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Effect of Inductive and Deductive Teaching Strategies on Senior Secondary School Students' Academic Achievement in Further Mathematics in Oyo State

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Abstract

This study investigates the Effect of Inductive and Deductive Teaching Strategies on Senior Secondary School Students' Academic Achievement in Further Mathematics in Oyo State.Three hypotheses were formulated and tested at 0.05 level of significance. A pretest–posttest quasi–experimental design was applied. Multi-stage sampling procedure was adopted to purposively select threeSchools of Science for the study from the three senatorial districts in Oyo state. A sample size of 108 participants comprises 50 male students and 58 female students were involved in the study. Differential and Integral Calculus Achievement Test (DICAT)(KR-20=0.84) was used as instrument for data collection. Analysis of Covariance (ANCOVA) was used for data analysis. There was a significant main effect of Deductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics [$F_{(1, 63)}=11.321$, $P<0.05$]. There was a significant interaction effect of Inductive and Deductive Teaching Strategies on Senior Secondary School Students' Academic Achievement in Further Mathematics [$F_{(2,104)}=10.128$, $P<0.05$]. From the results, it is concluded that the most effective and preferred teaching strategy is the Deductive Teaching Strategy. Base on the findings, it is suggested that application of Deductive Teaching Strategy or Combined Inductive and Deductive Teaching Strategies should be considered to improve students' academic achievement in Further Mathematics.

Keywords: Inductive Teaching Strategy, Deductive Teaching Strategy, Further Mathematics, Academic Achievement.

Introduction

Further Mathematics is an advanced level of mathematical study that goes beyond the standard curriculum covered in regular Mathematics courses. It is primarily designed for students who are highly motivated and mathematically gifted and who wish to investigate more into advanced and specialized areas (Olarewaju, Abdulrauf, Yusuf & Muraina, 2019). Further Mathematics is a regular course at the university level and it is also offered as an elective in high schools. It is significant to remember that depending on the educational institution and the curriculum it offers, the precise subjects and level of study might differ greatly. The appropriate course of action for students with interests in Further Mathematics should be discussed with their teachers or academic advisors. Students who intend to pursue jobs in subjects that demand a solid mathematical foundation, such as Economics, Physics, Engineering, Computer Science, and Mathematics, will benefit most from taking courses in Further Mathematics. It offers a strong basis for in-depth study and studies in various subjects (Badmus & Jita, 2023).

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

Mathematics while preparing them for more advanced coursework and study (Ibrahim, Wun & Nordin, 2020; Jeremiah & Eze, 2021).

In 2007, the Further Mathematics curriculum was revised and operation research and coordinate geometry were included due to the necessity to apply mathematical knowledge to real-world situations and difficulties. The goals for adding Further Mathematics to the curriculum are to prepare students for future studies in Mathematics and its applications, help students develop connectional and manipulative skills in Further Mathematics, reflect continuity with the curriculum used in universities and polytechnics and help students become future mathematicians, engineers, and scientists(Ibrahim, Wun & Nordin, 2020).

The level of proficiency in a particular academic domain, such as reading Mathematics, science, and social studies, among other subjects, is what defines academic achievement. Parents, teachers, and educational planners all have a significant role to play in maximizing academic achievement (Hillary & Iwok, 2018). The performance of students on either teacher-created tests or standardized achievement tests administered by examining bodies such as the West African Examination Council (WAEC), National Examination Council (NECO), National Business and Technical Examination Board (NABTEB) is the primary focus of Mathematics achievement (Lawal, 2021).

In Oyo State, students' academic achievement in Further Mathematics has been fluctuating over time as it was revealed in 2013 to 2022 May/June WAEC results analysis provided by Oyo State Ministry of Education, Science and Technology. The following are the percentage of students who achieved a credit pass or above in Further Mathematics, via trend analysis studies covering a decade of senior secondary school students' achievement pattern in May/June West African Examination Council (WAEC) SSCE results: 2013 (40.0%), 2014(49.6%), 2015 (54.3%), 2016 (57.4%), 2017 (58.7%), 2018 (60.0%), 2019 (52.0%), 2020 (52.4%), 2021 (74.8%) and 2022 (72.1%). The fluctuating

performance in Further Mathematics was attributed to a number of factors, including gender inequalities, poor Mathematics teacher quality, low motivation, inappropriate peer groups, low retention, negative student attitudes or interest in Further Mathematics, and ineffective teaching strategies (Omere, 2019; Oyo State May/June WAEC Results Analysis, 2024).

During a typical session of Further Mathematics class, the teacher solves problems on the chalkboard and assigns class-work to the students to solve. These exercises are marked, and corrections can be carried over to the lesson the following day. There is no prompt discussion of the problem at hand or student feedback from the teachers of Further Mathematics (Arthur,Courage & Samuel, 2022). This answer-oriented, rule-based, and computation-dominated view of Further Mathematics is a poor representation of what it really entails. The abstract nature and challenging course content of Further Mathematics makes many learners view it as a difficult subject and as such some of students offer it as a school subject. There is a widespread misconception that it is an exclusive subject for students with exceptional intelligence, for them, the classroom and the textbook are where Further Mathematics begins and ends. There are urgent steps that need to be taken to improve optimal performance because these may be factors that contribute to the fluctuating performance in Further Mathematics (Omere, 2019).

The awareness of various teaching strategies and their applications determines the manner in which tasks are presented to assist students in developing skills in learning. A teaching strategy is a method that the teacher of Further Mathematics employs to assist students in becoming independent, systematic learners by selecting appropriate methods and effectively utilizing them to complete tasks or reach goals. Further Mathematics can be taught using a variety of methods, such as; lecture, guided discovery, games, simulations, laboratory approach, problem solving, investigations, modeling,

demonstration, memorization, inductive and deductive method. It is one thing for these methods to already exist, but it is quite another for the Further Mathematics teacher to know which one to use and changing from instructing students by 'telling' them what to do to instructing students by getting them to use valuable mathematical problem-solving strategies while working creatively and cooperatively (Nguyen & Dung, 2022).

As far as this study is concerned, Inductive Teaching Strategy(ITS) and Deductive Teaching Strategy (DTS) are the two teaching strategies considered to be used to establish senior secondary school students' academic achievement in Further Mathematics. These two strategies are based on the two different forms of reasoning that people utilize while conducting proving processes, deductive reasoning and inductive reasoning, respectively. Deductive reasoning is distinctive because it is a method of drawing inferences from pre-existing knowledge (premise) based on formal logic principles. These conclusions must result from the information presented and do not require experimental validation. In contrast, inductive reasoning uses particular premises or observations to draw a conclusion or general rule (Siswono, Hartono & Kohar, 2020).

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

deductive teaching, it flows from general to specific (Mohammad & Moh'd, 2020).

Since the method of instruction in Further Mathematics is traditional method of teaching and the fluctuating performance in Further Mathematics over the years is partly due to instructional strategies. Hence, there is a need for further studies. A number of studies have been conducted in a number of areas to improve students' academic achievement in Further Mathematics. However, to the best of the researchers' knowledge there is dearth of literature in the area of effectiveness of Inductive Teaching Strategy (ITS) and Deductive Teaching Strategy (DTS) on Senior Secondary School Students' Academic Achievement in Further Mathematics in Oyo State. Therefore, this study intends to fill the research gaps and provide a solution with the established problems.

Aim and Objectives of the Study

The aim of this study is to investigate effect of inductive and deductive teaching strategies on senior secondary school students' academic achievement in Further Mathematics in Oyo State.

The objectives were to:

i. investigate the main effect of inductive teaching strategy on senior secondary school students' academic achievement in Further Mathematics.
ii. determine the main effect of deductive teaching strategy on senior secondary school students' academic achievement in Further Mathematics.
iii. examine the interaction effect of inductive teaching strategy and deductive teaching strategy on senior secondary school students' academic achievement in Further Mathematics.

Hypotheses

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

$H_0$1: There will be no significant main effect of inductive teaching strategy on senior secondary school students' academic achievement in Further Mathematics.

$H_0$2: There will be no significant main effect of deductive teaching strategy on senior secondary school students' academic achievement in Further Mathematics.

$H_0$3: There will be no significant interaction effect of inductive and deductive teaching strategies on senior secondary school students' academic achievement in Further Mathematics.

Methodology

The study adopted a quasi-experimental design to compare the academic achievement of students taught Calculus concepts inGroup A, Group B (Experimental Groups) and Group C (Control Group) using three teaching strategies: Inductive, Deductive and Conventional respectively. The research surveyed 1,604 Senior Secondary School II students from seven Oyo State schools of science, including 782 male and 822 female studentsat the time of the research.Multistage sampling procedure was used to select three Schools of Science (Ogbomoso (Group A), Pade (Group B) and Elekuro (Wesley College) (Group C)) purposively because they were the oldest Schools of Science, from each senatorial district in Oyo State and intact class was used in the study sample.The Differential and Integral Calculus Achievement Test (DICAT) was used to measure students' achievement in Calculus concepts. This study adopted both face and content validity assessment and Kuder-Richardson (KR-20) was used to calculate the reliability of the instrument (DICAT) with reliability value of 0.84. The research process was conducted within eight weeks. Inferential statistics was employed to

assess significant differences using ANCOVA at the 0.05 level of significance.

Results and Discussion of Findings

Demographic Data Analysis

Table 1: Study Sample

Teaching Strategies	Gender		Total
	Male	Female	
Inductive	17	25	42
Deductive	22	22	44
Conventional	11	11	22
Total	**50**	**58**	**108**

Source: *Fieldwork, 2024*

Presentation of Data

Hypotheses

$H_0$1: There will be no significant main effect of Inductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics.

The Analysis of Covariance (ANCOVA) result on the effect of teaching strategy on senior secondary school students' academic achievement in Further Mathematics after being taught with inductive strategy was: $F_{(1, 61)} = 0.339$ and Sig.=0.563. Since $P > 0.05$ the null hypothesis $H_0$1was retained. There was no significant main effect of Inductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics [$F_{(1, 61)} = 0.339$, $P > 0.05$]. The size of the effect of the conventional and inductive teaching methods was given by the partial Eta Squared value of 0.006, which

implies that the effect was small because its value fell between (0.1 – 0.2). The result also indicated that 0.6% of the variance in the students' performance was explained by the inductive and conventional teaching strategies. The coefficient results presented under the parameter estimates in (Table 3) shows that inductive strategy positively and insignificantly affects the students' performance in Further Mathematics($\beta=0.866$, Sig.$=0.563$). The result implies that a unit increase in inductive teaching strategy will lead to 0.866 increase in the students' performance in Further Mathematics.

Table 2: Summary of Senior Secondary School Students' Academic Achievement in Further Mathematics ANCOVA Result of the Difference in Posttest Mean for Inductive Teaching Strategy

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

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

Source: ***Fieldwork, 2024***

Table 3: Parameter Estimates of Senior Secondary School Students' Academic Achievement in Further Mathematics for Inductive Teaching Strategy.

Dependent Variable: Posttest

Dependent Variable: Posttest

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

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

Source: ***Fieldwork, 2024.***

$H_0$2: There will be no significant main effect of Deductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics.

The Analysis of Covariance (ANCOVA) result on the effect of teaching strategy on senior secondary school students' academic achievement in Further Mathematics after being taught with deductive methods was: $F_{(1, 63)}=11.321$and Sig.= 0.001. Since $P < 0.05$ the null hypothesis $H_0$2was rejected. There was a significant main effect of Deductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics [$F_{(1, 63)}=11.321, P < 0.05$]. The coefficient results presented under the parameter estimates in (Table 5)shows that deductive teaching strategy positively and significantly affects the students' performance in Further Mathematics ($\beta=4.261$, Sig.=0.001).

Table 4: Summary of Senior Secondary School Students' Academic Achievement in Further Mathematics ANCOVA Result of the Difference in Posttest Mean for Deductive Teaching Strategy.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Et Squared
Corrected Model	290.380[a]	2	145.190	6.258	0.003	0.166
Intercept	2106.574	1	2106.574	90.802	0.000	0.590
Pretest	11.107	1	11.107	0.479	0.492	0.008
Strategy	262.636	1	262.636	11.321	0.001	0.152
Error	1461.575	63	23.200			
Total	32519.000	66				
Corrected Total	1751.955	65				

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

Source: *Fieldwork, 2024*

$H_0$3: There will be no significant interaction effect of Inductive and Deductive Teaching Strategies on Senior Secondary School Students' Academic Achievement in Further Mathematics

The Analysis of Covariance (ANCOVA) result on effect of inductive and deductive strategies on senior secondary school students' academic achievement in Further Mathematics after being taught was: $F_{(2,104)}=10.128$and Sig.= 0.000. Since $P < 0.05$ the null hypothesis $H_0$3was rejected. There was a significant interaction effect of inductive and deductive teaching strategies on senior secondary school students' academic achievement in Further Mathematics [$F_{(2,104)}=10.128, P < 0.05$].

Table 5: Parameter Estimates of Senior Secondary School Students' Academic Achievement in Further Mathematics for Deductive Teaching Strategy

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

a. This parameter is set to zero because it is redundant.
Source: *Fieldwork, 2024*

Table 6: Summary of Senior Secondary School Students' Academic Achievement in Further Mathematics ANCOVA Result of the Difference in Posttest Mean for Interaction Effect of Inductive and Deductive Teaching Strategies.

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

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

Discussion of Findings

Findings showed that there was no significant main effect of Inductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics which isnot in line with previous study that investigated Critical Thinking Acquisition of Senior Secondary School Science Students in Lagos State, Nigeria: A Predictor of Academic Achievement (Okunuga, Awofala & Osarenren, 2020). The reason being the fact that in the previous study, Inductive Reasoning was used as part of predictors in Critical thinking skills to examine significant relationship and to predict achievement in Mathematics of senior secondary school science students which positively contributed significantly to the forecasting of achievement in Mathematics and also showed that there was a significant positive correlation between the science students' achievement in Mathematics. Also, the current result is not in agreement with the previous study that examined the Understanding of Learning Styles and Teaching Strategies towards Improving the Teaching and Learning of Mathematics (Cardino Jr. & Ortega-Dela Cruz, 2020). The

previous study result revealed the significant influence of Inductive approach among four (4) other teaching strategies have on the academic performance of Grade 9 students in Mathematics which is not congruent with the current study result because, the previous study was conducted to understand the influence of learning styles and teaching strategies.

Result showed that there was a significant main effect of Deductive Teaching Strategy on Senior Secondary School Students' Academic Achievement in Further Mathematics which is in line with previous study that investigatedthe Critical Thinking Acquisition of Senior Secondary School Science Students in Lagos State, Nigeria: A Predictor of Academic Achievement (Okunuga, Awofala & Osarenren, 2020). Though, in previous study, Deductive reasoning made the smallest significant positive contribution to the prediction of achievement in Mathematics, but both the current and previous studies show similar results that there was a significant main effect of Deductive reasoning on science students' achievement in Mathematics. This is also in line with previous study that examined the Understanding of Learning Styles and Teaching Strategies towards Improving the Teaching and Learning of Mathematics(Cardino Jr. & Ortega-Dela Cruz, 2020). Though, four (4) teaching strategies have significant influence on the academic performance of Grade 9 students in Mathematics from previous study result where Deductive approach was inclusive which implies that students enjoy and are content with the deductive method of instruction.

Result indicated that there was a significant interaction effect of Inductive and Deductive Teaching Strategies on Senior Secondary School Students' Academic Achievement in Further Mathematics; this is in line with the previous study that examined the Understanding of Learning Styles and Teaching Strategies towards Improving the Teaching and Learning of Mathematics (Cardino Jr. & Ortega-Dela Cruz,2020). Although, their subject matters, geographical locations and educational levelsare not the same but as a result of treatment, the previous study

result also revealed that Inductive and Deductive approach among four (4) other teaching strategies that were found to have a significant influence on the academic performance of Grade 9 students in Mathematics were in agreement with the current study result. This current finding is not in line with previous study that investigatedthe effect of Inductive and Deductive Teaching Methods on Students' Performance in Basic Science among Junior Secondary Schools Students: A Gender Study (Adams, Onwadi & Idika, 2021). The previous study result revealed that the experimental group two (students taught Basic Science through inductive teaching method) performed better than the experimental group one(students taught Basic Science through deductive teachingmethod)and the control group (student taught using combined teaching methods); that is, the students taughtBasic Sciencethrough inductive teaching method had the highest achievement, while the students taught Basic Science through deductive and combined methods had the lowest mean achievement which is not in agreement with current study result, since the students taught Basic Science through combined methods (Inductive and Deductive methods) had a lower mean achievement.

Conclusion

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

Recommendations

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

i. Other teaching strategies apart from inductive teaching strategy should be considered for teaching and learning Further Mathematics.
ii. Deductive teaching strategy should be considered applying in teaching and learning Further Mathematics.
iii. Use of combined inductive and deductive teaching strategies should be encouraged to enhance academic achievement in Further Mathematics.

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