gender diverse adults living in Texas*, **Journal of Community Psychology**, 51(3), 2023, 906-923.

Crăciun, A. F., Ţăran, A. M., Noja, G. G., Pirtea, M. G., & Răcătăian, R. I., *Advanced M Public Governance and Digital Transformation: New Empirical Evidence from St Gaussian and Mixed-Markov Graphical Models*. **Mathematics**, *11*(5), 2023,1168.

Cruz R. A., Firestone A. R. & Love M., "*Beyond a seat at the table: imagining educational equity through critical inclusion"*, **Educational Review**, 2023, 1-27.

Dali, N. R. S. M., Hamid, H. A., Nawang, W. R. W., & Nazarie W. N. F. W. M., "*Post pandemic consumer behavior: Conceptual framework*", **The Journal of Muamalat and Islamic Finance Research**. 17(special), 2020, 13-24 ISSN: 1823-075X, e-ISSN: 0126-5954.

Datta S. & Kingdon G. G., "*Class size and learning: Has India spent too much on reducing class size?"*, 2021. 1-35.

De Lima C., Belot D., Berkvens R., Bourdoux A., Dardari D., Guillaud M. & Wymeersch H., "*Convergent communication, sensing and localization in 6G systems: An overview of technologies, opportunities and challenges*", **IEEE Access**, 9, 2021, 26902-26925.

Dhiorbháin Ni. , "*A Sociocultural Rationale for an ExplicitInductive Approach to Grammar Teaching in L2 Teacher Education*", **Teaching Education**, 34(3), 2023, 319-334, Available Online: https://doi.org/10.1080/10476210.2022.2118703.

Dsouza N., "*Analyzing the Transformative and Multifaceted Impact of Social Media Platforms"*, **GPH-International Journal of Social Science and Humanities Research**, 6(07), 2023, 56-65.

Dustova U., "I*nductive and Deductive Grammar Teaching*", **Евразийский журнал социальных наук, философии и культуры**, 2(12), 2022, 247-251, Available Online: https://doi.org/10.5281/zenodo.7349586

Hoffer E. R., "*Case-Based Teaching: Using Stories for Engagement and Inclusion"*. **International Journal on Social and Education Sciences**, 2(2), 2020, 75-80.

Ekatushabe M., Kwarikunda D., Muwonge C. M., Ssenyonga J. & Schiefele, U., "*Relations between perceived teacher's autonomy support, cognitive appraisals and boredom in physics learning among lower secondary school students*", **International Journal of STEM Education,** 8(1), 2021, 1-15.

Emeka A. H., Margaret A. F., Jacob O. N., & Olatunde-Aiyedun T. G., "*Problems Facing Science Teachers in Public Secondary Schools in Nigeria and Way Forward*", **International Journal of Discoveries and Innovations in Applied Sciences,** 1(5) 2021, 118-129.

Ezenwa-Ohaeto N. & Ugochukwu E. N., "*Language Learning Theories: Behaviourism, Mentalism and Affectivism",* **Awka Journal of English Language and Literary Studies**, 8(1). 2021, 48 – 55.

Eisend M. & Rößner A., *Breaking gender binaries*, **Journal of Advertising**, 51(5), 2022, 557-573.

Felszeghy S., Pasonen-Seppänen S., Koskela A., Nieminen P., Härkönen K., Paldanius K. M., & Mahonen A., "*Using online game-based platforms to improve student performance and engagement in histology teaching",* **BMC medical education**, 19, 2019, 1-11.

Fernández-Gutiérrez M., Gimenez G. & Calero J., "*Is the use of ICT in education leading to higher student outcomes? Analysis from the Spanish Autonomous Communities*", **Computers & Education**, 157, 2020, 103969.

Franklin H., & Harrington I., "*A review into effective classroom management and strategies for student engagement: Teacher and student roles in today's classrooms*", **Journal of Education and Training Studies**, 7(12), 2019, 1-12.

Fubile F. T. & Sawe J., "*The Impact of Pupil-Teacher Ratio on Performance in Mastering Reading, Writing and Arithmetic Competencies in Morogoro Municipality. A Case Study of Standard Four Pupils in Primary Schools*", **East African Journal of Education Studies**, 5(3), 2022, 250-258.

Förster M, Maur A., Weiser C. & Winkel K., "*Pre-class video watching fosters achievement and knowledge retention in a flipped classroom*", **Computers & Education**, 179, 2022, 104399.

Gbeleyi O. A. & Potokri O. C., "*Gender beliefs framed on culturo-techno-contextual approach about learning of difficult stem concepts in African secondary schools*", **African Perspectives of Research in Teaching & Learning (APORTAL)**, 7(1), 2023.

GHipólito I., Winkle K. & Lie M., "*Enactive artificial intelligence: subverting gender norms in human-robot interaction"*, **Frontiers in Neurorobotics**, 17, 2023, 1149303.

Gu X. & Yeung W. J. J., "*Hopes and hurdles: Rural migrant children's education in urban China*", **Chinese Sociological Review**, 52(2), 2020, 199-237.

Gustems-Carnicer J., Calderón C., & Calderón-Garrido D., "*Stress, coping strategies and academic achievement in teacher education students*", **European Journal of Teacher Education**, 42(3), 2019, 375-390.

Harding D., Marsh S.& Lennie Y., *Perioperative considerations for transgender and gender diverse adults*, **BJA education**, 23(4), 2023, 136-143.

Hardy J. G., Sdepanian S., Stowell A. F., Aljohani A. D., Allen M. J., Anwar A. &Wright K. L., "*Potential for chemistry in multidisciplinary, interdisciplinary, and transdisciplinary teaching activities in higher education*", **Journal of Chemical Education**, 98(4), 2021, 1124-1145.

Haug B. S. & Mork S. M.,"*Taking 21st century skills from vision to classroom: What teachers highlight as supportive professional development in the light of new demands from educational reforms*", **Teaching and Teacher Education**, 100, 2021, 1 -12, 103286.

Hayat A. A., Shateri K., Amini M., & Shokrpour N., "*Relationships between academic self-efficacy, learning-related emotions, and metacognitive learning strategies with* *academic performance in medical students: a structural equation model*", **BMC Medical Education**, 20(1), 2020, 1-11.

Hennessy S., D'Angelo S., McIntyre N., Koomar S., Kreimeia A., Cao L., & Zubairi., "*A. Technology use for teacher professional development in low-and middle-income countries: A systematic review*", **Computers and Education Open**, 3, 2022, 1 – 32, 100080.

Hieng S., Thlang S. & Nget, S., "*A comparison of concept-based instruction and a deductive approach in teaching English grammar*", **Cambodian Journal**, 20, 2023 , 1 – 24.

Hossain S. F. A., Xi, Z., Nurunnabi M., & Anwar B., "*Sustainable academic performance in higher education: a mixed method approach*", **Interactive Learning Environments**, 30(4), 2022, 707-720.

Hutapea N. M. "*Improving Senior High School Students Learning Autonomy through Generative Learning*", **Journal of Educational Sciences**, 3(1), 2019, 84-95.

Iglesias-Pradas S., Hernández-García Á., Chaparro-Peláez J., & Prieto J. L., "*Emergency remote teaching and students' academic performance in higher education during the COVID-19 pandemic: A case study*", **Computers in Human Behavior**, 119, 2021, 106713.

Imam S. S., Adamu H. M. & Haruna R., "*Effects of Kolb's Experiential Learning Model and Gardner's Multiple Intelligence Learning Model on Students' Psychomotor Achievement in Electrical Installation and Maintenance Wor*", **Bije-bichi Journal of Education**, 17(1), 2023, 40-51.

Jacob O. N & Onoge H., "Administration *of Mathematics Programme in Nigerian Higher Institutions: Issues, Challenges and Ways Forwards*", **Central Asian Journal of Mathematical Theory And Computer Sciences**, 2(3), 2021, 27-36.

Jerrim J., Sims S., & Oliver M., "*Teacher self-efficacy and pupil achievement: much ado about nothing? International evidence from TIMSS*", **Teachers and Teaching,** 29(2), 2023, 220-240.

Jones T. R. & Burrell S., "*Present in class yet absent in science: The individual and societal impact of inequitable science instruction and challenge to improve science instruction"*, **Science Education**, 106(5), 2022, 1032-1053.

Jreisat S. F., "*The effectiveness of a proposed training program based on the technological approach to improve the deductive thinking skills of students*", **Science and Education**, 62(2), 2023, 141-157.

Jumayeva N., Abdurakhmonov G. & Shopulotova S., "*Innovations in Teaching of Mathematics. Academic research in educational sciences*", **Scientific Journal Impact Factor (SJIF),** 2(1), 2021. 1142-1147, ISSN: 2181-1385 2021: 5.723.

Kamiza A. B., Toure S. M., Vujkovic M., Machipisa T., Soremekun O. S., Kintu C. & Fatumo S., *Transferability of genetic risk scores in African populations*, **Nature Medicine**, 28(6), 2022, 1163-1166.

Khan I. A., Iftikhar M., Hussain S. S., Rehman A. , Gul N., Jadoon W., & Nazir B., "*Redesign and validation of a computer programming course using Inductive Teaching Method*". **PloS one**, 15(6), 2020, 1 – 21, e0233716.

Kim J., Lee H. & Cho Y. H., *Learning design to support student-AI collaboration: Perspectives of leading teachers for AI in education*, **Education and Information Technologies,** 27(5), 2022, 6069-6104.

Kirby M. S., Spencer T. D. & Spiker S. T., "*Humble behaviorism redux*", **Behavior and Social Issues**, 31(1), 2022, 133-158.

Kovarik M. L., Robinson J. K. & Wenzel T. J., "*Why Use Active Learning? In Active Learning in the Analytical Chemistry Curriculum*", **American Chemical Society**, 2022, 1-12.

Kulik C. T., "*Gender (in) equality in Australia: good intentions and unintended consequences"*, **Asia Pacific Journal of Human Resources**, 60(1), 2022, 97-115

Kusuma J. W., "*Constructivism from philosophy to mathematics learning*", **International Journal of Economy, Education, and Enterpreneurship**, 1(2), 2021, 104 -111.

Lasamahu B., Siregar E. & Sukardjo M., "*Online Learning with Project Based Learning Approach in the Human Performance Technology Course*", **Journal of Education Research and Evaluation**, 5(2), 2021, 208-215.

Lemantara J., Hariadi B., Sunarto D., Amelia T. & Sagirani T., "*An Innovative Strategy to Anticipate Students' Cheating: The Development of Automatic Essay Assessment on The "MoLearn" Learning Management System*", **IEEE Transactions on Learning Technologies**, 2023.

Li J. & Che W., "*Challenges and coping strategies of online learning for college students in the context of COVID-19: A survey of Chinese universities*", **Sustainable Cities and Society**, 83, 2022, 1 – 14, 103958.

Lundin M. & Bombaci S., "*Making outdoor field experiences more inclusive for the LGBTQ+ community"*, **Ecological Applications**, 33(5), 2023, e2771.

Maass K., Cobb P, Kraine K & Potari D., "*Different ways to implement innovative teaching approaches at scale"*, **Educational Studies in Mathematics**, 102, 2019, 303-318.

Mahdi O. R., Nassar I. A. & Almuslamani H. A. I., "*The Role of Using Case Studies Method in Improving Students' Critical Thinking Skills in Higher Education"*, **International Journal of Higher Education**, 9(2), 2020, 297-308.

Marzaini A. F. M., Sharil W. N. E. H., Supramaniam K. & Yusoff S. M., "*Evaluating Teachers' Assessment Literacy in Enacting Cefr-Aligned Classroom-Based Assessment in Malaysian Secondary Schools ESL Classroom"*, **International Journal of Academic Research in Progressive Education and Development**, 12(1), 2023, 661-675.

Mashrabovna U. M., " *Using inductive and deductive teaching to improve grammar"*. **International Journal of Formal Education**, 2(7), 2023, 43-46.

Melhuish K., Fukawa-Connelly T., Dawkins P. C., Woods C., & Weber K., "*Collegiate mathematics teaching in proof-based courses: What we now know and what we have yet to learn*", **The Journal of Mathematical Behavior**, 67, 2022, 100986.

Miranda D. A., Lizcano-Dallos A. R., & Pinzón E. F., *"Improving the physics learning outcomes of engineering students through just in time teaching (JiTT)"*, **IEEE Revista Iberoamericana de Tecnologias del Aprendizaje,** 18(2), 2023, 190 – 197,

Mkhize Z., "*'They Are Just Women, What Do They Know?': The Lived Experiences of African Women Doctoral Students in the Mathematics Discipline in South African Universities*", **Transformation in Higher Education**, 7, 2022, 218.

Mohibu Y. & Ismail H., "*The application of the cooperative learning model (picture and picture) to improve the students' reading skill*", **Langua: Journal of Linguistics, Literature, and Language Education**, 4(2), 2021, 6-17.

Mohammed I. B., Uche S. A. & Kasim M. S. "*Effect of Class Size on the Academic Achievement of Students in Basic Science and Technology in Gwagwalada Area Council FCT Abuja*", **CARD International Journal of Educational Research and Management Technology (IJERMT),** 2(3), 2017.

Muhammad S. B. A; Razia Y. & Zeeshan M., "*The Impact of Technology Integration on Student Engagement and Achievement in Mathematics Education: A Systematic Review"*, **International Journal of Computer Integrated Manufacturing,** 6(3), March 2023, 222-232, Available Online: https://www.researchgate.net/publication/370446167.

Mupfudze I & Mapolisa T., "*Variables Affecting Learners' Performance at Ordinary Level in Zimbabwean Secondary Schools*", **Indiana Journal of Humanities and Social Sciences,** 2(2), 2021, 25-40, Available Online: https://indianapublications.com/articles/IJHSS_2(2)_25-40_604331e1a4ba71.98905801.pdf

Mustapha M.A., Kachallah M. & Abulfathi F.A., "*Relationship between Class Size and Students` Academic Performance in English Language*", **Journal of Curriculum and Media Technology Research (J-CUDIMAC)**, 9 (1), 2021,1-9.

Männistö M., Mikkonen, Kuivila K. H. M., Virtanen M., Kyngäs H. & Kääriäinen M., "*Digital collaborative learning in nursing education: a systematic review*", **Scandinavian Journal of Caring Sciences**, 34(2), 2020, 280-292.

Mehmet O., *Factors Affecting Students' Academic Achievement according to the Teachers' Opinion,* **Education Reform Journal**, 6(1), 2021, 1 -18.

Nadim D., "*Interplay between constructivism and metacognitive regulation: An experimental study on mathematics students*", **Towards Excellence**, 14(4). December, 2022, 24 – 33.

Nair R. T. & Kulkarni U. K., "*Study Habits and it's Impact on Academic Performance in English of Secondary School Students in Kalaburgi Region*", **PalArch's Journal of Archaeology of Egypt/Egyptology**, 17(12), 2020, 670-682.

Navaz A. M. M. & Hanaan Khaathoon M. F., "*Teaching grammar: A Comparison between Schools and University.KALAM*", **International Research Journal Faculty of Arts and Culture, South Eastern University of Sri Lanka**, 13(4), 2020, 58-70.

Namaziandost E., & Çakmak F., "*An account of EFL learners' self-efficacy and gender in the Flipped Classroom Model*", **Education and Information Technologies**, 25(5), 2020, 4041-4055.

Ngereja B. J., & Hussein B. "*An examination of The Preconditions of Learning to Facilitate Innovation in Digitalization Projects: A Project Team Members' Perspective*", **International Journal of Information Systems and Project Management**, 9(2), 2021, 23-41.

Nonyelum D. N., Ogugua I K. & Abah J. A., "*Influence of Student-Teacher Relationship on the Academic Performance of Junior Secondary School Students in Mathematics in Makurdi Local Government Area of Benue State, Nigeria*", **VillageMath Educational Review (VER),** 3(1), 2020, 27-52.

O'Flaherty J., & Costabile M., "*Using a science simulation-based learning tool to develop students' active learning, self-confidence and critical thinking in academic writing*", **Nurse Education in Practice**, 47, 2020. 102839.

O'Meara N. & Faulkner F., "*Professional Development for Out-of-field Post-Primary Teachers of Mathematics: an Analysis of the Impact of Mathematics Specific Pedagogy Training*", **Irish Educational Studies**, 41(2), 2022, 389-408.

Obeidat M. M. & Alomari M. D. A., "*The Effect of Inductive and Deductive Teaching on EFL Undergraduates' Achievement in Grammar at the Hashemite University in Jordan*", **International Journal of Higher Education**, 9(2), 2020, 280-288.

Obiakor M. I & Oguejioffor C. N., "*Impact of Classroom size on Academic Performance of Secondary School Students in Enugu local Government Are of Enugu State, Nigeria*", **African Journal of Educational Management, Teaching and Entepreneurship studies**. 1 (1), 2020, 51-59.

Ojo S. G., "*Generating, and Sustaining Interest of Students in Mathematics in Secondary School*", **Mathematics Education Series**, 47(1), 2022, 99-114.

Okechukwu J. N., & Oboshi B. C., "*Influence of Overcrowded Classroom on Pupils' academic Achievement In Public Primary Schools In Idemili South Local Government Area Of Anambra State, Nigeria*", **Journal of Educational Research & Development**, 4(2), 2021.

Okwelogu I. S., & Jacob O. N. "*Science Education in Nigerian Public Universities: Challenges and Way Forward*", **International Journal on Economics, Finance and**

Sustainable Development, 3(9), 2021, 38-45. Available Online: https://journals.researchparks.org/index.php/IJEFSD/article/view/2174

Pan Y., Ke F. & Xu X., "*A Systematic Review of the Role of Learning Games in Fostering Mathematics Education in K-12 Settings*", **Educational Research Review**, 36, 2022, 1 – 14, 100448.78.

Pande M. & Bharathi S. V., "*Theoretical Foundations of Design Thinking–A constructivism learning approach to design thinking*", **Thinking Skills and Creativity**, 36, 2020, 100637, Available Online: https://www.sciencedirect.com/science/article/abs/pii/S1871187119 303104

Papavlasopoulou S., Giannakos M. N. & Jaccheri L., "*Exploring Children's Learning Experience in Constructionism-based Coding Activities Through Design-based Research*", **Computers in Human Behavior**, 99, 2019, 415-427.

Park S., & Weng W., "*The relationship between ICT-related factors and student academic achievement and the moderating effect of country economic index across 39 countries*", **Educational Technology & Society**, 23(3), 2020, 1-15.

Paulino S. F., "*Mathematical language in the modeling learning process in the technologic course in fashion design: a case study at a private college in Recife-PE*", **Revista de Ensino em Artes, Moda e Design**, 4(2), 2020, 252-270.

Peteros E., Gamboa A., Etcuban J. O., Dinauanao A., Sitoy R. & Arcadio R., "*Factors affecting mathematics performance of junior high school students*", **International Electronic Journal of Mathematics Education**, 15(1), 2019. em0556. e-ISSN: 1306-3030. 2020, 15(1), em0556.

Qu X., *Structural barriers to inclusive education for children with special educational needs and disabilities in China*, **Journal of Educational Change**, 23(2), 2022, 253-276.

Radford L. "*Introducing equations in early algebra*", **ZDM–Mathematics Education**, 54(6), 2022,1151-1167, Available Online: https://rdcu.be/cU5SG.

Radjiev A. B., Gapparovich I. A., Yuldoshevich K. A. & Turdiboevich M. I., "*Does the Quality of Education Today Depend on the Number of Students?"*, **International Journal on Integrated Education**, 5(6), 2022, 109-114.

Rahman M. M., "*21st century Skill 'Problem Solving': Defining the Concept*", **Asian Journal of Interdisciplinary Research**, 2(1), 2019, 64-74.

Rassaei E. "*The Effects of Text-based and Audio-based Dynamic Glosses on L2 Vocabulary Learning: a Dynamic Assessment Approach*", **The Language Learning Journal**, 2023, 1-14.

Rillo A. G., Martínez-Carrillo B. E., Castillo-Cardiel J. A. & Rementería-Salinas J. M., "*Constructivism: An interpretation from medical education*", **IOSR J Res Method Educ**, 10, 2020,1-12.

Rioux C., Paré A., London-Nadeau K., Juster R. P., Weedon S., Levasseur-Puhach S., & Tomfohr-Madsen L. M., "*Sex and gender terminology: a glossary for gender-inclusive epidemiology",* **J Epidemiol Community Health**, 76(8), 2022, 764-768.

Rivard S., "*Theory building is neither an art nor a science. It is a craft*", **Journal of Information Technology**, 36(3), 2021, 316-328.

Rodríguez-Hernández C. F., Cascallar E., & Kyndt E., "*Socio-economic status and academic performance in higher education: A systematic review*", **Educational Research Review**, *29*, 2020, 100305.

Rodriguez S., Regueiro B., Piñeiro I., Estévez I. & A. Valle., "*Gender Differences in Mathematics Motivation: Differential Effects on Performance in Primary Education*", **Frontiers in Psychology**, 10, 2020, 1-8.

Rufii R. & Rochmawati D., "*Evaluation of Universal Design for Constructivist-Based Statistics Learning Module for Students' Increased Motivation*", **Journal of Education and Learning (EduLearn)**, 13(3), 2019, 431-440.

Salvati M. & Koc Y., "*Advancing research into the social psychology of sexual orientations and gender identities: Current research and future directions"*, **European Journal of Social Psychology**, 52(2), 2022, 225-232.

Samanta R. P., "*Inductive Approach: Its Pros & Cons*", **Scholars International Journal of Linguistics and Literature**, 2021, 351-353..

Santyasa I. W., Rapi N. K. & Sara I., "*Project based Learning and Academic Procrastination of Students in Learning Physics*", **International Journal of Instruction**, 13(1), 2020, 489-508.

Shen T. & Konstantopoulos, S. *Are class size and teacher characteristics associated with cognitive outcomes in early grades?*, **School effectiveness and school improvement**, 33(3), 2022, 333-359.

Shi Y. & Qu S., "*Cognitive ability and self-control's influence on high school students' comprehensive academic performance*", **Frontiers in Psychology**, 12, 2021, 1-10, 783673.

Shirav A., & Nagai E., "*The Effects of Deductive and Inductive Grammar Instructions in Communicative Teaching*", **English Language Teaching**,15(6), 2022, 102-123.

Simamora R. E. & Saragih S., "*Improving Students' Mathematical Problem Solving Ability and Self-Efficacy through Guided Discovery Learning in Local Culture Context*" ,**International Electronic Journal of Mathematics Education**, 14(1), 2019, 61-72.

Souisa T. R., & Yanuarius L., "*Teachers' Strategies on Teaching Grammar: Facts and Expectations of Senior High School Teachers at Ambon*", **International Journal of Evaluation and Research in Education**, 9(4), 2020, 1121-1127.

Stilwell P. & Harman K., "*Phenomenological research needs to be renewed: Time to integrate enactivism as a flexible resource*", **International Journal of Qualitative Methods**, 20, 2021, 1-15, 1609406921995299.

Strübel J. & Goswami S., :*Clothing and self concept in cisgender and transgender individuals",* **Gender Issues**, 39(4), 2022, 387-408.

Sulistyowati T., "*Bottom-up and top-down listening processes within cognitive constructivist learning theory*", **Prominent Journal**, 2(1), 2019,92-100.

Suwastini N. K. A., Ersani N. P. D., Padmadewi N. N. & Artini L. P., "*Schemes of scaffolding in online education*", **Retorika: Jurnal Ilmu Bahasa**, 7(1), 2021,10-18.

Szyliowicz D. & Green T. G., "*Making strategy "Real": Using reality television for innovating teaching approaches*", **The International Journal of Management Education**, 17(3), 2019, 100304.

Teibowei M. T., "*Challenges to The Implementations of Internal Quality Assurance Mechanisms in Bayelsa Medical University*", **British Journal of Multidisciplinary and Advanced Studies**, 4(2), 2023. 102-108.

Tohir M., Maswar M., Atikurrahman M., Saiful S. & Pradita, D. A. R., "*Prospective Teachers' Expectations of Students' Mathematical Thinking Processes in Solving Problems*". **European Journal of Educational Research**, 9(4), 2020, 1735-1748.

Tong D. H., Nguyen T. T., Uyen B. P., Ngan L. K., Khanh L. T., & Tinh P. T., "*Realistic Mathematics Education's Effect on Students' Performance and Attitudes: A Case of Ellipse Topics Learning*", **European Journal of Educational Research**, 11(1), 2022, 403-421.

Umida K., Farida A., Dilnoza B. & Lenie X., "*Development Stages of the Concept to Constructivism*", **湖南大学学报 (自然科学版),** 49(07). 2022, 1020 – 1029.

Vooren M., Haelermans C., Groot W. & Van den Brink H. M., "*Comparing success of female students to their male counterparts in the STEM fields: an empirical analysis from enrollment until graduation using longitudinal register data*", **International Journal of STEM Education**, 9(1), 2022, 1-17.

Wanjiku Wang'ang'a A., "*Dyscalculia in Kenyan Schools: Implications for Transition to Higher Education and Employment, Literature Review*", **East African Journal of Education Studies**, 6(2), 2023, 121-138.

Wang M. T., Smith L. V., Miller-Cotto D. & Huguley J. P., "*Parental ethnic-racial socialization and children of color's academic success: A meta-analytic review*", **Child Development**, 91(3), 2020, e528-e544.

Wardani S. & Kusuma I. W., "*Comparison of Learning in Inductive and Deductive Approach to Increase Studentâ€™ s Conceptual Understanding based on International Standard Curriculum*", **Jurnal Pendidikan IPA Indonesia**, 9(1), 2020, 70-78.

Weeden K. A., D. Gelbgiser, & Morgan S. L., "*Pipeline dreams: Occupational plans and gender differences in STEM major persistence and completion*", **Sociology of Education**, 93(4), 2020, 297-314.

Widyantoro A., "*Teaching Conditional Sentence Using Presentation, Practice, Production (PPP) Technique in Vocational School*", **CLLiENT (Culture, Literature, Linguistics, And English Teaching)**, 1(02), 2019, 147-164.

Wood R.M., "*A Review on Education differences in Urban and Rural Areas*". Telfer School of Management; the University of Ottawa, Ottawa, ON K1N 6N5, **Canada International Research Journal of Educational Research ,** 14(2), March, 2023, 1-3.

Yeo S., Shim H., Hwang S. & Campbell T. G., "*Relations Between Elementary Mathematics Growth Trajectories and Middle School Mathematics Achievement: Moderating

Effects of Student Perception of Teaching Styles", **International Journal of Science and Mathematics Education**, 21(6), 2023, 1889-1912.

Zahara E., Murni A. & Hutapea N. M., "*Development of Mathematics Learning Tools by Implementing Numbered Head Together Type Cooperative Models to Improve Students' Mathematical Understanding Ability in Matrix Topic*", **Journal of Educational Sciences**, 4(2), 2020, 250-260.

Šimunović M. & Babarović T., "*The role of parents' beliefs in students' motivation, achievement, and choices in the STEM domain: a review and directions for future research*", **Social Psychology of Education**, 23, 2020 ,701-719.

Thesis

Adjei M. Y. , "*Assessment Practices of Christian Religious Studies Teachers in Senior High Schools in Ghana: A Survey*" , (Doctoral dissertation, University of Cape Coast), 2021.

Kamau H. N., "*Selected Teaching Strategies and Performance of Students in Mathematics in Public Secondary Schools of Bahati Subcounty*", Nakuru County, KENYA **,**(Doctoral dissertation, The Catholic University of Eastern Africa), 2022, Available Online: http://ir.cuea.edu/jspui/handle/1/12153

Maloney K. "*The Effects of Class Size on Student Achievement*", A Starred Paper Submitted to the Graduate Faculty of St. Cloud State University in Partial Fulfillment of the Requirements for the Degree Master of Science in Curriculum and Instruction, May, 2020.

Muthmainnah C. R., "*The Effect of Deductive and Inductive Instruction on Students' Grammar Ability (A Comparative Study) (Doctoral dissertation, UIN Ar-Raniry)*", 2019, 21

Roberts K. L. W., "*The Experiences of Male Early Childhood Teachers: Navigating Suitability to Teach*", (Doctoral dissertation, Edgewood College), 2021.

Sawhney H. K.. "*Self-study Exploring Pedagogy to Engage Community College Students in Chemistry*" (Doctoral dissertation, San Francisco State University), 2020.

Website

Benbow J., Mizrachi A., Oliver D., & Said-Moshiro L., "*Large Class Sizes in the Developing World: What Do We Know and What Can We Do?"* American Institutes for Research under the EQUIP1 LWA, October 2007, 1 – 14, Available Onliine: https://www.edu-links.org/sites/default/files/media/file/Large_Class_Sizes_in_the_Developing_World__What_Do_We_Know_and_What_Can_We_Do_.pdf

Basit I. F. F. A. T., Bakhsh K. H. U. D. A. & Hafeez M., "*Adult Learning Theories and their Role in Instructional Design, Curriculum Development and Educational Technology*"**,** Wseas Transactions on Environment and Development, 17, 2021, 1149-1159. Available Online: https://wseas.com/journals/articles.php?id=698

Lists of Colleges of Education in Oyo State, https://samphina.com.ng/federalstate-private-colleges-education-oyo-state/

Lynch T., "*Theories, Models and Approaches: Physical Education and Wellbeing"*, Physical Education and Wellbeing. 2019. 15-34, Available Online: https://api.semanticscholar.org/CorpusID:198770527

Appendix I

Tale 1.1: Distribution Of Students' Academic Achievement Score for Three Sessions Between 2019-2022

		Session					
	Colleges	**2019/2020**		**2020/2021**		**2021/2022**	
		No of passed	**No of failed**	**No of passed**	**No of failed**	**No of passed**	**No of failed**
1	Emmanuel Alayande College of Education, Oyo	1,972	170	1,849	205	1,343	183
		92.06%	7.94%	90.02%	9.98%	88.01%	11.99%
2	Federal College of Education (Special), Oyo	2,838	181	2,377	207	2,200	272
		94.0%	6%	91.99%	8.01%	89%	11%
3	Oyo State College of Education, Lanlate	610	32	575	50	435	54
		95.02%	4.98%	92%	8%	88.96%	11.04%

Source: Department of General Studies Education from each School

Appendix II

Lesson Plan For Inductive Method

Name: Folasade Oluwayemisi, Iyanda

Matric No: LCU/PG/002712

Degree in view: MSc.(Ed) Mathematics Education

Subject: Basic General Mathematics

Topic: Expansion and Factorizing of Algebraic Expression.

Sub Topic: - Expansion of Special Products

Class: N.C.E II

Date:

Duration: One Hour

Previous Knowledge: Students have been taught the expansion of Algebraic expression

Behavioural Objectives: At the end of the lessons, students should be able to:

i. Expand the special product
ii. Derive the square of a difference of two quantities
iii. Derive the square of the sum of the sum of any two quantities
iv. Derive the product of the sum and the difference of two quantities

Instructional Aid: Chart showing expansion of special products.

References:

1. O S. Raimi et al (2010) BASIC GENERAL MATHEMATICS II. SIBIS Ventures Lagos pg 6-10 ISBN 978-37433-1-7
2. M.F Macrae et al 2013 NEW GENERAL MATHEMATICS for Junior Secondary School 2 Pearson England pg 46-52.
3. M.F Macrae et al 2013 NEW GENERAL MATHEMATICS for Senior Secondary School 1 Pearson, England, pg 58-68.

Teaching Procedure:

Introduction: The teacher introduces the lesson by writing an example of special products on the board: $(a + b)^2 = a^2 + 2ab + b^2$

Step 1:- The teacher will write an example of an expression on the board in the form of addition of two terms and ask the students to find its square by the method of multiplication. Students will multiply $(x + y)$ by $(x + y)$

$(x + y)(x + y)$ by breaking the expression into two

$(x + y)(x + y)$, using $(x + y)$ to multiply each in the second bracket $(x + y)$

$(x + y)(x + y) = x(x + y) + y(x + y)$

Then the bracket in right hand side can now be removed.

$(x + y)(x + y) = x^2 + xy + yx + y^2$

$= x^2 + 2xy + y^2$

Example II: The teacher will write another example based on the difference of two square quantities $(x - y)^2 = x^2 - 2xy + y^2$

$(x - y)^2 = (x - y)(x - y)$

$= x(x - y) - y(x - y)$

Remove the bracket, we get

$$x^2 - xy - yx + y^2$$

$$= x^2 - 2xy + y^2$$

Example III: The teacher gives another example on the product of the sum and the difference of two quantities

$(x + y)(x - y) \quad = x^2 - y^2$

$(x + y)(x - y) \quad = x(x - y) + y(x - y)$

$x^2 - xy + yx - y^2$

$x^2 - y^2$

Then give them a number of similar cases to solve

i) $(p+q)^2$ ii) $(x + 2)^2$

iii) $(x-4)^2$ iii) $(3a - 2b)^2$

vi) $(m+3)(m - 3)$ vi) $(n - 7)(n + 7)$

And then ask them to find the square in each case by the same method. Students will find the square in case.

Step II: - The teacher will ask the student to tell the square of each expression separately and will put it on board, in the following form

i. $(p + q)^2 \quad = p^2 + q^2 + 2pq$

ii. $(x + 2)^2 \quad = x^2 + 4 - 4x$

iii. $(x - 4)^2 \quad = x^2 + 16 - 8x$

iv. $(3a - 2b)^2 \quad = 9a^2 + 4b^2 - 12ab$

v. $(m+3)(m-3) = m^2 - 9$

vi. $(n-7)(n+7) = n^2 - 49$

Step III: - The teacher will tell the students to observe the square of them.

Assignment: - Expand the following expression.

(i) $(2x - 5y)^2$ (ii) $(2x + 2)^2$ (iii) $(5y + 7x)$

Conclusion:

Teachers Remark:-

Appendix III

Lesson Plan For Deductive Teaching Strategy

Name: Folasade Oluwayemisi IYANDA

Matric No: LCU/PG/002712

Degree In View: M.(Ed) Mathematics Education

Subject: Basic General Mathematics

Topic: Expansion and Factorizing of Algebraic Expression

Sub-Topic: Expansion of Special Products

Class: NCE II

Date:

Duration: One Hour

Previous Knowledge: Students have been taught the Expansion of Algebraic expansion.

Behaviour Objective: At the end of the lesson, students should be able to apply the formula to solve the given related problems.

Instructional Aids: Chart showing application of formula of expansion of special products.

References:

1. O S. Raimi et al (2010) BASIC GENERAL MATHEMATICS II. SIBIS Ventures Lagos pg 6-10 ISBN 978-37433-1-7
2. M.F Macrae et al 2013 NEW GENERAL MATHEMATICS for Junior Secondary School 2 Pearson England pg 46-52.
3. M.F Macrae et al 2013 NEW GENERAL MATHEMATICS for Senior Secondary School 1 Pearson, England, pg 58-68.

Teaching Procedure: The teacher introduced the lesson by writing an example of special products on the board.

$(a + b)^2 = a^2 + b^2 + 2ab$

$(a – b)^2 = a^2 + b^2 - 2ab$

$(a – b)(a + b) = a^2 - b^2$

Step I: The teacher will tell the students if an algebraic expression is given to find the expansion of special product of any two quantities, the formula is given below:

$(a + b)^2 = a^2 + b^2 + 2ab$

$(a – b)^2 = a^2 + b^2 - 2ab$

$(a – b)(a + b) = a^2 - b^2$

Step II: The teacher will expect the students to apply the formula to the same related problem.

Example: Expand

i.) $(x – 3)^2$

ii.) $(p + 2q)^2$

iii.) $(r + s)(r – s)$

Solution:

* $(x – 3)^2$

Rule: $(a – b)^2 = a^2 + b^2 - 2ab$

Now ,let apply this rule to the express $(x – 3)^2$

$(x – 3)^2 = x^2 - 2(x)(3) + (3)^2$

Simplify each term

$X^2 - 6X + 9$

* $(p + 2q)^2 = p^2 + 4q^2 + 4qp$

* $(r + s)(r - s) = r^2 - s^2$

The teacher will ask the students to the problem of this type given on the board. The student will solve them in the line with the example.

(i) $(3a - 2b)^2$ (ii) $(5h + k)^2$ (iii) $(5a - 2b)(5a + 2b)$

Inference: After solving few problems with the help of given formula, the students will infer that this formula holds true and can be used to solve another related problem.

Verification: Students may verify the validity of formula by using it to solve another problem related with the explanation of special product and then memorized this formula for use in future.

Assignment: Expand i. $(5x - 6)^2$

ii. $(5y - 2)(5y + 2)$

iii. $(f + g)^2$

Conclusion:

Evaluation:

Teacher's Remark:

Appendix IV

Lesson Plan For Conventional Teaching Strategy

Name: Folasade Oluwayemisi, Iyanda

Matric No: LCU/PG/002712

Degree In View: M.(Ed) Mathematics Education

Subject: Basic General Mathematics

Topic: Expansion and Factorizing of Algebraic Expression.

Sub Topic: Expansion of Special Products

Class: N.C.E II

Date:

Duration: One Hour

Previous Knowledge: Students have been taught the expansion of Algebraic expression

Behavioural Objectives: At the end of the topic students should be able to:

i. Expand the special product

ii. Derive the square of a difference of two quantities

iii. Derive the square of the sum of the sum of any two quantities

iv. Derive the product of the sum and the difference of two quantities

Instructional Aid: Chart showing expansion of special products.

References:

1. O S. Raimi et al (2010) BASIC GENERAL MATHEMATICS II. SIBIS Ventures Lagos pg 6-10 ISBN 978-37433-1-7

2. M.F Macrae et al 2013 NEW GENERAL MATHEMATICS for Junior Secondary School 2 Pearson England pg 46-52.

3. M.F Macrae et al 2013 NEW GENERAL MATHEMATICS for Senior Secondary School 1 Pearson, England, pg 58-68.

Teaching Procedure:

Introduction: The teacher introduces the lesson by writing an example of special products on the board $(a + b)^2 = a^2 + 2ab + b^2$

Step I:- The teacher will write an example of an expression on the board in form of additional of two terms and find its square by the method of multiplication .

$(x + y)^2 = x^2 + y^2 + 2xy$

The teacher will assume that the students have known the procedure.

Example II:- The teacher will write another example based on the difference of two square quantities $(x – y)^2 = x^2 + y^2 – 2xy$

Class work

i. $(3a – 2b)^2$
ii. $(x + 4)^2$

Step II:- The teacher will give the student assignment to be submitted before the next class.

i. $(2x – 5y)^2$
ii. $(2x + 2)^2$
iii. $(5y + 7x) (5y – 7x)$

Appendix V

Department of Science Education

Basic Mathematics Achievement Test (BMAT)

Dear Respondents,

The Basic Mathematics Achievement Test is drawn to assist the researcher in determining the effects of Inductive and Deductive Teaching Strategies on the Students' Achievement in Basic General Mathematics in Colleges of Education, Oyo State. Your maximum cooperation is solicited as your respond to the following questions.

The answer provided through this test will be used mainly for academic purpose and will be kept confidentially. Thanks very much for your understanding and cooperation.

SECTION A:

Please, fill in the blank space

1. College
2. Sex: Male { } Female{ }

SECTION B: Basic Mathematics Achievement Test

Course Title: Basic General Mathematics II

Topic: Expansion and Factorizing of Algebraic Expression.

Duration: 40 Minutes

Level: 200

Instruction: Answer all the questions by ticking the right option from A to E

1. Solve for x in the equation 5(x - 7) -7x = – 3(4x – 5)

a) 1/5

b) 5/6

c) 2

d) 5

e) 4

2. If 5x – 3 = 4x – 7, what is the value of 6x

a. 26

b. 6

c. 4

d. -4

e. -24

3. If 6x + 7 = 4x – 3, what is the value of 8x – 4

a. -44

b. -5

c. -1

d. 36

e. 44

4. Solve the equation 3(2x – 7) = 2(x – 8)

a. $\frac{5}{4}$

b. ¾

c. ½

d. -1

e. $-\frac{5}{4}$

5. Simplify $\frac{3x}{5}+\frac{2x}{15}=\frac{3}{5}$

a. $\frac{9}{11}$

b. $\frac{9}{7}$

c. $\frac{7}{11}$

d. $\frac{9}{7}$

e. $\frac{7}{9}$

6. Solve $\frac{3b}{9}+\frac{1}{2}=\frac{3}{4}+\frac{\boldsymbol{b}}{\boldsymbol{4}}$

a. -3

b. -2

c. 2

d. 3

e. 4

7. Expand the expression (3a – xy) (3a + xy)

a. $9a^2 - x^2y^2$

b. $9a^2 + x^2y^2$

c. $9a^2 - xy$

d. $9a^2 + x^2y$

e. $9a^2 - xy^2$

8. If $x^2 - 5x + c = (x - 8)(x + 3)$. Find the value of C

a. 24

b. 5

c. -5

d. -9

e. -24

9. What is the coefficient of x in the expansion $(2x - 3)(3x + 8)$?

a. -25

b. -24

c. 6

d. 7

e. 25

10 Find the coefficient of xy in the expansion $(x - 4y)(3x + 2y)$

a. 14

b. 12

c. 10

d. -10

e. -12

11. Factorize $(25y^2 - 4)$

a. $(5y - 2)(5y + 2)$

b. $(2y - 5)(5y + 2)$

c. $(5y - 2)(5y - 2)$

d. $(5y + 2)(5y + 2)$

e. $(5y - 2)(2 - 5y)$

12. Factorize $(5d - 2e)^2 - 9e^2$

a. $(5d - 2e)(3d - 3e)$

b. $5(d - e)(5d - e)$

c. $5(d - e)(5d + e)$

d. $(5d - 3e)(3d - 3e)$

e. $(5d - e)(3d - e)$

13. Expand the expression $(2x + 2)^2$

a. $4x^2 + 8x + 4$

b. $2x^2 + 4x - 4$

c. $4x^2 - 8x + 4$

d. $4x^2 - 8x - 4$

e. $2x^2 + 4x + 4$

14. Expand the expression $(p - q)^2$

a. $P^2 + q^2 + 2pq$

b. $P^2 + q^2 - 2pq$

c. $P^2 - q^2 - 2pq$

d. $P^2 + q^2 - pq$

e. $P^2 - q^2 + pq$

15. Expand the expression $(4x – 1)^2$

a. $16x^2 – 1$

b. $16x^2 + 1$

c. $16x^2 - 8x$

d. $16x^2 + 2$

e. $4x^2 - 1$

16. Factorize $y^2 - 4$

a. $(y + 2)(y + 2)$

b. $(y + 2)(y - 2)$

c. $(y - 1)(y + 2)$

d. $(y - 1)(y - 4)$

e. $(y - 2)(y - 2)$

17. Factorize $5a^2 - 45$

a. $5 (a + 3) (a – 3)$

b. $5 (a + 3) (a + 3)$

c. $5 (a - 3) (a – 3)$

d. $5 (a + 3) (5a – 3)$

e. $5 (a - 9) (a – 3)$

18. Simplify $(f + g)^2 + (f – 2g)^2$

a. $2f – 2fg + 5g^2$

b. $2f + 3fg + 5g^2$

c. $5g – 2f + 2fg$

d. $3fg - 2f + 5g^2$

e. $2f^2 - 2fg + 5g^2$

19. Multiply (3 + a) by (5 – 2a)

a. $15 - a - 2a^2$

b. $2a^2 - a + 15$

c. $a - 3a + 15$

d. $2a^2 + a + 15$

e. $2a^2 -3a + 15$

20. Find the value of 4 (3d – e) – 2f when d = 2, e = 4 and f = 3

a. 2

b. 3

c. 14

d. 5

e. 4

21. Factorize critically $(4x^2 + 4y^2 - 8xy) / (4x^2 + 16y^2 + 16xy)$

a. $(x - y) / (2y + x)$

b. $(x + y) / (2y + x)$

c. $(x + y) / (2y - x)$

d. $(x - y) / (2y - x)$

22. Factorize completely $(m^2 + 2mn + n^2) / ((m - n)(m + n))$

a. $(m + n)^2 / (m^2 - n^2)$

b. $(m - n)^2 / (m^2 - n^2)$

c. $(m + n)^2 / (m^2 + n^2)$

d. $(m - n)^2 / (m^2 + n^2)$

23. Factorize completely $(2x + y) / (4x^2 + 4xy + y^2)$

a. $1/(2x + y)$

b. $-1 / (2x + y)$

c. $1 / (2x - y)$

d. $- 1 / (2x - y)$

24. Factorize $(a^2 + 2ab + b^2) / (a^2 + 2ab^2 + b^4)$

a. $(a + b)^2 / (a + b^2)^2$

b. $(a - b)^2 / (a + b^2)^2$

c. $(a + b)^2/(a - b^2)^2$

d. $(a - b)^2/(a - b^2)^2$

25. $Solve\ (a^4 + 3a^3) / (a^2 + 2a)$

a. $a(a^2 + 3) / (a + 2)$

b. $a(a^2 - 3) / (a + 2)$

c. $a(a^2 + 3)/(a - 2)$

d. $a(a^2 - 3)/(a - 2)$

Answers

1. D
2. E
3. E

4. A
5. A
6. D
7. A
8. E
9. D
10. D
11. A
12. C
13. A
14. B
15. A
16. A
17. A
18. E
19. A
20. A
21. A
22. A
23. A
24. A
25. A

Appendix VI

Table 3.5: Table of Specification for Basic Mathematics Achievement Test (BMAT)

		OBJECTIVES			
S/N	**CONTENT**	**KNOWLEDDGE**	**COMPREHENSION**	**APPLICATION**	**TOTAL OF ITEMS**
1.	Expansion of Algebraic Expression	**3**	**3**	**2**	**8**
2.	Expansion of Special Products	**2**	**4**	**2**	**8**
3.	Factorization of Algebraic Expression	**1**	**2**	**1**	**4**
4.	Application of Algebraic Expression	**2**	**2**	**1**	**5**
	TOTAL	**8**	**11**	**6**	**25**

Source: Developed by researcher

Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
treatment	1.00	Inductive Teaching Strategy	66
	2.00	Deductive Teaching Strategy	109
	3.00	control Group (Lecture method)	60

Tests of Between-Subjects Effects

Dependent Variable: post_test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2884.785[a]	3	961.595	574.187	.000
Intercept	161.726	1	161.726	96.570	.000
pre_test	2757.851	1	2757.851	1646.765	.000
Treatment	301.201	2	150.600	89.926	.000
Error	386.858	231	1.675		
Total	25548.000	235			
Corrected Total	3271.643	234			

a. R Squared = .882 (Adjusted R Squared = .880)

Estimated Marginal Means

1. Grand Mean

Dependent Variable: post_test

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
9.580[a]	.087	9.408	9.752

a. Covariates appearing in the model are evaluated at the following values: pre_test = 6.7915.

2. treatment

Dependent Variable: post_test

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Inductive Teaching Strategy	7.917[a]	.160	7.602	8.233
Deductive Teaching Strategy	10.532[a]	.124	10.288	10.776
control Group (Lecture method)	10.291[a]	.168	9.961	10.621

a. Covariates appearing in the model are evaluated at the following values: pre_test = 6.7915.

```
UNIANOVA post_test BY gender WITH pre_test
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
```

```
/EMMEANS=TABLES(OVERALL) WITH(pre_test=MEAN)
/CRITERIA=ALPHA(.05)
/DESIGN=pre_test gender.
```

<u>Univariate Analysis of Variance</u>

Between-Subjects Factors

		Value Label	N
Gender	1.00	Male	88
	2.00	Female	147

Tests of Between-Subjects Effects

Dependent Variable: post_test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2583.600[a]	2	1291.800	435.580	.000
Intercept	251.848	1	251.848	84.920	.000
pre_test	2565.249	1	2565.249	864.972	.000
Gender	.016	1	.016	.005	.942
Error	688.043	232	2.966		
Total	25548.000	235			
Corrected Total	3271.643	234			

a. R Squared = .790 (Adjusted R Squared = .788)

Estimated Marginal Means

Grand Mean

Dependent Variable: post_test

Mean	Std. Error	95% Confidence Interval Lower Bound	Upper Bound
9.738[a]	.116	9.510	9.967

a. Covariates appearing in the model are evaluated at the following values: pre_test = 6.7915.

```
UNIANOVA post_test BY class_size WITH pre_test
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
  /EMMEANS=TABLES(OVERALL) WITH(pre_test=MEAN)
  /CRITERIA=ALPHA(.05)
  /DESIGN=pre_test class_size.
```

Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
class_size	1.00	Large	109
	2.00	Small	126

Tests of Between-Subjects Effects

Dependent Variable: post_test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2710.521[a]	2	1355.260	560.342	.000
Intercept	249.087	1	249.087	102.987	.000
pre_test	2627.258	1	2627.258	1086.259	.000
class_size	126.937	1	126.937	52.483	.000
Error	561.122	232	2.419		
Total	25548.000	235			
Corrected Total	3271.643	234			

a. R Squared = .828 (Adjusted R Squared = .827)

Estimated Marginal Means

Grand Mean

Dependent Variable: post_test

Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
9.790[a]	.102	9.589	9.990

a. Covariates appearing in the model are evaluated at the following values: pre_test = 6.7915.

```
UNIANOVA post_test BY treatment gender WITH pre_test
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
  /EMMEANS=TABLES(OVERALL) WITH(pre_test=MEAN)
  /CRITERIA=ALPHA(.05)
  /DESIGN=pre_test treatment gender treatment*gender.
```

Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
treatment	1.00	Inductive Teaching Strategy	66
	2.00	Deductive Teaching Strategy	109
	3.00	control Group (Lecture method)	60
Gender	1.00	Male	88
	2.00	Female	147

Tests of Between-Subjects Effects

Dependent Variable: post_test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2997.857[a]	6	499.643	416.087	.000
Intercept	163.587	1	163.587	136.230	.000
pre_test	2721.806	1	2721.806	2266.635	.000
Treatment	209.960	2	104.980	87.424	.000
Gender	1.294	1	1.294	1.077	.300
treatment * gender	112.675	2	56.337	46.916	.000
Error	273.785	228	1.201		
Total	25548.000	235			
Corrected Total	3271.643	234			

a. R Squared = .916 (Adjusted R Squared = .914)

Estimated Marginal Means

Grand Mean

Dependent Variable: post_test

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
9.589[a]	.077	9.437	9.740

a. Covariates appearing in the model are evaluated at the following values: pre_test = 6.7915.

UNIANOVA post_test BY treatment class_size WITH pre_test

```
/METHOD=SSTYPE(3)
/INTERCEPT=INCLUDE
/EMMEANS=TABLES(OVERALL) WITH(pre_test=MEAN)
/CRITERIA=ALPHA(.05)
/DESIGN=pre_test treatment class_size treatment*class_size.
```

Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
treatment	1.00	Inductive Teaching Strategy	66
	2.00	Deductive Teaching Strategy	109
	3.00	control Group (Lecture method)	60
class_size	1.00	Large	109
	2.00	Small	126

Tests of Between-Subjects Effects

Dependent Variable: post_test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2884.785[a]	3	961.595	574.187	.000
Intercept	179.547	1	179.547	107.211	.000
pre_test	2757.851	1	2757.851	1646.765	.000
treatment	174.264	1	174.264	104.057	.000
class_size	.000	0	.	.	.
treatment * class_size	.000	0	.	.	.
Error	386.858	231	1.675		
Total	25548.000	235			
Corrected Total	3271.643	234			

a. R Squared = .882 (Adjusted R Squared = .880)

Estimated Marginal Means

Grand Mean

Dependent Variable: post_test

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
9.580[a,b]	.087	9.408	9.752

a. Covariates appearing in the model are evaluated at the following values: pre_test = 6.7915.

b. Based on modified population marginal mean.

Tests of Between-Subjects Effects
Dependent Variable

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2997.857[a]	6	499.643	416.087	0.000
Intercept	181.451	1	181.451	151.107	0.000
pre_test	2721.806	1	2721.806	2266.635	0.000
treatment	95.630	1	95.630	79.638	0.000
gender	0.941	1	0.941	0.784	0.377
class_size	0.000	0	.	.	.
treatment * gender	110.711	1	110.711	92.197	0.000
treatment * class_size	0.000	0	.	.	.
gender * class_size	0.000	0	.	.	.
treatment * gender * class_size	0.000	0	.	.	.
Error	273.785	228	1.201		
Total	25548.000	235			
Corrected Total	3271.643	234			

R Squared = .916 (Adjusted R Squared = .914)

Bio-data

A. Personal Data

1	**Name in Full:**	Folasade Oluwayemisi IYANDA
2	**Address:**	Oba-Adeyemi Area, Oyo.
3	**Nationality:**	Nigeria
4	**Marital Status:**	Married
5	**Email Address:**	folasadeiyanda014@gmail.com
6	**Phone Number:**	07939739865
7	**Date and Place of Birth:**	24 April,1976
8	**Name and Address of Next of Kin:**	Master Eden Inioluwa IYANDA
9	**Address of Next of Kin:**	Natural & Applied Science, Lead City Univ Ibadan

B. Educational Background

	Educational Institutions Attended	**Qualifications With Dates**	
(i).	L.A. Primary School, Isokun, Ilesa	Leaving Certificate	1988
(ii).	Durbar Grammar School, Oyo	SSCE	1997
(iii).	St. Andrew's College of Education, Oyo	NCE	2001
(iv).	University of Ado-Ekiti, Ado-Ekiti	BSc(Ed.)Maths	2007

C. Work Experiences with Date

i. Emmanuel Alayande College Of Education ,Oyo(Non-Teaching) July,2002-Sept,2021

ii. Emmanuel Alayande College Of Education ,Oyo(Lecturer III) Sept,2021 till Date

D. Award and Fellowship (If any): Nil

E. Membership:

i. Member, College of Education Academic Staff Union (COEASU), EACOED Chapter

ii. Member, Women in Colleges of Education (WICE), EACOED Chapter

F. Publication

Iyanda, F.O. & Odeleye, F.A., Gabriel, E.T., Wahab, R.A. & Adesina, E.A (2021). *Enhancing science education with learning management system: The Views of Lecturers in Colleges of Education in Oyo Township*

.

G. Major Conference Attended with Date

1. 12th National Conference of the colleges of education Academic staff union, Southwest zone

Theme: Educational Delivery System Amidst Dwindling Economy and National Insecurity. Held at Emmanuel Alayande College of Education, Oyo, between 28 of March and 1of April 2022

2. 6th National Conference of the School of Education.

Theme: Revitalizing Teacher Education for Higher Productivity in the New Normal. Held at Emmanuel Alayande College of Education, Oyo, between 9 and 12 of May, 2022.

3. 5th Faculty of Arts and Education international Conference on Sustainable development

Theme: Pragmatic Human Capital for Sustainable Development. Held at Lead City University, Ibadan, between 6 of June and 8 of June, 2022

H. References

1. Dr. C.O. Sam-Kayode
Science Education Department,
Faculty of Education,
Lead City University, Ibadan.

2. Dr. S.O. Raimi
General Studies Department,
Emmanuel Alayande College of Education, Oyo.

3. Dr. P.I. Farayola
Mathematics Department,
Emmanuel Alayande College of Education, Oyo.

....

Signature **Date**

The University Compliance Certification

This is to certify that the thesis by Folasade Oluwayemisi IYANDA in the Department of Science Education, Faculty of Art and Education, Lead City University, Ibadan, Oyo state is in full compliance with the approved University Format Style

....

Signature **Date**