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Instructional Manipulatives and Students' Academic Performance and Retention in Mathematics in Mkpat Enin Local Government Area of Akwa Ibom State, Nigeria

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Abstract
This study investigated the effect of instructional manipulatives on JSS2 students' academic performance and retention in mathematics in Mkpat Enin Local Government Area of Akwa Ibom State. The study adopted a quasi-experimental pretest-posttest control group research design. Sample for the study consisted of 97 JSS2 students randomly drawn from two schools in Mkpat Enin Local Government Area. The instrument used for data collection was a Mathematics Performance Test (MAT) with a reliability coefficient of 0.87. The experimental group was taught the concept of 3-dimensional geometric shapes using instructional manipulatives while the control group, on the other hand, was taught same without using manipulatives. Analysis of Covariance (ANCOVA) was used for data analysis. The three hypotheses were tested at 0.05 level of significance. The results revealed that the experimental group performed and retained concepts taught significantly better than the control group. However, there was no significant mean difference in the performance of the experimental group based on gender. Based on the findings of the study, it was recommended that Mathematics teachers should endeavour to always utilize instructional manipulatives in teaching concepts in Mathematics in Junior Secondary Schools in Mkpat Enin Local Government Area of Akwa Ibom State.
Keywords: instructional, manipulatives, academic, performance, retention

Introduction
Mathematics probably started with the early man's attempt to keep track of his belongings. For example he would want to know how many arrow-heads he had, how

many wives he had, how many people there were in his household after children had been born and other members had died. He probably wanted to know how many chicken he now had after the last hatching. This humble beginning of Mathematics then gave rise to counting of numbers which are basic to mathematics concept development. Mathematics as a discipline is an indispensable tool in the study of science, technology and humanities (Udo, 2015). The study of Mathematics helps one's understanding of the world around him or her through the instrumentality of symbols and abstract representation of concepts. Knowledge in Mathematics is applied in almost every school subject. In Nigeria, Mathematics features prominently as one of the core subjects in the entire curricula of nursery, primary and secondary schools, even in year one of higher institutions. Mathematics serves as one of the critical filters for selection into higher educational programmes.

Despite the recognition accorded to Mathematics, Elekwa (2010) remarked that students exhibit nonchalant attitude towards Mathematics, even when they know that they need it to forge ahead in their studies and in life. Such students who have already conditioned their minds that Mathematics is the most difficult subject are usually not serious in the learning of Mathematics; hence they perform poorly in Mathematics tests and examinations. As important as Mathematics is in human development, many investigations have shown that students in secondary schools are still not performing satisfactorily well in Mathematics. Also, available records indicate unsatisfactory Mathematics performance of students in the West African School Certificate Examination (WASCE) and National Examination Council (NECO) examination.

The Chief Examiners' Reports of West African Examinations Council for the past few years have highlighted students' weakness in solving problems in Mathematics (WAEC Chief Examiners' Report, 2016, 2017, 2018, 2019, 2020). Some of the persistent weaknesses as identified by the Chief Examiner are in the areas of drawing graphs and reading from them, mensuration, distances and bearings, graphical solutions to quadratic equations, geometry circle theorems and plane geometry, measures of dispersion inter quartile range, circle geometry and its applications, geometrical constructions, and mensuration of compound shapes.

This poor performance of students is further worsened by gender imbalance, which now constitutes a major research focus across the globe (UNESCO, 2003). For full realization of the laudable objectives of mathematics education, subject mastery and demonstrated achievement should be evenly distributed across gender. Unfortunately, gender inequality in education has remained a perennial problem of global scope (Bordo, 2011; UNESCO, 2003; Reid, 2003). Gender and academic performance in Mathematics exist in different views and findings. Though the issue of gender inequality in science, technology, and Mathematics education (STME) has produced inconclusive results, it is believed that bridging gender gap is one of the major ways of achieving egalitarianism and enhancing human development. There is need therefore to give boys and girls the same opportunities and challenges. Attempts to find solution to gender disparity and the incessant failure rates

of students have made researchers in Mathematics education to consider a number of factors. One of the factors, as examined in this study, is that of appropriate instructional materials for teaching.

Evidence abound that many non-professional and inexperienced teachers present topics in Mathematics to the students in ways that students find it difficult to grasp some Mathematics concepts (Iji, 2002; Onose, 2007). Many teachers cling to traditional methods in which answers to previous day's homework are first given, then teacher-directed explanations are used to present materials for the new lesson (Odili, 2006). The ability to critically understand and retain information is therefore not developed in students. It is one thing to teach Mathematics using an appropriate method and another for the learner to remember it after some reasonable period must have elapsed; this is what is called retention.

Retention, according to Denga, Osim and Udoh (2009), is the process of keeping knowledge over time. It is the ability of an organism to store, retain, and recall information. The human mind acquires the materials of knowledge through sensation and perceptions. Whenever a stimulating situation occurs, retained images are revived or reproduced to make recall possible (Kundu & Tutoo, 2002). This implies that any pedagogical strategy adopted to improve achievement should be able to improve students' retentive ability in the subject. This is because retention in Mathematics is not acquired by mere memorization but through an appropriate teaching approach. Since performance in Mathematics depends on ability to retain learnt materials longer, any effort to tackle the problem of poor performance in Mathematics may not be meaningfully effective if students' retentive ability is not taken into consideration.

Onose (2007) states that the teaching and learning of Mathematics requires the discovery of innovative approaches that will promote knowledge retention, which in turn enhances better achievement. According to Onose (2007), the teaching of Mathematics should involve activities that give room for students to think or reason about what they are doing in order to look for relationships, which may enlarge and build a store of Mathematical techniques. This is why the use of manipulatives as instructional materials is considered in this study as such innovative, hands-on teaching aids that Mathematics teachers should adopt for effective teaching and learning of Mathematics.

Manipulatives are often dynamic visual and pictorial replicas of physical manipulatives (such as pattern blocks, base-10 blocks, geometric solids, tangrams, or geoboards). They are hands-on objects that the students can touch, hold, feel and play with in the course of instruction. Manipulatives are very important instructional materials that can be used to enhance the interest of students in learning Mathematics. Lack of teachers' presentation of learning activities in the form of manipulatives has been shown to be prevalent and also to cause reduced achievement in Mathematics (Umeh, 2006).

Manipulatives in teaching/learning environments are very vital tools in education. They aid teaching and learning and include everything that provides information to the teacher as well as the learner. They make learning real and imprint a lifelong experience in the memory of the student. The teaching and learning of Mathematics requires an intensive application of manipulative resources that will appeal to the sense of perception to improve the effectiveness of instruction as well as learning. Akinsola (2010) stated that teaching and learning of Mathematics can only be meaningful and effective if supported by necessary hands-on activities to enrich instruction. This is the reason why selection of appropriate instructional gadgets for a particular concept in classroom instruction is an important routine that a resourceful teacher should undertake in lesson preparation (Adedibu & Olayiwola, 2006).

Rowly (2020) investigated the effect of Math manipulatives in the classroom. The study was a quantitative study of the correlation between students' achievement and the use of individual Math toolkits. The sample for the study was made up of students and teachers. In this study, students with individual toolkits comprised of many manipulatives from their programme of study were followed over a nine-week period. Students had access to manipulatives and exhibit voice and choice when choosing manipulatives to help make meaningful math connections. Students were given a pretest in which percentages are compared and cross-referenced with a log of daily toolkit use. Teachers were also surveyed about toolkit promotion during the course of nine-week study. The findings of the study indicated that the use of manipulatives had a positive effect on students' learning in Math classrooms.

Still on the impact of manipulatives, Ngozi et al. (2020) conducted a study to establish the effect of virtual manipulatives on pupils' achievement and attitude to Mathematics in Owerri Municipal Council of Imo State, Nigeria. Quasi experimental research design was used. A sample size of 214 primary six pupils was used for the study. Three research questions and two hypotheses were postulated to guide the study. The instrument used for data collection was the researchers-made Mathematics achievement test (MAT). Mean and standard deviation were used to answer the research questions, while ANCOVA was used to test the hypotheses at 0.05 level of significance. The results of the study revealed that virtual manipulatives are effective strategy for teaching and learning geometry. Gender was not a barrier to achievement. Based on the result, it was recommended that Mathematics teachers should adopt innovative technology in teaching Mathematics at the primary school level.

Furthermore, Kontas (2016) researched on the effect of manipulative on Mathematics achievement and attitudes of secondary school students towards Mathematics in the Southeastern Region of Turkey. Pretest-posttest control group experimental model, which is one of the quasi-experimental research designs, was used in the study. The study group consisted of 48 seventh grade students (24 in the experiment group and 24 in the control group) studying in a state school in the Southeastern Region of Turkey in 2014-2015 school year. Mathematics achievement test and Mathematics attitude scale were used to

collect the research data. The findings indicated that manipulatives were effective in increasing achievement scores of the experiment group significantly. The scores of attitude towards Mathematics for the experimental and control groups were significantly different in the post-tests, which was in favour of the experimental group.

Okri, Obi, and Allahoki (2021) examined the effect of the collaborative instructional strategy on students' academic achievement in Mathematics in Calabar education zone of Cross River State. The study was guided by three research questions and three null hypotheses. The study adopted a quasi-experimental research design using pre-test and post-test control group design involving intact classes. A sample of eighty-five (85) students was used for the study. The study made used of two instruments: first was non-cognitive and involved the design of two instructional strategies which were collaborative instructional strategies (CIS) and the conventional traditional method (CTM), and a Mathematics Achievement Test (MAT) which was made up of 25 essay questions designed specifically to measure the achievement of students in some units of instructions in Mathematics. Data collected were subjected to statistical analysis using ANCOVA, independent t-test and mean and standard deviation. The findings of the study showed that collaborative instructional strategies had significant effect on students' academic achievement in Mathematics.

Effective teaching requires a thorough understanding of the learning process, characteristics of students at different stages of development, individual differences, and factors that influence retention, all of which relate to improved achievement. It is in the light of the foregoing that the present study explored the effect of instructional manipulatives on students' academic performance and retention in Mathematics in Mkpat Enin Local Government Area of Akwa Ibom State, Nigeria.

Statement of the problem

Many children struggle to learn Mathematics and often do not achieve success through their learning. This may stem from the fact that they do not construct appropriate understanding of fundamental Mathematics concepts through their learning strategies. This has left students with poor performance in both public and terminal examinations. The problem of students' poor performance in Mathematics is a major one that requires urgent and serious attention. The teaching and learning of Mathematics in Nigeria has been characterized by many differing viewpoints about the necessity of different types of reforms and methods in its teaching. Most researches in Mathematics education have dealt with curriculum issues, teaching effectiveness and the use of student-friendly instructional materials. One therefore wonders why all the methods used so far, have not been able to reverse the ugly trend of poor performance. Thus, this study was an attempt to see if instructional manipulatives could be used to remedy the problem of poor performance of students in Mathematics education in Nigerian secondary schools. It is in view of the foregoing, that the problem of this study posed the question: what is the effect of instructional manipulatives on students' academic performance and retention in Mathematics?

Purpose of the study

The main purpose of this study was to investigate the effects of instructional manipulatives on students' academic performance in Mathematics in Mkpat Enin Local Government Area, Akwa Ibom State. Specifically, the study sought to:

1. Determine the difference in the mean performance scores of students in Mathematics when taught using instructional manipulatives and when taught without using them.
2. Ascertain the difference in the mean performance scores of male and female students in Mathematics when taught using instructional manipulatives and when taught without using them.
3. Examine the difference in the mean retention scores of students in Mathematics when taught using instructional manipulatives and when taught without using them.

Research questions

The following research questions guided the study:

1. What is the difference in mean performance scores of students in Mathematics when taught using instructional manipulatives and when taught without using them?
2. What differences exist in the mean performance scores of male and female students in Mathematics when taught using instructional manipulatives and when taught without using them?
3. What is the difference in the mean retention scores of students in Mathematics when taught using instructional manipulatives and when taught without using them?

Hypotheses

The following null hypotheses were formulated for this study:

Ho1: There is no significant difference in the mean performance scores of students in Mathematics when taught using instructional manipulatives and when taught without them.

Ho2: There is no significant difference in the mean performance scores of male and female students in Mathematics when taught using instructional manipulatives and when taught without them.

Ho3: There is no significant difference in the mean retention scores of students in Mathematics when taught using instructional manipulatives and when taught without them.

Methodology

The research design employed in the study is the quasi-experimental pretest-posttest control group design. The population for the study consisted of all junior secondary II students in all the public secondary schools in Mkpat Enin Local Government Area. Presently, there are 16 public secondary schools with a total enrolment of 1,935 JSS 2 students in Mkpat Enin LGA (Local Education Authority, 2018/2019). In deriving the sample for this study, simple random sampling technique was used. From the population of 16 public secondary schools, two schools were randomly selected using balloting. From each of the schools selected, one school was assigned to be taught using instructional

manipulatives while the other school was assigned to be taught without using instructional manipulatives. One arm of JSS 2 intact class in each of the school was randomly drawn to obtain sample for the study. At the end of the instructional process, all JSS 2 students found in each of the intact class became sample for the study. A total of 97 students comprising of male and female were found as sample in the two intact classes of the two schools selected for the study. Since coeducational schools were used for the study, each gender representation was ensured, as each intact class is made up of male and female students.

Researchers-made instrument tagged Mathematics Performance Test (MPT) was employed for obtaining data for the study. MPT consisted of sections A and B. Section A was on demography. Section B consisted of twenty multiple choice items with four options, one option being correct and the other three distractors. Each correct response was awarded one mark. The MPT was used to measure students' academic performance and retention in Mathematics when taught the concept of 3-dimensional geometric shapes. The MPT was validated by two experts in science education and Measurement and Evaluation; it was further subjected to Kuder Richardson (KR-20) reliability estimate to ascertain its internal consistency. A reliability coefficient of 0.87 was obtained; thus showed high level of internal consistency. It was considered reliable enough to be used for data collection in this study. The MPT was administered to students as pretest, posttest and retention test after successive reshuffling so as to measure students' retention.

The teachers teaching Mathematics in the selected schools were used as research assistants. They were trained for two days each and were provided with detailed instructions and lesson packages for the experimental and control groups respectively. The lesson package for the experimental group was designed using instructional manipulatives while the control group lesson package was without instructional manipulatives. The two groups of students were administered the MPT as pretest before treatment started. The experimental group was taught the concept of 3-dimensional geometric shapes using instructional manipulatives while the control group was taught without using instructional manipulatives. However, after the actual teaching which lasted for two weeks of six periods, the MPT was administered as post-test though reshuffled. The pre-test scores constituted the covariance of the post-test scores. Researchers allowed a gap of two weeks in order to find out if the knowledge gained is retained. The MPT was then reshuffled and administered as retention test to measure students' retention in each of the groups. The MPT was collected, scored and used for analysis. The research questions were answered using mean and standard deviation scores while the hypotheses were tested at .05 probability level using Analysis of Covariance (ANCOVA).

Presentation of results
The research questions were answered using mean, standard deviation and mean gain.

Research question one: What is the difference in the mean performance scores of students in Mathematics when taught using instructional manipulatives and when taught without them?

Table 1: Mean and standard deviation of students' performance pretest posttest scores based on instructional resources

Instructional Resources	N	Pretest Mean	SD	Posttest Mean	SD	Mean Gain
With manipulatives	49	7.5	2.6	16.3	2.2	8.8
Without manipulatives	48	7.9	2.3	12.7	2.0	4.8

Table 1 showed that the mean gain performance scores (8.8) of students taught the concept of 3-dimensional geometric shapes using instructional manipulatives was greater than the mean gain performance scores (4.8) of those taught without using instructional manipulatives. This implies that students taught the concept of 3-dimensional geometric shapes using instructional manipulatives benefited more and scored higher than those that were taught without them. Hence, the use of instructional manipulatives has proven to be an effective teaching and learning resource in enhancing students' performance in Mathematics when taught the concept of 3-dimensional geometric shapes.

Ho1: There is no significant difference in the mean performance scores of students in Mathematics when taught using instructional manipulatives and when taught without them.

Table 2: ANCOVA result on students' pre-test post-test performance scores in Mathematics based on instructional resources

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Pretest	20.400	1	20.400	5.538	.021^{S}
Methods	329.525	1	329.525	89.454	.000^{S}
Gender	51.787	1	51.787	14.058	.000
Methods*Gender	.129	1	.129	.035	.852^{NS}
Error	338.904	92	3.684		
Total	21089.000	97			
Corrected Total	738.227	96			

S= Significant at .05 level of significance
NS= Not significant at .05 level of significance
As shown in table 2, the analysis of pretest scores of the two groups of students taught the concept of 3-dimensional geometric shapes, using instructional manipulatives and when

taught without them is significant, since the calculated p-value (.021) is less than the significant level (.05): indicating the groups were not comparable. The comparability of the two groups is, however, addressed by analysis of covariance that regressed the pretest and posttest scores of students taught the concept of 3-dimensional geometric shapes using instructional manipulatives and when taught without them. The table also showed that the calculated p-value (.000) of Methods was less than the alpha level (.05). Therefore, the null hypothesis was rejected. This implied that there was a significant difference in the mean performance scores of students in Mathematics when taught the concept of 3-dimensional geometric shapes, using instructional manipulatives and when taught without them. Thus, the mean difference earlier observed was statistically significant at .05 probability level.

Research question two: What differences exist in the mean performance scores of male and female students in Mathematics when taught using instructional manipulatives and when taught without them?

Table 3: Mean and standard deviation of male and female students' pre-test post-test performance scores based on instructional resources

Instructional Resources	**Gender**	**N**	**Pretest Mean**	**SD**	**Posttest Mean**	**SD**	**Mean Gain**
With manipulatives	Male	24	7.8	2.6	17.1	2.3	9.3
	Female	25	7.2	2.5	15.5	1.8	8.3
Without manipulatives	Male	23	8.0	2.4	13.4	2.3	5.4
	Female	25	7.8	2.2	12.0	1.5	4.2

As shown in table 3, the mean gain performance scores (9.3 and 8.3) of male and female students taught the concept of 3-dimensional geometric shapes using instructional manipulatives were greater than the mean gain performance scores (5.4 and 4.2) of male and female students taught without them. This implies that male and female students taught with instructional manipulatives had better understanding of the concept of 3-dimensional geometric shapes, thereby doing better in their performance than their counterpart taught without using instructional manipulatives. Manipulatives have been shown to be a gender friendly teaching/learning resource, thus, enhancing both male and female students' performance when taught the concept of 3-dimensional geometric shapes in Mathematics.

Ho2: There is no significant difference in the mean performance scores of male and female students in Mathematics when taught using instructional manipulatives and when taught without them.

Table 2 also revealed that analysis of the pretest scores of male and female students taught the concept of 3-dimensional geometric shapes using instructional manipulatives and those taught without them was significant, since the calculated p-value (.021) was less

than the significant level (.05), indicating the groups were not comparable. The comparability of the two groups was however addressed by analysis of covariance that regressed the pretest and posttest scores of male and female students taught the concept of 3-dimensional geometric shapes using instructional manipulatives and those taught without them. The table also showed that the calculated p-value (.852) of methods on gender was greater than the alpha level (.05). Therefore, the null hypothesis was retained. This implied that there was no significant difference in the mean performance scores of male and female students in Mathematics when taught the concept of 3-dimensional geometric shapes using instructional manipulatives and when taught without them. Hence, both gender benefited from the instructional resources use in teaching.

Research question three: What is the difference in the mean retention scores of students in Mathematics when taught using instructional manipulatives and when taught without them?

Table 4: Mean and standard deviation of students' retention score on instructional resources

Instructional Resources	**N**	**Retention Test**	
		Mean	**SD**
With manipulatives	47	16.5	2.2
Without manipulatives	48	15.8	2.4

Result of analysis as shown in table 4 revealed that the mean retention scores (16.5) of students taught the concept of 3-dimensional geometric shapes using instructional manipulatives was higher than the mean retention scores (15.8) of those taught without them. This implied that students taught using instructional manipulatives had a more retentive memory of the concept of 3-dimensional geometric shapes than those that were taught without using instructional manipulatives. Hence, the use of instructional manipulatives had proven to be an effective teaching and learning resource in enhancing students' retention in Mathematics on the concept of 3-dimensional geometric shapes.

Ho3: There is no significant difference in the mean retention scores of students in Mathematics when taught using instructional manipulatives and when taught without them.

Table 5: ANCOVA result on students' post-test retention scores in Mathematics based on instructional resources

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Posttest	.021	1	.021	.006	.940^{NS}
Methods	26.663	1	26.663	4.228	.042^{S}
Error	655.896	94	6.307		
Total	19901.000	97			
Corrected Total	709.514	96			

S = significant at .05 level of significance

As shown in table 5, the analysis of post-test scores of the two groups of students, taught the concept of 3-dimensional geometric shapes using instructional manipulatives and when taught without them, is not significant since the calculated p-value (.940) is greater than the significant level (.05), indicating the groups were comparable. However, comparability of the two groups is also addressed by analysis of covariance that regressed the post-test and retention scores of students taught the concept of 3-dimensional geometric shapes using instructional manipulatives and those taught without them. The table also showed that the calculated p-value (.042) of Methods was less than the alpha level (.05). Therefore, the null hypothesis was rejected. This implied that there was a significant difference in the mean retention scores of students in Mathematics when taught the concept of 3-dimensional geometric shapes using instructional manipulatives and when taught without them. Hence, the use of instructional manipulatives significantly enhanced students' retention ability when compared with students that were taught without the use of instructional manipulatives.

Discussion of the findings

This study examined the effects of use of instructional manipulatives on students' academic performance and retention taught 3-dimensional geometric shapes. The findings of the study revealed a significant difference between the mean performance and retention scores of students taught 3-dimensional geometric shapes using instructional manipulatives and those taught same without using instructional manipulatives. Hence, students taught 3-dimensional geometric shapes using instructional manipulatives had higher performance and retention scores than their counterparts taught same without using instructional manipulatives. This finding agreed with the findings of Rowly (2020) and Kontas (2016) who in their study indicated that the use of manipulatives had positive effect on students' learning in the Math classroom. Students taught with manipulatives were superior in terms of performance than those taught without them.

The findings of this study also revealed that there was no statistically significant difference between male and female students' academic performance in 3-dimensional geometric shapes taught using instructional manipulatives and those taught without using instructional manipulatives. This implies that gender, with instructional methods, had no

significant effects on students' performance in Mathematics. Thus, both male and female students' academic performance in Mathematics was enhanced equally when taught using instructional manipulatives. This finding agreed with the findings of Ngozi et al. (2020) who found, in a similar study, that gender was not a barrier to students' academic achievement in Mathematics when taught using virtual manipulatives.

Conclusion

Based on findings of the study, it was concluded that manipulatives are better instructional resources for learning and teaching Mathematics. This implies that they were viable instructional resources in enhancing students' academic performance and retention in Mathematics. Manipulatives can be conveniently used to promote and foster students' motivation to learn and consequently improve their academic performance in Mathematics irrespective of their gender.

Recommendations

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

1. Mathematics teachers should be encouraged to incorporate the use of manipulatives while teaching; this will help students learn independently and as well share ideas among themselves for better learning outcomes.
2. Government and other relevant stakeholders in education should provide in service training to Mathematics teachers on how to use good instructional materials to teach and enhance students' cognitive ability in Mathematics.

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