Effects of Concrete Manipulative and Lecture Approaches on Mathematics Students' Academic Achievement in Delta North Senatorial District

ENUMA, Obielumani Peace
Department of Science Education, Faculty of Education,
Delta State University, Abraka

Dr. S. B. Ijeh
Department of Science Education, Faculty of Education,
Delta State University, Abraka

DOI: 10.56201/ijee.v10.no2.2024.pg161.172

Abstract
The study examined how using concrete manipulative and lecture approaches impacted students' achievement in mathematics in Delta North Senatorial District. The study employed a 2x2 factorial pretest, posttest planned variation quasi-experimental design. 5,813 SSII students made up the study's population. The study utilised a sample of 357 students from intact classes in six secondary schools located in the Delta North Senatorial District. Mathematics Achievement Test (MAT) was used for data gathering. The MAT's content validity was assessed using a table of specification. Three specialists did the assessment of facial validity. The construct validity was confirmed through the evaluation of difficulty and discriminating indicators. The reliability of the MAT was evaluated using the Kuder-Richardson 21, which produced a reliability coefficient of 0.86. The administration of the MAT involved two independent phases: pretest and posttest. The collected scores were using t-tests and ANCOVA. The study found a substantial difference in the average achievement scores of students who learned mathematics through concrete manipulatives compared to those who were taught through lectures. The results showed a preference for using the concrete manipulative method. There was no statistically significant difference in the mean achievement scores between male and female students who were taught mathematics using concrete manipulatives. The study found that using concrete manipulatives in mathematics led to greater improvements in students' achievement compared to traditional lecture-based methods. Mathematics educators were advised to apply a pedagogical method that incorporates concrete manipulatives during mathematics teaching.

Keywords: *Concrete Manipulative Approach, Lecture Approach, Academic Achievement, Sex*

Introduction

Every nation teaches mathematics in her schools with the hope of developing their industrial and technological sectors. Mathematics is also beneficial in practically every vocation and in more advanced specialised courses of study. The field of mathematics has evolved through the process of abstraction and logical reasoning, stemming from activities such as counting, estimating, measuring and evaluating the shapes and movements of concrete entities. In light of its significance and usefulness in daily life as well as the fact that it serves as a launching pad for a variety of future occupations, mathematics should be taught at both the basic and secondary levels of education (Umameh, 2011).

Mathematics is regarded as the mother of all subjects, with other subjects in the arts and sciences deriving their principles from it (Ijeh, 2022). It's also an international language that is essential in almost every area, including money handling, fashion and carpentry measurements, technical economics, and so on. Mathematics is also known as the "queen" of all sciences, including chemistry, physics, biology, economics and others ((Ijeh, 2014). Mathematics is a scientific discipline that involves the organisation and logical analysis of arguments. It can be employed to ascertain the veracity of a notion, or at the very least, its plausibility as a cognitive framework, as it offers valuable insights into the cognitive capabilities of the human mind and presents a stimulating proposition for intellectual inquisitiveness (Habtamu, 2017). In modern civilizations, the acquisition of mathematical knowledge has become essential in order to properly navigate the rapid advancements in science and technology. The justification for incorporating mathematics into the school curriculum as a fundamental subject for all students of school age stems from its substantial impact on human existence. Mathematics equips individuals with essential mathematical abilities that are crucial for navigating and addressing the obstacles encountered in various aspects of life.

Despite the significance attributed to mathematics, students continue to exhibit poor performance in external examinations, such as WASSCE. In the year 2016, a nationwide enrollment of 1,543,974 students was recorded. A total of 807,780 students successfully earned credit in the subject of mathematics. This figure corresponds to 52.97% of the overall student population. In 2017, the pass percentage for mathematics among students was recorded at 59.22% (923,486), out of a total of 1,471,151 students who had registered for the examination. In the year 2018, a total of 1,572,396 students registered for the examination. Out of this number, 786,016 students, which is approximately 49.98%, achieved a credit mark in mathematics. In the year 2019, a significant proportion of candidates, specifically 1,309,570 individuals, achieved a credit in mathematics, accounting for around 82.04% of the total number of candidates who had enrolled for the examination, which amounted to 1,596,161 individuals. In 2020, 1,003,668 students representing 65.24 percent, obtained credit in mathematics out of the 1,456,727 students that registered for the examination. 79.7% (1,243,470 students) and 76.36% (1,222,505 students) obtained credit in mathematics in 2021 and 2022, out of 1,560.470 and 1,601,047 students that sat for the exam respectively. Continuous efforts are needed to tackle the problem of kids' underperformance in

mathematics. The present study was conducted as a reaction to the researcher's endeavours to address the high incidence of academic underachievement.

The elements that influence students' academic achievement have been categorised into three main groups; teachers' factor, schools' factor and students' factor (Suleiman & Hammed, 2019; Ozofor & Onos, 2018). The researcher interest is keenly on teachers' factor. The researcher is of the opinion that the teachers' factor is very critical. This is because the teacher is main actor in the implementation of the mathematics curriculum. For effective and efficient implementation of the mathematics curriculum, the teacher adopts variety of teaching methods depending the nature of the topic, objective of the lesson and level of students among others. The degree of success in implementation is heavily contingent upon the suitability of the instructional approach employed by the educator.

From personal observation, most secondary schools' teachers, adopt the conventional lecture approach. The lecture method is an instructional approach characterised by instructor control and an emphasis on imparting information, with teachers assuming the role of learning facilitators within the classroom setting. This pedagogical approach involves a one-way communication pattern, in which the teacher assumes the role of the primary speaker and the students adopt a passive listening position. Consequently, there is a lack of interaction between the teacher and students, resulting in a repetitive classroom environment. The limited engagement of students in the teaching-learning process fosters a tendency towards rote memorization and the uncritical reproduction of acquired knowledge. Therefore, the students lack practical skills that could have promoted complete comprehension of learnt concept. Mathematics as a subject contained abstract topics that require concrete activities for easy comprehension. Therefore, the use of concrete manipulative approach, in which students actively participate in hands-on activities, has the potential to positively affect students' achievement in mathematical principles.

Concrete manipulative approach is a teaching approach whereby students are taught with concrete materials in addition to classroom explanation and discussion. Manipulatives refer to concrete educational resources that facilitate students' understanding of abstract concepts by making them more concrete. They aid in establishing a connection between the manipulatives and abstract mathematical ideas by providing hands-on experiences. Ultimately, manipulatives contribute to the long-term retention of mathematical skills (Laski et al., 2015). Mathematics is a scholarly field mostly concerned with abstract concepts. The concrete manipulative approach is an educational technique that prioritises student engagement and centres around the construction of intricate knowledge structures. This is achieved by the active utilisation of concrete materials, fostering a hands-on learning experience. Additionally, abstract mathematical concepts are comprehended by students through the lens of concrete experiences, facilitating a deeper understanding. It is argued that students had limited cognitive capacity, making it challenging for them to comprehend and acquire abstract mathematical concepts exclusively through direct instructional methods, such as lectures. Nevertheless, it is conceivable that students can acquire comprehension of abstract mathematical concepts through their interactions with concrete objects and materials.

Implementing concrete manipulatives in the classroom is consistent with the constructivist pedagogical philosophy. According to educational philosophers, learning is a dynamic process wherein students actively construct and develop their own knowledge, as opposed to merely receiving it passively (Kwon & Capraro, 2018). Students are active participants as opposed to inert recipients in the learning process, according to this view. Because they are able to physically interact with these tangible objects, the use of concrete manipulatives in educational settings encourages student engagement and active participation in the learning process (Carbonneau et al., 2013). Incorporating concrete manipulatives into the mathematical process can thus enhance students' cognitive capacities.

According to Carbonneau et al. (2013), a significant number of students lack the capacity for abstract thinking. Nevertheless, the utilisation of concrete manipulatives can potentially offer a viable resolution for students encountering abstract notions. According to a study conducted by Carbonneau et al. (2013), it has been observed that students who actively engaged with manipulatives had enhanced comprehension and were able to establish connections between abstract and tangible mathematical concepts. This can be attributed to their ability to visualise these concepts through the construction of models using manipulatives. Therefore, the utilisation of concrete manipulatives as educational aids might effectively boost students' capacity for abstract reasoning, consequently fostering their academic achievement.

Academic achievement refers to the successes that a student is able to acquire via the successful completion of coursework within an educational institution. Academic achievement encompasses the accomplishments of those engaged in formal education at various levels, such as primary school, secondary school, college,or university. These endeavours often occur within the confines of a classroom, laboratory or field setting. The term "Academic Achievement" typically denotes the extent or level of accomplishment or competence achieved in academic endeavours (Arora, 2016). It fosters a culture of diligence and promotes increased knowledge acquisition among the students. Academic achievement pertains to the educational progress of a student, encompassing the acquisition of knowledge and the cultivation of skills during their academic journey. This progress is evaluated by educational institutions through the utilisation of assessments, which may take the form of tests devised by teachers or standardised examinations to ascertain students' level of understanding.

Another factor that may affect students' academic achievement is students' sex. Sex pertains to the phenomenon of individuals identifying as either male or female within the context of a scholastic environment. Mathematics is seen as a masculine subject. Therefore, it is believed that male students outperform their female counterparts irrespective of the teaching approach adopted by mathematics teachers. Nevertheless, there exists a lack of definitive research findings regarding the effect of sex on the academic achievement of students. This study aimed to investigate if the utilisation of concrete manipulative and lecture approaches would have a similar effect on the academic achievement of male and female students in mathematics. Additionally, the research further examined the interaction between teachers' instructional approaches and students' sex in relation to students' academic in mathematics. Against this backdrop, the present study aimed to

investigate the effect of utilising concrete manipulative and lecture approaches on students' academic achievement. The objective was to determine the most effective approach for teaching mathematics between these two approaches.

Statement

Every year, Nigerian schools witness a significant enrollment of students, encompassing both those inclined towards science and those with an artistic inclination, who choose to study mathematics as part of their curriculum for WASSCE. An analysis of the WAEC Chief Examiner's reports spanning the years 2015 to 2022 reveals a concerning trend. Despite a consistent rise in annual enrollment in mathematics, there is a concurrent and alarming decline in academic achievement, coupled with a significant prevalence of examination misconduct. The suboptimal academic achievement of mathematics students in the WASSCE may be attributed to a range of causes, one of which is the ineffective teaching approaches employed by mathematics educators.

Based on the researcher's observations, it is evident that the lecture approach is extensively employed by mathematics educators in Nigerian Secondary Schools. Due to their minimal involvement in the educational process, students have turned to memorising mathematical concepts. In the lecture approach, students are not afforded the opportunity to engage in hands-on manipulation of concrete objects, hence limiting their ability to draw inferences based on direct experiential encounters with these things. The utilisation of this approach does not effectively cultivate students' critical thinking skills as it primarily focuses on the dissemination of factual information. This necessitates the exploration of alternative pedagogical approaches that possess the potential to provide students the opportunity to engage with concrete items during instructional sessions, thereby augmenting their comprehension of abstract mathematical principles. Concrete manipulative approach possessed the requirement of ensuring students' active involvement as well as giving students the opportunity of manipulating concrete materials during instruction. The problem of the study is to find out if concrete manipulative approach enhances students' academic achievement in mathematics than the lecture approach.

Purpose of the Study

The study aimed to investigate the effects of concrete manipulative and lecture approaches on students' achievement in mathematics. Specifically, the study sought to find out:

1. the difference in the mean achievement scores between students taught mathematics using concrete manipulative approach and those taught using lecture approach;
2. the difference in the mean achievement scores between male and female students taught mathematics using concrete manipulative approach;
3. the interaction effect of instructional approaches and sex on students' achievement in mathematics.

Hypotheses

The study was guided by three hypotheses:

1. There is no significant difference in the mean achievement scores between students taught mathematics using concrete manipulative approach and those taught using lecture approach.
2. There is no significant difference in the mean achievement scores between male and female students taught mathematics using concrete manipulative approach.
3. There is no significant interaction effect of instructional approaches and sex on students' achievement in mathematics.

Methods

The research utilised a 2x2 factorial pretest, posttest planned variation quasi-experimental design. The study consisted of two instructional groups, namely the concrete manipulative group and the lecture group, as well as two levels of sex, specifically male and female. Table 1 displayed the independent variable, which consisted of two instructional approaches: concrete manipulative and lecture approaches. The moderator variable is sex, while the dependent variables are students' academic achievement in mathematics. The choice of this design is predicated on the fact that the researcher used students in intact classes for this study in order not to disrupt classroom teaching.

Table 1

Variable Matrix of the Study

Independent Variables	Moderator Variables	Dependent Variable
Instructional approaches	Sex	Academic achievement
i. Concrete manipulative approach	i. Male	
ii. Lecture approach	ii. Female	

The study's population consisted of 5,813 SS II mathematics students in public secondary schools within Delta North Senatorial District. The study's sample size comprised 376 SS II Mathematics students from six selected public secondary schools. The process of selecting the six (6) schools for this investigation was conducted utilising the simple random sampling technique. Mathematics Achievement Test (MAT) is the instrument that was used for data collection. The MAT was drawn from a six-week lesson plan on: (i) meaning of locus; (ii) five fundamental loci; (iii) points at a distant; (iv) equidistant from two points; (v) equidistant from two parallel lines/intersecting lines; and (vi) points equidistant from a point and a line. The face, construct and content validities of the instrument (MAT) was established to ensure the instrument measure what was purports to measure. The reliability of the MAT was determined by the utilisation of the Kuder-Richardson 21. The rationale behind selecting this strategy is its suitability for multiple alternatives objective test items that dichotomous in nature. The MAT was conducted on a sample of 20 students offering mathematics in a school located in the Uvwie Local Government Area of Delta State. The data obtained were analysed using the Kuder-Richardson 21. Upon conducting an analysis, a reliability coefficient value of 0.86 was found.

The initial step in the treatment involved the allocation of selected schools into distinct groups, namely concrete manipulative and lecture groups. The study randomly assigned the six classes

selected into two groups, consisting of three concrete manipulative groups and three lecture groups. The students in the concrete manipulative group were instructed using a concrete manipulative approach, while the students in the lecture group were instructed using the lecture approach.

Concrete Manipulative Group: The instructor provided instruction on mathematical ideas and engaged students in hands-on activities outside of the classroom to enhance their understanding of the material. These concrete activities were designed to assist comprehension of the mathematics concepts covered during instruction. In particular, students were tasked with the construction of roofs for houses and the establishment of farms, during which they conducted measurements that would subsequently be utilised for calculations. The primary focus was directed towards the concepts of linear paths, circular/elliptical curves, trajectories, and parabolic forms. Subsequently, the instructor assessed the instructional session.

Lecture Group: The teacher revised the previous lesson and introduce the topic. Thereafter, the teacher explained the topic in detail using appropriate examples. Thereafter, teacher evaluated the lesson.

During the course of the treatment exercise, the researcher conducted regular monitoring and supervision to ensure effective instruction of the students in both experimental groups. Following the completion of the instructional treatment, a posttest was administered to the students in both experimental groups, utilising MAT as an assessment tool. The posttest's content exhibited similarities to the pretest, albeit with variations in the order of items. Posttest scores were collected for both groups. Subsequently, the scores from the pretest and posttest of students in both groups were recorded for the purpose of analysis. The obtained scores were analysed using Analysis of Covariance (ANCOVA) and t-test.

Results

HO_1: There is no significant difference in the mean achievement scores between students taught mathematics using concrete manipulative approach and those taught using lecture approach.

Table 2

ANCOVA Summary on Mean Pretest and Posttest Scores of Students in Concrete Manipulative and Lecture Groups

Source	Type III Sum of Squares	df	Mean Square	f	Sig.
Corrected Model	15465.097[a]	2	7732.548	80.093	.000
Intercept	115823.826	1	115823.826	1199.698	.000
Pretest	9342.530	1	9342.530	96.770	.000
Approaches	5104.486	1	5104.486	52.872	.000
Error	36010.965	373	96.544		
Total	1175605.000	376			
Corrected Total	51476.061	375			

The estimated f-value of 52.872 with a p-value of 0.000 indicates a significant difference in mean achievement scores between students taught mathematics using concrete manipulative or lecture approaches. Hence, the null hypothesis 1 is rejected. A notable disparity in mean achievement scores is evident between students taught mathematics using a concrete manipulative approach and those instructed through a lecture approach. This difference favours the concrete manipulative approach.

HO_2: There is no significant difference in the mean achievement scores between male and female students taught mathematics using concrete manipulative approach.

Table 3
t-test Summary on Mean Achievement Scores of Male and Female Students in Concrete Manipulative and Lecture Groups

Strategy	Sex	N	Posttest		df	t-cal	Sig.(2-tailed)
			Mean	SD			
CM	Male	87	59.43	12.85	183	0.659	0.511
	Female	98	58.20	12.34			

Table 3 shows no significant difference in the average achievement scores of male and female students who were taught mathematics using a concrete manipulative approach. The t-value of 0.659 and the p-value of 0.511 exceed the significance level of 0.05, thereby confirming the conclusion. Therefore, it can be inferred that there is no statistically significant difference in the average achievement scores between male and female students who were taught mathematics using a concrete manipulative approach.

HO_3: There is no significant interaction effect of instructional approaches and sex on students' achievement in mathematics.

Table 4
ANCOVA Summary on Interaction Effects Between Instructional Approaches and Sex on Students' Achievement

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	15886.381[a]	4	3971.595	40.739	.000
Intercept	110498.447	1	110498.447	1133.459	.000
Pretest	9303.516	1	9303.516	95.433	.000
Approaches	5353.055	1	5353.055	54.910	.000
Sex	.005	1	.005	.000	.994
Approaches * Sex	79.154	1	79.154	.812	.368
Error	36167.978	371	97.488		
Total	1172905.000	376			
Corrected Total	52054.359	375			

Table 4 reveals a non-significant interaction effect between instructional approaches and sex on students' achievement in mathematics, $F(1, 371) = 0.812$, $P(0.368) > 0.05$. The null hypothesis is, therefore, not rejected. Therefore, there is no significant interaction effect between instructional approaches and sex on students' achievement in mathematics.

Discussion

The study revealed a significant difference in the mean achievement scores between students who were instructed in mathematics through the utilisation of concrete manipulation approaches and those who were taught through traditional lecture approach. The results indicated a preference for the concrete manipulative approach. This suggests that students who were instructed in mathematics using concrete manipulative approach achieved greater scores compared to students who were taught using lecture approach. The effectiveness of this approach may be contingent upon the implementation of active learning strategies. The use of concrete manipulatives engages students actively in the learning process. They can physically interact with objects, manipulate them, and observe the changes happening. This hands-on experience helps students to form a deeper understanding of mathematical concepts. Again, the use of concrete manipulatives encourages students to explore and think critically. They can experiment with different strategies and solutions, promoting a problem-solving mindset. By engaging with concrete manipulatives, students can develop logical reasoning, spatial awareness, and analytical thinking skills, which are essential for mathematical problem-solving. The use of concrete manipulatives in teaching mathematics may have led to higher performance scores among students compared to those taught through lectures, especially if they were less engaged during instruction. Students' lack of engagement may have led to the low academic performance observed in the lecture group. This study further corroborates Kontas' (2016) results, which showed a notable disparity in posttest mathematics academic performance between the groups that engaged in concrete manipulation and those that attended lectures. The posttest scores were higher in the concrete manipulative group. This result aligns with Bayram's (2014) research, which found a statistically significant difference in mean scores between students taught with concrete models and those taught with lectures. The findings supported the utilisation of tangible models.

Additionally, the study found no significant difference in the average achievement scores of male and female students who were taught mathematics using concrete manipulative approach. This indicates that using a concrete manipulative approach has a comparable favourable impact on the academic achievement levels of both male and female students. This finding may be explained by the equal chance for participation and favourable learning environment. The use of a concrete manipulative approach may have helped create equal opportunities for both male and female students to participate in the educational process. This practise guarantees that both sexes are provided with equal opportunities, hence resulting in comparable levels of academic achievement. Likewise, the utilisation of concrete manipulatives may have fostered a conducive learning milieu. The presence of a pleasant culture may have had a beneficial impact on academic achievement for both male and female students, leading to comparable scores. This observation is consistent with

the findings of Akaazua (2017), who argued that female students who were exposed to the concrete manipulative method demonstrated comparable achievement to their male peers.

The findings of the study indicated that there is no significant interaction between instructional approaches and sex in relation to students' academic achievement in the field of mathematics. The potential lack of significance in the interaction effect could be attributed to the comparable effectiveness of both the concrete manipulative and lecture approaches for students of both sexes. In essence, the impact of these instructional approaches on academic achievement was found to be independent of students' sex. This discovery is consistent with the findings of Bayram (2014), who observed that there was no statistically significant interaction between instructional approaches and sex in relation to students' achievement scores in geometry.

Conclusion

The following conclusions were reached based on the findings of this study: concrete manipulative approach enhances students' academic achievement in mathematics than the lecture approach. Concrete manipulative equally boosts male and female students mean achievement scores in mathematics. Concrete manipulative and lecture approaches do not interact with students' sex to influence students' academic achievement in mathematics.

Recommendations

In view of the findings of this study, the following were recommended:

1. Mathematics teachers should employ concrete manipulative approach in mathematics instruction at the Secondary Level of Education.
2. Mathematics teachers can use the lecture method as alternative teaching approach when it is not practicable to use concrete manipulative approach.

References

Akaazua, T. J. (2017). *Effect of concrete manipulative approach on attitude, retention and performance in geometry among junior secondary school students in Benue State, Nigeria*. Retrieved 10th August, 2023, from: https://kubanni-backend.abu.edu.ng/server/api/core/bitstreams/c9b8b237-2517-48af-bdac-943e92ed4d42/content.

Arora, R. (2016). Academic achievement of adolescents in relation to study habits. *The International Journal of Indian Psychology,* 3(2), 48-54.

Bayram, S. (2014). the effect of instruction with concrete models on eighth grade students' geometry achievement and attitude towards geometry (Published Master's thesis). Middle East Technical University.

Carbonneau, K. K., Marley, S. M., & Selig, J. P. (2013). A meta-analysis of the efficacy of teaching mathematics with concrete manipulatives. *Journal of Educational Psychology,* 105(2), 380-400.

Habtamu S. B. (2017). Factors affecting learning mathematics in the case of Assosa University Collage of Natural Science. *International Journal of Education, Culture and Society.* 2(1), 6-12.

Ijeh, S. B. (2014). Mathematics teachers' knowledge of learners' difficulties during classroom practice in teaching statistics. *DELSU Journal of Educational Research and Development,* 13(1), 111-134.

Ijeh, S. B. (2022). Exploring the ICT software for teaching mathematics at the secondary schools in Nigeria and South Africa. *International Journal of Academic Pedagogical Research (IJAPR),* 6(8), 139-144.

Kontas, H. (2016). The effect of manipulatives on mathematics achievement and attitudes of secondary school students. *Journal of Education and Learning,* 5(3), 10-20.

Kwon, H., & Capraro, M. M. (2018). The effects of using manipulatives on students' learning in problem posing: The instructors' perspective. *Journal of Mathematics Education,* 11(2), 35-47.

Laski, E., Jordan, J., Daou, C., & Murray, A. (2015). What makes mathematics manipulatives effective? Lessons from cognitive science and montessori education. SAGE Open, 2, 1-8. http://dx.doi.org/10.1177/2158244015589588.

Ozofor, N. M., & Onos, C. N. (2018). Effect of ethnomathematics on senior secondary school students' achievement in Ikwuano Local Government Area, Abia State. *Researchjournali's of Mathematics,* 5(1), 1-14.

Suleiman, Y., & Hammed, A. (2019). Perceived causes of students' failure in mathematics in Kwara State junior secondary schools: Implication for educational managers. *International Journal of Educational Studies in Mathematics,* 6(1), 19-33.

Umameh, M. A. (2011). *A survey of factors responsible for students' poor performance in mathematics in senior secondary school certificate examination (SSCE) in Idah Local Government Area of Kogi State, Nigeria*. Retrieved 29th March, 2023 from https://www.researchgate.net/publication/274069472_a_survey_of_factors_responsible_for_students_poor_performance_in_mathematics_in_senior_secondary_school_certificate_examination_ssce_in_idah_local_government_area_of_kogi_state_nigeria/link/5513f7560cf23203199cce41/download

West African examination Council. (2015-2022). *WAEC Chief Examiner's report on students' performance in mathematics.* Lagos: WAEC Press.