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Effect of Hands-on Activities on Numeracy Achievement in Mathematics among Public Primary School Pupils in Itu Local Government Area, Akwa Ibom State, Nigeria

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Abstract

This study examined the effect of hands-on activities on the numeracy achievement of ECC II pupils in public primary schools in Itu Local Government Area, Akwa Ibom State, Nigeria. A quasi-experimental pretest–posttest non-equivalent control group design was adopted. The sample comprised 152 pupils in six intact classes from six randomly selected schools; the experimental group (n = 72) received six weeks of hands-on numeracy instruction, while the control group (n = 80) was taught by the conventional method. Data were collected with a researcher-developed Numeracy Achievement Test (NAT; KR-20 = 0.80). Means and standard deviations answered the research questions, and analysis of covariance (ANCOVA) tested the hypotheses at the 0.05 level of significance. Pupils taught with hands-on activities significantly outperformed those taught conventionally in counting (mean gains of 5.47 against 0.68) and in addition (5.64 against 0.64), $p < .001$. Among pupils who received the treatment, school location (urban versus rural) made no significant difference to numeracy achievement ($p = .527$). Hands-on activities are therefore an effective strategy for early numeracy in both settings. Teachers should integrate hands-on activities and manipulatives into numeracy lessons, and education authorities should provide instructional materials and in-service training for their use.

Keywords: hands-on activities, numeracy achievement, early childhood education, manipulatives, school location, Nigeria

Introduction

Numeracy, the ability to understand, interpret and apply mathematical knowledge in varied contexts (Organisation for Economic Co-operation and Development [OECD], 2023), underpins logical reasoning, problem-solving and later academic success (Hidayah & Retnawati, 2024). Early mathematics skill is an especially strong signal: in a six-study analysis, mathematics skills at school entry predicted later achievement more strongly than reading or attention skills (Duncan et al., 2007). Yet foundational numeracy remains weak in many low- and middle-income countries, where an estimated 70 per cent of ten-year-olds lack foundational literacy and numeracy skills (World Bank, 2025), and gaps are already visible before formal schooling in Sub-Saharan Africa (Buhl-Wiggers et al., 2025). In Itu Local Government Area, many ECC II pupils perform poorly in counting, number recognition and basic arithmetic. This has been attributed to ineffective teaching methods, a shortage of instructional materials and limited opportunities for pupils to participate actively. Conventional numeracy teaching relies mainly on verbal explanation, chalkboard demonstration and recitation, with little or no use of concrete objects. Hands-on activities offer an alternative. They use concrete materials such as blocks, counters, beads and shapes to help learners grasp abstract mathematical ideas (Clements & Sarama, 2021). Three theories support the approach: Piaget (1952) holds that children construct knowledge by acting on objects; Vygotsky (1978) stresses guided, social learning within the zone of proximal development; and Skinner (1953) emphasises reinforcement and repeated practice. Empirically, a meta-analysis of 55 studies found small-to-moderate positive effects of manipulative-based instruction (Carbonneau et al., 2013), and a scoping review of 102 studies found gains in counting from curriculum-based mathematics programmes, although most studies were conducted in the United States (Byrne et al., 2023). In Nigeria, primary two pupils taught with a guided, activity-based scaffolding strategy achieved higher mathematics scores than those taught by lecture (Olota, 2015). The evidence also carries a caution: manipulatives help only when pupils understand what the objects represent (Uttal et al., 1997). Findings on school location are mixed. Rural students outperformed urban students after a games-and-simulations intervention in geometry (Ajai & Imoko, 2013), whereas school location moderated mathematics achievement in favour of urban pupils, who generally had better access to resources (Iroko et al., 2024). This suggests that the effect of location depends on teaching method and resource availability. This study, therefore, examined

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the effect of hands-on activities on the counting and addition skills of ECC II pupils in Itu Local Government Area, compared with conventional instruction, and whether numeracy achievement under hands-on instruction differed between urban and rural schools.

Research Objectives

The main objective of the study is to determine the effect of hands-on activities on numeracy achievement of ECC II pupils in Itu Local Government Area of Akwa Ibom State. Specifically, the study seeks to:

1. determine the mean difference in the counting ability of pupils exposed to hands-on activities and those exposed to conventional methods of instruction;
2. ascertain the mean difference in the addition ability of pupils exposed to hands-on activities and those exposed to conventional methods of instruction; and
3. examine the mean difference in numeracy achievement between urban and rural pupils exposed to hands-on activities.

Research Questions

1. What is the mean difference in the counting ability of pupils exposed to hands-on activities and those exposed to conventional methods?
2. What is the mean difference in the addition ability of pupils exposed to hands-on activities and those exposed to conventional methods?
3. What is the mean difference in numeracy achievement between urban and rural pupils exposed to hands-on activities?

Research Hypotheses

1. There is no significant mean difference in the counting ability of pupils exposed to hands-on activities and those exposed to conventional methods.
2. There is no significant mean difference in the addition ability of pupils exposed to hands-on activities and those exposed to conventional methods.
3. There is no significant mean difference in numeracy achievement between urban and rural pupils exposed to hands-on activities.

Research Methodology

This study adopted a quasi-experimental pretest–posttest non-equivalent control group design, in which random assignment of pupils is not possible (Campbell & Stanley, 1963). Intact classes served as the experimental and control groups. The independent variable was the method of instruction (hands-on activities versus conventional), the moderator was school location, and the dependent variable was numeracy achievement. The population comprised 761 ECC II pupils in 39 public primary schools in Itu Local Government Area (Source: Local Education Authority, Itu). Six schools were selected by simple random sampling, and one intact class in each gave a sample of 152 pupils: 72 in the experimental group (three schools) and 80 in the control group (three schools). Both urban and rural schools were represented. The instrument was the researcher-developed Numeracy Achievement Test (NAT). Section A collected personal data and Section B contained five tasks (counting, number writing, number identification, addition and subtraction), each scored out of 20 marks; this paper reports the counting and addition tasks and the total score. The same test served as pretest and posttest. Face and content validity were established by an early childhood education expert, a tests and measurement expert and an ECC II mathematics teacher. A pilot test on 20 pupils outside the sample gave a Kuder-Richardson Formula 20 reliability coefficient of 0.80. After permission was obtained from head teachers, trained research assistants helped to administer the pretest to both groups. For six weeks the experimental group was taught using counting objects, beads, blocks, number charts and interactive numeracy games, while the control group was taught the same concepts through explanation, demonstration and discussion without hands-on materials. The NAT was re-administered as a posttest in the seventh week. Informed consent was obtained, and pupils completed the test anonymously.

Data Analysis

Mean and standard deviation were used to answer the research questions, while analysis of covariance (ANCOVA) was used to test the hypotheses at the 0.05 level of significance. Pretest scores served as the covariate for the posttest scores. ANCOVA was chosen because it adjusts for initial differences between intact classes. The group with the higher mean gain was judged to have performed better. A null hypothesis was rejected if $p < .05$ and retained if $p > .05$.

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Presentation of Results

Research Question One

What is the mean difference in the counting ability of pupils exposed to hands-on activities and those exposed to conventional methods?

Table 1

Mean and Standard Deviation of Counting Scores of Pupils Taught with Hands-on Activities and Those Taught with the Conventional Method of Instruction (Each Skill Scored Out of 20)

Group	*N*	Pretest		Posttest		Mean Difference
		$\bar{X}$	*SD*	$\bar{X}$	*SD*	
Hands-on Activities	72	6.97	1.41	12.44	1.71	5.47
Conventional Method of Instruction	80	7.12	1.50	7.80	2.53	0.68

Table 1 shows the pretest and posttest means of the experimental group (hands-on activities) as 6.97 and 12.44, with standard deviations of 1.41 and 1.71 respectively. The control group (conventional method of instruction) had pretest and posttest means of 7.12 and 7.80, with standard deviations of 1.50 and 2.53 respectively. The comparison reveals a clear difference in counting mean scores between pupils taught with hands-on activities and those taught with the conventional method. Pupils exposed to hands-on activities recorded the higher mean gain (5.47 against 0.68).

Research Question Two

What is the mean difference in the addition ability of pupils exposed to hands-on activities and those exposed to conventional methods?

Table 2

Mean and Standard Deviation of Addition Scores of Pupils Taught with Hands-on Activities and Those Taught with the Conventional Method of Instruction (Each Skill Scored Out of 20)

Group	*N*	Pretest		Posttest		Mean Difference
		$\bar{X}$	*SD*	$\bar{X}$	*SD*	
Hands-on Activities	72	6.66	1.53	12.30	1.63	5.64
Conventional Method of Instruction	80	7.21	1.41	7.85	2.64	0.64

Table 2 shows the pretest and posttest means of the experimental group (hands-on activities) as 6.66 and 12.30, with standard deviations of 1.53 and 1.63 respectively. The control group (conventional method of instruction) had pretest and posttest means of 7.21 and 7.85, with standard deviations of 1.41 and 2.64 respectively. Pupils taught addition with hands-on activities therefore recorded a much higher mean gain (5.64) than those taught with the conventional method (0.64).

Research Question Three

What is the mean difference in numeracy achievement between urban and rural pupils exposed to hands-on activities?

Table 3

Mean and Standard Deviation of Numeracy Achievement Scores of Urban and Rural Pupils Taught with Hands-on Activities (Total Score Out of 100)

Location	*N*	Pretest		Posttest		Mean Difference
		$\bar{X}$	*SD*	$\bar{X}$	*SD*	
Urban	45	34.64	3.32	61.68	3.23	27.04
Rural	27	35.22	3.17	62.25	4.06	27.03

Table 3 shows that urban pupils had a pretest mean of 34.64 (*SD* = 3.32) and a posttest mean of 61.68 (*SD* = 3.23), with a mean gain of 27.04. Rural pupils had a pretest mean of 35.22 (*SD* = 3.17) and a posttest mean of 62.25 (*SD* = 4.06), with a mean gain of 27.03. For both groups, posttest means were higher than pretest means, and the two groups gained almost identically.

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Hypothesis One

There is no significant mean difference in the counting ability of pupils exposed to hands-on activities and those exposed to conventional methods.

Table 4

Analysis of Covariance (ANCOVA) of Counting Scores of Pupils Taught with Hands-on Activities and Those Taught with the Conventional Method of Instruction

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.
Corrected Model	826.478[a]	2	413.239	87.026	< .001
Intercept	494.576	1	494.576	104.155	< .001
Pretest	9.055	1	9.055	1.907	.169
Method of Instruction	824.211	1	824.211	173.574	< .001
Error	707.522	149	4.748		
Total	16734.000	152			
Corrected Total	1534.000	151			

Note. [a]R^2 = .539 (Adjusted R^2 = .533).

Table 4 shows an *F*-ratio of 173.574 (*df* = 1, 149), $p < .001$, for the difference in counting mean scores between pupils taught with hands-on activities and those taught with the conventional method of instruction. Since $p < .05$, the null hypothesis was rejected. This indicates a significant difference in counting mean scores, with hands-on activities being more effective (partial $\eta^2 = .54$). The pretest covariate was not significant ($p = .169$), confirming that the groups were comparable at the outset.

Hypothesis Two

There is no significant mean difference in the addition ability of pupils exposed to hands-on activities and those exposed to conventional methods.

Table 5

Analysis of Covariance (ANCOVA) of Addition Scores of Pupils Taught with Hands-on Activities and Those Taught with the Conventional Method of Instruction

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.
Corrected Model	782.867[a]	2	391.434	79.446	< .001
Intercept	535.456	1	535.456	108.677	< .001
Pretest	6.949	1	6.949	1.410	.237
Method of Instruction	776.570	1	776.570	157.614	< .001
Error	734.126	149	4.927		
Total	16697.000	152			
Corrected Total	1516.993	151			

Note. [a]R^2 = .516 (Adjusted R^2 = .510).

Table 5 shows an *F*-ratio of 157.614 (*df* = 1, 149), $p < .001$, for the difference in addition mean scores between pupils taught with hands-on activities and those taught with the conventional method of instruction. Since $p < .05$, the null hypothesis was rejected. This indicates a significant difference in addition mean scores, with hands-on activities being more effective (partial $\eta^2 = .51$). The pretest covariate was not significant ($p = .237$).

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Hypothesis Three

There is no significant mean difference in numeracy achievement between urban and rural pupils exposed to hands-on activities.

Table 6

Analysis of Covariance (ANCOVA) of Numeracy Achievement Scores of Urban and Rural Pupils Taught with Hands-on Activities

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.
Corrected Model	5.897[a]	2	2.949	0.229	.796
Intercept	2275.016	1	2275.016	176.691	< .001
Pretest	0.407	1	0.407	0.032	.859
Location	5.194	1	5.194	0.403	.527
Error	888.422	69	12.876		
Total	276795.000	72			
Corrected Total	894.319	71			

Note. [a]R^2 = .007 (Adjusted R^2 = −.022).

Table 6 shows an *F*-ratio of 0.403 (*df* = 1, 69), *p* = .527, for the difference in numeracy achievement mean scores of urban and rural pupils taught with hands-on activities. Since *p* > .05, the null hypothesis was retained. This indicates no significant difference in numeracy achievement between urban and rural pupils.

Discussion of Findings

The results revealed that hands-on activities produced significantly higher achievement than the conventional method in both counting and addition, with large effects in each case. This is consistent with meta-analytic evidence that manipulative-based instruction improves mathematics learning (Carbonneau et al., 2013), with evidence that hands-on mathematics programmes improve counting in young children (Byrne et al., 2023), and with Olota's (2015) Nigerian findings on guided, activity-based instruction. The study's three theories offer plausible explanations. In line with Piaget (1952), handling counters and beads gave pupils concrete experiences from which to build number concepts. In line with Vygotsky (1978), teacher modelling and peer discussion probably scaffolded tasks that pupils could not yet complete alone. In line with Skinner (1953), repeated practice with immediate feedback reinforced correct responses. By contrast, the control group, taught by explanation and demonstration alone, gained less than one point on average. Because manipulatives help only when pupils understand what they represent (Uttal et al., 1997), and because the type of material matters (Petersen & McNeil, 2013), these benefits depend on how activities are structured and guided, not on materials alone. The absence of a location difference suggests that hands-on teaching works similarly in urban and rural classrooms. The activities relied on simple materials, such as counters, beads, blocks and improvised aids, which schools in either setting can obtain or make. This is in line with Ajai and Imoko's (2013) conclusion that the choice of method can outweigh the effect of location, although it contrasts with the urban resource advantage reported by Iroko et al. (2024). Because location was compared only among pupils who received the treatment, the study cannot show whether hands-on teaching narrows a gap that exists under conventional teaching.

Conclusion

Hands-on activities significantly improved the counting and addition skills of ECC II pupils in Itu Local Government Area compared with conventional instruction, and the benefit did not depend on whether pupils attended urban or rural schools. The strategy offers a practical response to weak early numeracy where teaching has relied on verbal explanation and chalkboard demonstration. The study used intact classes, a six-week treatment and no delayed posttest, so the lasting effect of the gains remains unknown.

Recommendations

1. ECC II teachers should integrate hands-on activities into daily numeracy lessons, using counters, beads, blocks, number cards and locally available or improvised materials.
2. The State Universal Basic Education Board (SUBEB) and curriculum planners should include hands-on numeracy activities in the early childhood curriculum and supply manipulatives to urban and rural schools.

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3. Education authorities should organise regular workshops and in-service training on structuring and guiding hands-on activities, and colleges of education should include these methods in pre-service programmes.

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