

Effect of Inducto-Deductive Approach on Children's Early Numerical Aptitude in Mathematics in Ebonyi North Education Zone of Ebonyi State, Nigeria.

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DOI: [10.56201/ijasmt.vol.11.no3.2025.pg25.33](https://doi.org/10.56201/ijasmt.vol.11.no3.2025.pg25.33)

Abstract

This study examined the effect of the inducto-deductive approach on children's early numerical aptitude in mathematics in Ebonyi North Education Zone of Ebonyi State, Nigeria. The study was guided by two research questions and three hypotheses. The study adopted a quasi-experimental research design involving 246 primary six pupils selected from two public primary schools. The experimental group (134 pupils) was taught using the inducto-deductive approach, while the control group (112 pupils) received instruction through the traditional expository method. The instrument for data collection used was Numerical Aptitude Test (NAT). Research questions were answered using mean and standard deviation, While the hypotheses were tested using Analysis of Covariance (ANCOVA) at a 0.05 alpha level of significance. The results revealed that pupils taught using the inducto-deductive approach achieved significantly higher mean numerical aptitude scores than those taught with the expository approach. The method proved effective for both male and female pupils, with no significant gender differences observed in numerical aptitude outcomes. Additionally, there was no interaction effect between instructional approaches and gender on pupils' numerical aptitude, indicating that the inducto-deductive approach offers an equitable learning experience. It was recommended among others that mathematics teachers should adopt this approach to improve pupils' engagement and performance in mathematics.

Keywords: Inducto-Deductive Approach, Children's Early Numerical Aptitude, Mathematics.

Introduction

Mathematics is a fundamental discipline within the Nigerian education system, taught from primary through tertiary levels (Agah, 2020). It involves numbers, quantities, shapes, logical reasoning, and symbolic notations across arithmetic, algebra, geometry, and analysis (Jagat, 2020). At the primary school level, mathematics education is designed to lay a strong foundation for scientific, technological, and reflective thinking, equipping children with problem-solving, logical reasoning, and adaptability skills (Federal Government of Nigeria [FGN], 2014). However, despite the critical role of mathematics, primary school pupils in Nigeria, particularly in Ebonyi State, continue to struggle with early numerical aptitude, as evidenced by poor performance in numerical aptitude tests (Ikegwu, 2013).

Numerical aptitude refers to a child's potential ability to understand and manipulate numbers, which is crucial for developing a solid mathematical foundation (Santrock, 2011). It is a predictor of a student's ability to learn mathematical concepts and apply them effectively in problem-solving (Osborn, as cited in Nwocha, 2010). Early numerical aptitude is particularly important because it can affect children's academic success in mathematics throughout their educational journey (Willie & Bondi, 2011). Achieving strong numerical aptitude involves not only cognitive ability but also interest and engagement with mathematical concepts (Enunwa, 2016).

One of the significant challenges affecting children's numerical aptitude in mathematics is the instructional approach used by teachers. Traditional teaching methods, such as the expository approach, which involve direct instruction and passive learning, have often been criticized for limiting student engagement and creativity (Zakariyya, 2014). Research suggests that innovative teaching methods that involve active participation and critical thinking can significantly enhance learning outcomes (Kihwele & Mkomwa, 2022). The inducto-deductive approach is one such method, combining inductive and deductive reasoning to facilitate deeper understanding and retention of mathematical concepts (Narendra & Ajay, 2017).

The inducto-deductive approach involves two phases: the inductive phase, where students observe specific examples to identify patterns and formulate general rules, and the deductive phase, where these rules are applied to solve new problems (Jagat, 2020). This approach is grounded in cognitive theories by Jean Piaget and David Ausubel. Piaget's cognitive development theory emphasizes active learning through concrete experiences, which is particularly relevant to primary school children who are in the concrete operational stage of cognitive development (Piaget, 1977). Ausubel's meaningful learning theory complements this by advocating for teaching methods that connect new knowledge to existing cognitive structures, promoting long-term retention and understanding (Adhikari, 2020).

The study also considers gender as an important variable, given the mixed findings in existing literature regarding its influence on mathematical achievement and aptitude. While some studies report no significant gender differences in mathematical performance (Ajai & Imoko, 2015), others suggest that gender stereotypes may influence students' interest and achievement in mathematics (Igbo, Onu, & Obiyo, 2015). Understanding how the inducto-deductive approach interacts with gender can provide insights into whether this method offers an equitable learning experience for all students.

This study aims to evaluate the effect of the inducto-deductive approach on children's early numerical aptitude in mathematics in Ebonyi North Education Zone of Ebonyi State, Nigeria. It seeks to determine whether this approach can improve children's mathematical performance and interest, considering the potential moderating effect of gender. The findings of this study could contribute to the development of effective teaching strategies that enhance early mathematical education, promoting a strong foundation for future academic and career success.

Statement of the Problem

Despite the critical role of mathematics in everyday life and national development, primary school pupils in Ebonyi North Education Zone of Ebonyi State, Nigeria, continue to perform poorly in mathematics, particularly in numerical aptitude. Reports from the Examination Development Centre (EDC) indicate a persistent decline in pupils' performance in the Transition Placement Examinations (TPE) from 2019 to 2023. This trend raises concerns about the effectiveness of traditional teaching methods, such as the expository approach, which often leads to passive

learning, low engagement, and poor retention of mathematical concepts (Zakariyya, 2014). Additionally, research highlights gender disparities in mathematics achievement, suggesting a need for instructional methods that promote equitable learning opportunities (Alordiah, Akpadaka, & Oviogboda, 2015).

The inducto-deductive approach, which combines inductive and deductive reasoning, has shown promise in enhancing students' numerical aptitude, engagement, and interest in mathematics (Narendra & Ajay, 2017). However, there is limited empirical evidence on its effectiveness at the primary school level, particularly in relation to children's early numerical aptitude and gender differences. This study, therefore, seeks to determine the effect of the inducto-deductive approach on children's early numerical aptitude in mathematics in Ebonyi North Education Zone, considering the influence of gender.

Significance of the Study

This study is significant because it provides empirical evidence on the effectiveness of the inducto-deductive approach in enhancing children's early numerical aptitude in mathematics at the primary school level. By integrating inductive and deductive reasoning, this approach promotes active learning, critical thinking, and deeper understanding of mathematical concepts (Narendra & Ajay, 2017). The findings of this study could help educators adopt more effective teaching methods that improve not only pupils' mathematical performance but also their interest and engagement in the subject. Additionally, the study aligns with educational theories by Piaget and Ausubel, emphasizing the importance of linking new knowledge with existing cognitive structures (Adhikari, 2020). This approach could support curriculum planners and policymakers in designing instructional materials and teaching strategies that enhance early mathematics education in Nigeria.

The study also addresses the influence of gender on children's numerical aptitude, providing insights into whether the inducto-deductive approach offers equitable learning opportunities for both male and female pupils. Given the mixed findings in existing literature regarding gender differences in mathematics achievement (Alordiah, Akpadaka, & Oviogboda, 2015), this research could guide educators in creating inclusive classrooms where all learners can thrive. Furthermore, the Ministry of Education and curriculum developers could use the study's findings to develop targeted interventions that reduce gender disparities and improve mathematics education outcomes. Ultimately, this study has the potential to contribute to better academic performance, critical thinking skills, and long-term educational success for primary school pupils in Ebonyi North Education Zone and beyond.

Purpose of the Study

The purpose of this study is to determine the effect of inducto-deductive approach on children's early numerical aptitude in mathematics in Ebonyi North Education Zone of Ebonyi State, Nigeria. Specifically, the study seeks to determine the:

1. Mean numerical aptitude scores of pupils taught mathematics with IDA and those taught with EA.
2. Mean numerical aptitude scores of male and female pupils taught mathematics with IDA.
3. Interaction effect of instructional approaches (IDA & EA) and gender on the mean numerical aptitude scores of pupils in mathematics.

Research Questions

The following research questions guided the study:

1. What are the mean numerical aptitude scores of pupils taught mathematics with IDA and those taught with EA?
2. What are the mean numerical aptitude scores of male and female pupils taught mathematics with IDA?

Hypotheses

The following null hypotheses were formulated and each was tested at 0.05 alpha level of significance:

H₀₁: There is no significant difference between the mean numerical aptitude scores of pupils taught mathematics with inducto-deductive approach (IDA) and those taught with expository approach (EA).

H₀₂: There is no significant difference in the mean numerical aptitude scores of male and female pupils taught mathematics with IDA.

H₀₃: There is no interaction effect of instructional approaches (IDA & EA) and gender on the mean numerical aptitude scores of pupils in mathematics.

Methodology

This study adopted a quasi-experimental research design, specifically the pre-test post-test non-equivalent control group design. The population comprised all primary six pupils in the Ebonyi North Education Zone of Ebonyi State, Nigeria. The sample included 246 pupils randomly selected from two public primary schools, with 134 pupils (61 males and 73 females) in the experimental group and 112 pupils (49 males and 63 females) in the control group. The experimental group was taught mathematics using the inducto-deductive approach, while the control group received instruction through the traditional expository method. Numerical Aptitude Test (NAT) was the instrument for data collection used to assess pupils' aptitude in mathematics. The NAT was a placement examination into Junior Secondary one developed by the state Universal Basic Education Board (UBEB, 2023), Ebonyi State. NAT is a 50 multiple choice items which is used to test the numerical aptitude of Upper Basic Six pupils. The instrument was validated by experts. The reliability coefficients of the instrument was established using Kuder Richardson formula 20 (K-R20) and it yielding a reliability indices of 0.70.

Data was collected through pre-tests and post-tests for both experimental and control groups. The experimental group was exposed to the inducto-deductive approach, which involved presenting examples, guiding students through observation and reflection, facilitating generalization and rule formation, and applying these rules to problem-solving. The control group was taught using the expository method, focusing on direct instruction and memorization. Mean and standard deviation were used to analyze the research questions, while Analysis of Covariance (ANCOVA) was applied to test the hypotheses at a 0.05 level of significance. The ANCOVA helped control for pre-existing differences between groups and ensured that any observed effect on numerical aptitude was due to the instructional method rather than other extraneous variables.

Results

Research Question 1: What are the mean numerical aptitude scores of pupils taught mathematics with IDA and those taught with EA?

Table 1: Mean and Standard deviation of numerical aptitude scores of pupils taught mathematics with IDA and those taught with EA

Group	N	Pre-Test		Post-Test		Gained Mean
		Mean	SD	Mean	SD	
Experimental	134	28.25	4.89	68.16	9.81	39.91
Control	112	29.86	6.01	56.32	8.54	26.46
Mean Difference		1.61		11.84		13.45

The result presented in Table 1 show that inducto-deductive approach (experimental group) had a pre-test numerical aptitude mean score of 28.25 and a post-test numerical aptitude mean score of 68.16. The difference between the pre-test and post-test numerical aptitude mean score for inducto-deductive approach (experimental group) was 39.91. The Expository approach (control group) had a pre-test numerical aptitude mean score of 29.86 and a post-test numerical aptitude mean score of 56.32. The difference between the pre-test and post-test numerical aptitude mean score of for Expository approach (control group) is 26.46. For both inducto-deductive approach (experimental group) and the Expository approach (control group), the post-test numerical aptitude mean score was greater than the pre-test numerical aptitude mean score. This is indicative that inducto-deductive approach improved pupils' numerical aptitude. The standard deviation for the experimental group was 4.89 in the pre-test and increased to 9.81 in the post-test, indicating a broader spread of scores after instruction. The control group had a pre-test standard deviation of 6.01 and a post-test standard deviation of 8.54, showing an increase in variability. The statistical significance of this variation will be determined in testing Hypothesis 1 as presented in Table 2 below.

Hypotheses 1: There is no significant difference between the mean numerical aptitude scores of pupils taught mathematics with inducto-deductive approach (IDA) and those taught with Expository approach (EA).

Table 2: Analysis of Covariance (ANCOVA) of the numerical aptitude of pupils taught mathematics with inducto-deductive approach (IDA) and those taught with expository approach (EA).

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Decision
Corrected Model	8838.910 ^a	4	2209.727	25.848	.000	
Intercept	29857.105	1	29857.105	349.250	.000	
Pre-test_	26.811	1	26.811	.314	.576	
Group	8720.575	1	8720.575	102.008	.000	Sig.
Gender	54.861	1	54.861	.642	.424	Not Sig.
Group * Gender	234.300	1	234.300	2.741	.099	Not Sig.
Error	20602.883	241	85.489			
Total	998647.000	246				
Corrected Total	29441.793	245				

The result in Table 2 shows that an F-ratio of 102.008 with associated probability value of 0.000 was obtained with regards to the mean numerical aptitude score of pupils taught mathematics with inducto-deductive approach and those taught with expository approach. Since the associated probability (0.000) was less than 0.05, the null hypothesis (**H₀₁**) was rejected. Thus, there was a significant difference between the mean numerical aptitude score of pupils taught mathematics with inducto-deductive approach and those taught with expository approach. This implies that the use of inducto-deductive approach improves the mean numerical aptitude score of pupils in mathematics.

Research Question 2: What are the mean numerical aptitude scores of male and female pupils taught mathematics with IDA?

Table 3: Mean and Standard deviation of numerical aptitude scores of male and female pupils taught mathematics with IDA

Group	Gender	N	Pre-Test		Post-Test		Gained Mean
			Mean	SD	Mean	SD	
Experimental	Male	61	28.43	5.23	68.72	10.02	40.29
	Female	73	28.11	4.62	67.68	9.67	39.57
Mean Difference			0.32		1.04		0.72

The result presented in Table 3 show that the male pupils taught mathematics with inducto-deductive approach had a pre-test numerical aptitude mean score 28.43 with a standard deviation of 5.23 and a post-test numerical aptitude mean score 68.72 with a standard deviation of 10.02. The difference between the pre-test and post-test numerical aptitude mean score for male pupils is 40.29. The female pupils had a pre-test numerical aptitude mean score 28.11 with a standard deviation of 4.62 and a post-test numerical aptitude mean score 67.68 with a standard deviation of 9.67. The difference between the pre-test and post-test numerical aptitude mean score for female group is 39.57. For each of the two groups, the post-test numerical aptitude mean scores were greater than the pre-test numerical aptitude mean scores with male group having slightly higher numerical aptitude mean gain. This is an indication that inducto-deductive approach appears to have improved male pupils' numerical aptitude more than that of female. For the experimental group, the standard deviation of pre-test and post-test numerical aptitude scores for males were 5.23 and 10.02, while for females, it were 4.62 and 9.67 respectively. Whether this variation is statically significant or not will be confirmed when testing Hypothesis 2 (**H₀₂**) in Table 2.

Hypotheses 2: There is no significant difference in the mean numerical aptitude scores of male and female pupils taught mathematics with IDA.

The result for this hypothesis is presented in Table 2 above.

The result in Table 2 shows that an F-ratio of 0.642 with associated probability value of 0.424 was obtained with regards to the mean numerical aptitude score of male and female pupils in mathematics. Since the associated probability (0.424) was greater than 0.05, the null hypothesis (**H₀₂**) was not rejected. Thus, there was no significant difference in the mean numerical aptitude scores of male and female pupils taught mathematics with IDA. This implies that the use of IDA does not result in difference in the numerical aptitude score between male and female pupils in mathematics.

Hypotheses 3: There is no interaction effect of instructional approaches (IDA & EA) and gender on the mean numerical aptitude scores of pupils in mathematics.

The result for this hypothesis is presented in Table 2 above.

Table 2 further shows that there is no interaction effect of instructional approaches and gender on the mean numerical aptitude scores of pupils in mathematics $F(1, 241) = 2.741, P = 0.099 > 0.05$. Therefore, the null hypothesis was not rejected meaning that there is no interaction effect of instructional approaches and gender on the mean numerical aptitude scores of pupils in mathematics.

Discussion

The findings of this study revealed that the inducto-deductive approach significantly improved children's early numerical aptitude in mathematics compared to the traditional expository method. This aligns with previous studies that highlighted the effectiveness of the inducto-deductive approach in enhancing students' cognitive engagement and problem-solving skills (Narendra & Ajay, 2017; Jagat, 2020). By combining inductive reasoning, where pupils explore specific examples to discover general rules, and deductive reasoning, where they apply these rules to solve problems, the approach promotes deeper understanding and retention of mathematical concepts (Adhikari, 2020).

The study also showed that the inducto-deductive approach benefited both male and female pupils equally, as evidenced by the lack of significant gender differences in numerical aptitude scores. This finding is consistent with research by Ajai and Imoko (2015), who reported that effective teaching strategies could bridge gender gaps in mathematics performance. Moreover, the absence of an interaction effect between instructional approaches and gender further confirms the method's inclusiveness. This is a crucial insight, given the mixed results from earlier studies, with some suggesting that male students often outperform females in mathematics (Alordiah, Akpadaka, & Oviogboda, 2015). The findings suggest that when provided with an engaging and participatory instructional method, both genders can achieve comparable learning outcomes.

The improved numerical aptitude observed among pupils taught with the inducto-deductive approach could be attributed to its alignment with cognitive development theories. According to Piaget's theory, children at the concrete operational stage (typically ages 7-11) benefit from learning methods that involve active exploration and manipulation of concrete examples before moving to abstract concepts (Piaget, 1977). The inductive phase of this approach supports this developmental stage by allowing pupils to construct knowledge through observation and discovery. Similarly, Ausubel's meaningful learning theory emphasizes linking new knowledge to existing cognitive structures, which is effectively facilitated through the deductive phase of this approach (Adhikari, 2020).

These results have practical implications for mathematics education at the primary school level. The study supports the integration of the inducto-deductive approach into teaching practices to enhance early numerical aptitude and create a gender-inclusive learning environment. Curriculum developers and policymakers could use these insights to design instructional materials and teacher training programs that emphasize active learning and critical thinking. Overall, the study contributes to the body of knowledge on effective instructional strategies and underscores the potential of the inducto-deductive approach in promoting early mathematical competence among primary school pupils in Ebonyi North Education Zone and beyond.

Conclusion

The study concluded that inducto-deductive approach significantly improved children's early numerical aptitude in mathematics compared to traditional expository method. It was found that pupils taught with the inducto-deductive approach achieved higher numerical aptitude scores, and the method was equally effective for both male and female pupils, indicating no significant gender difference. Furthermore, there was no interaction effect between instructional method and gender, suggesting that the inducto-deductive approach offers an equitable and inclusive learning experience for all pupils. Therefore, the inducto-deductive approach is recommended as an effective strategy for enhancing early mathematics aptitude at the primary school level.

Recommendations

Based on the findings of this study, the following recommendations were made:

- i. Mathematics teachers at the primary school level should adopt inducto-deductive approach in teaching mathematics.
- ii. Training workshops and seminars should be organized to equip teachers with the necessary skills to effectively implement inducto-deductive approach in the classroom.
- iii. Curriculum planners and educational policymakers should integrate the inducto-deductive approach into mathematics curriculum.
- iv. Efforts should be made to eliminate gender stereotypes in mathematics education by promoting an environment where both boys and girls feel equally capable of excelling in mathematics.
- v. Ministry of Education and other relevant stakeholders should support schools by providing instructional resources and organizing professional development programs that emphasize innovative teaching strategies like inducto-deductive approach.

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