

## Effect of Dienes base ten block manipulative on middle basic pupils' performance in Mathematics in rivers State, Nigeria

Rosemary Nchelem George<sup>1\*</sup> and Peace Chituru Ihunwo<sup>2</sup>

<sup>1</sup>Department of Mathematics/Statistics, Ignatius Ajuru University of Education Port Harcourt, Rivers State Nigeria.

<sup>2</sup>Department of Curriculum Studies & Instructional Technology, Ignatius Ajuru University of Education Port Harcourt, Rivers State Nigeria.

Corresponding Author Email: [nchelemgeorge@gmail.com](mailto:nchelemgeorge@gmail.com)

### ABSTRACT

*This study focused on the effect of Dienes base ten block manipulative on middle basic pupils' performance in mathematics in Obio/Akpor local government area of Rivers State, Nigeria. Quasi-experimental design of pre-test and posttest was adopted. The population of the study consisted of 4,503 basic five pupils in 55 middle basic schools in the local government area. The sample of the study was one hundred and ninety-three basic five pupils. The multi-stage and simple random sampling techniques were used to select two schools and basic five level of primary education. One hundred and two students were in the experimental group while the control group was 91 students; and in all 72 high ability and 121 low ability students. The instrument used for data collection was Mathematics Performance Test (MPT) with twenty (20) multiple choice items in Highest Common Factor and Lowest Common Multiple and types of fractions. Three research questions and three hypotheses were answered and tested at 0.05 level of significance respectively. The study used mean, standard deviation and ANCOVA for analysis. It was found among others that: there was a significant difference in the performance mean score of pupils taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method; and there was a significant difference in the performance of pupils taught mathematics with Dienes base ten manipulative and those taught using the deductive teaching method. It was also found that Dienes base ten block manipulative improved the academic performance of students in mathematics. It was recommended among others that, the Dienes base ten block manipulative should be procured and used in public primary schools.*

**Keywords:** Base ten block, Mathematics, Performance, Retention, Manipulative

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## INTRODUCTION

Mathematics is a field of study that deals with the basic concept of numbers, space and quantity as well as the application and manipulation of those concepts that have to be taught using appropriate instructional methods that will provide positive changes in the performance and retention of students. When learners keep possession of what has been learnt (mathematical concepts and procedures) for a relative long period of time, they are said to have retained learning which is measured by repeated performance level within a given period. From the above description of mathematics, numbers and numerals are foundational concept which every child of school age must first meet and learn and advance to computation in order to develop required numeracy skill for further studies. This explains the reason, the Federal Republic of Nigeria (2014) emphasized that the first goal of primary education is to inculcate permanent literacy and numeracy, and ability to communicate effectively. Mathematics uses numbers or numerals to assign measures and value to other physical quantities. A rudimentary knowledge of numbers and numerals is needed by every Nigerian child and must be properly taught to avoid distortion in future procedural learning.

To help both the teachers and students to develop sound number and numeration activities that will enhance learners' ability to handle numbers, incorporating manipulative during instructional processes is necessary. No doubt, number is the main object of mathematics and is embedded in abstractions. For students to develop a good number sense, they must be conversant with numeration. Numeration will therefore precede operations in numbers and numerals. In teaching and learning mathematics from the pre-nursery, primary and even through the junior secondary schools, numeration as an activity is a fundamental part of young children's mathematics experience (Paga, 2013). The use of manipulative such as counting objects makes numeration a very excellent entry point for teaching children more formal mathematics. Numeration may involve mere counting exercise with or without a stable order, while denoting the items being counted may involve numerals; and furthermore, the manipulation of these numerals based on the intended mathematical operations. The need to cultivate adequate numeracy skills is paramount at the primary education level which prepares young children for procedural activities in mathematics.

Generally, grouping of students enables the schools to meet the need of the students by creating a more homogeneous learning environment and facilitate instruction. The practice of grouping students is built on Romanticism, a student-centered philosophy that focuses on differentiation- meeting the students learning readiness which is determined by entry behavior and previous performance of the students (Centre of Educational Resources- Johns Hopkins University, 2021). Such grouping can take on different forms that involves the

separation of learners based on high, middle and low aptitude, cross-grading grouping for reading or arithmetic, special classes for the gifted and talented and within class grouping. The primary aim of grouping learners is to stimulate their thinking and to sharpen their communicative skills, which to a large extent depend on the organization of the work (Ambreen, 2017). However, grouping based on students' ability has occupied enormous space in research works on grouping.

Formally, ability grouping or tracking as it is often referred in literature began as a debate among members of the panel- National Education Association headed by Charles Eliot, the President of Harvard University (Kelley, 2018). The panel found it necessary to design programmatic changes in the schools to provide increased support in preparing students for college and future employment in the United States. One of the first of the experiment on ability grouping was conducted in 1927 in Salt Lake City, Utah in the United States among others that have continued for more than half a century. Ambreen (2017) recorded that in the early 1930s, research findings showed that grouping led to better school outcomes when ability grouping are combined or matched with methods and materials that suit children aptitude level.

In the late 1950s, when Sputnik, the Soviet Union Space advancement was launched the practice of ability grouping became prominent in schools as a counter to the advancement (Kelley, 2018). At this time, Americans were worried that their students were not working hard enough, were not learning enough and were not keeping pace with pupils abroad. Since then, there have been several research extensive works on grouping with mixed results on effects of ability grouping on learning and access to balanced instruction. There were several positive and negative results. Some showed that ability grouping promotes higher learning and others that it promotes inequality. Loveless (2013) reported that ability grouping is still a continued practice in the schools and most frequently in mathematics.

In recent times, researches have also considered characteristics of learning along topical issues as multiple intelligence, learning styles, personality type brain development, all of which determine performance of learners' (Kelley, 2018). The meaning and practice of ability grouping has been clearly delineated as some scholars perceive it as a permanent structure while others view it as a practice in class and for special purpose. For example, Ambreen (2017) affirmed that ability-based grouping can be used to set learning targets for pupils, in especially core subject areas. Ability grouping can be based on homogeneous (fixed ability) and heterogeneous (mixed ability).

The term ability grouping is often used to reflect this type of separation in grade schools, K- 12 or elementary schools while tracking is used for middle and high schools. Some scholars refer to it as mere homogeneous

groupings. Kulik (1992) opined that in the schools (educational institutions) children can be separated into ability groupings on the bases of test scores and school records. Findley and Bryan (1971) defined ability grouping as the practice of organizing classroom groups in a graded school to put together children of a given age or grade who have most nearly the same learning achievement or capability, largely on the bases of standardized test. Ability grouping or tracking is the separation of same grade school children into group or classes that differ markedly in school aptitude (Kulik in Ambreen, 2017). It has been identified that ability grouping is an instructional practice that has three key features; namely- placing students into different classroom or smaller groups based on their initial achievement skills level, readiness or abilities; having the main purpose of such placement is to create a more homogeneous learning environment so that teachers can provide instruction better matched to students need and also that students can benefit from interaction with their comparable academic peers; and the placement are not permanent school administrative arrangement that lead to restrictions on students graduation, destination or career path (Steenbergen-Hu, et al., 2016).

Gamoran (2022) asserted that use of fixed ability grouping tends to favour the academic ability of pupils of high ability than other groups since they are given complex tasks related to their higher cognitive capabilities. On this basis, researches on ability grouping perceive these differentiated task and effect on pupils' academic achievement as a disadvantage of ability grouping as it hampers learning and social development. To the average or low ability students, homogeneous grouping creates a group label mindset that lowers their self-esteem (Kelley, 2017). Many scholars do not perceive homogeneous ability grouping as a means to enhance pupils' learning except for research purpose for on-going experimentation to arrive at evidence based findings at a given time (Mark, 2013). In as much as it has been criticized because of the social and academic interactions as well as giving the high achievers the opportunity to attain higher learning; it can also motivate the middle and low ability group to aspire to move away from their group.

The other variance, mixed ability grouping (heterogeneous) often allows for cross grading where pupils or learners of various abilities are put together to achieve specific education goals, one of which is to enhance interaction between the experts and novice. Mixed ability grouping creates proximal zones of development for less competent peers as emphasized by the social learning theory of Lev Vygotsky (Ambreen, 2017). It is known to encourage collaboration among the pupils. Saleh et al. (2007) in their study established that pupils from average and low ability groups appear to gain more academic benefits while working in heterogeneous group.

The place of mathematics in the education system and its utilitarian value therefore calls for appropriate instructional method in the primary and secondary schools

because of some observable missing links between mathematics concepts and procedures that may exist. Connecting the two has been the preoccupation of mathematics educators in order to build a strong mathematics foundation for pupils to carry out operations. The sense of number and how numbers are manipulated has transcended the history of mathematics and ancient cultures that contributed to its development; from the Sumerians, Babylonians, Egyptians, Greeks, Hindus (Indian), Chinese, to the Arabs. Various base systems have existed in the past across cultures as well as their denotations (numerals) and many cultures currently pronounce numerals differently. However, base ten system has gained wider acceptance in daily living and as symbols of instruction in mathematics in the schools (Kim & Albert, 2014).

Against this background, many pupils in the middle basic classes still find it difficult to comprehend what numbers are all about, perform mathematical operations effectively and to call/pronounce numbers especially when they are of numerous digits. As a result, many of the attempts by mathematics educators to improve mathematics instruction have called for greater use of concrete objects. Uttal et al. (1997) affirmed that the idea that young children learn best through interacting with concrete object has sparked much interest in the use of mathematics manipulatives. Manipulatives are known to help pupils/students to connect abstract mathematical concepts to real object, thus making the most difficult mathematical concept easier to understand.

It is therefore obvious that a good number sense can be closely related to understanding and proficiency in mathematics which must start with sound understanding of the value of numerals and their relative position in the place value system. In other words, the understanding of the concept of place value system is central to developing number sense and is the basis of the fundamental operations on number. Dienes' multi-base block provides a special model to teach place value and other topics at the basic school levels and thus considered one type of manipulative that supports learners' modeling of abstract numeral concepts (Tahidu, 2018; Kim & Albert, 2014). The multi- base block model/ manipulative is practical, learner-centred, minds-on and hands-on innovative method of teaching topics under numbers and numeration as well as perform basic mathematical operations, and demystify the learning of mathematical concepts.

The fact that manipulative promote mind-on and hand-on activities, thus emphasizing on doing rather than receptive learning that encourage rote memorization, they have the potency of increasing retention time and performance. As an effective instructional method, it is attuned with the popular Chinese proverb: I hear and I forget; I see and I remember; I do and I understand (Ononogbu, 2003). This is suggesting that learning by doing is capable of promoting meaningful learning through proper use of manipulative. This innovative instructional method may be a good means of unlearning past wrong

conceptual understanding and consolidate learning by guided verification of facts about numbers. Retaining facts about number may be enhanced since retention is basically concerned with the process by which new information is transferred from the short-term to the long-term memory. According to Edoho, et al. (2020), retention in mathematics is not acquired by mere memorization but through appropriate teaching method.

The extent of learners' retention ability is determined by various performance level at specified intervals. The knowledge of mathematics is not acquired and learnt only for school examination but also for external standardized examinations that may serve the purpose of placement either from one programme to another, or from one institution to another, or from one level of education to another. The concept of retention and performance in mathematics are inter-related. Any attempt of enhancing students' retention in number sense is to make them to continue to be proficient and skillful in dealing with numbers in the classroom, school examinations and external examinations. Based on this, Adeniji, et al. (2018) averred that teaching and learning are done in different subjects including mathematics so that students could pass both internal and external examinations. It is then clearly obvious that performance through appropriate administration of test whether delayed or immediately depends on the extent of retention (possession of knowledge). In other words, performance ( $p$ ) at any given time is a function of retention ( $r$ ), and retention is a function of time ( $t$ ) between knowledge acquisition and test administration. Striking a balance between these two concepts has been the preoccupation of mathematics educators with reference to different instructional methods and strategies.

However, care and caution may be expected of the mathematics teacher on the multiple interpretations of materials (manipulative) by perceiving ahead the possible mixed learning that may occur; and to drive home the intended concepts. This is very paramount and crucial when teaching beginners in numbers and numeration. For example; the order of dealing with fractions where there is 'of' and 'multiplication' in the arithmetic with fractions.

Furthermore, mathematics teachers have to be aware that manipulative do not need to be physical in order to be effective, of which there are virtual manipulative and concrete manipulative. While concrete manipulative are concrete (objects) learning material that allow learners to comprehend abstract concepts through concretizing them, virtual manipulative are dynamic visual representation of concrete manipulative. Using manipulative appropriately for intended concepts and results like the sense of numbers and how they are manipulated in mathematical operations had been adjudged to help learners in the lower and middle basic.

Several studies have been conducted on effectiveness of manipulative on pupils'/student's performance in different subjects, topics in other climes and findings have also been different. Thus, the use of materials for

instruction purpose has come a long way in children education. The basic education programme in Nigeria since 1999, requires that children who passed or completed the primary education (lower and middle basic) must be proficient in numeracy skills. It is worthy to note that mastery of numbers and their patterns and characteristics which are the basis of mathematics is the prerequisites for the study of the sciences at the secondary school level.

Building meaningful structure for multi-digit number using block of various number of cubes/units or Unifix cubes is also possible with mathematics manipulative with foundations laid at the lower basic level. The Dienes base ten blocks have been suggested for use in teaching arithmetic in various forms like numbers bases, place value, arithmetic operations, decimal fractions, basic algebra etc. at the lower basic education level, thus with the foundation provided it can be used to further demonstrate factors, multiples and fractions. However, teaching of these topics may have progressed at this level of education using talk chalk method. In the middle basic level in Obio/Akpor local government area, the provision and use of innovative instructional methods and strategy in mathematics lessons have been a serious hydra-headed constraint to the teaching and learning of mathematics. Mathematics by its very nature is abstract and additional effort is essential to enable learners to understand its concepts, principles and applications (George & Charles-Ogan, 2023). With abundant literature in support of the Dienes base ten blocks, a study on the effect of this old but innovative apparatus on pupils' performance and retention in number sense and mathematics computations is necessary. This is because instructional method and strategy promote active-learning of mathematics in the schools.

The fact that developing pupils number sense; numeracy skill and ability at the lower basic level of education is fundamental to their computational ability in future, teaching mathematics using the appropriate instructional method is paramount even in the middle basic to enable the learners cultivate and understand the flexibility and procedures inherent in mathematic operations. The multi-base arithmetic block of Zoltan Dienes is very effective in inculcating numeracy fluency commonly called number sense; and computational skills in young and older children in primary schools since it has yielded unprecedented and outstanding performance and retention of learners in teaching arithmetic, place value, fractions, factor, and multiples of numbers. As topics in primary mathematics curriculum, pupils and teachers must learn and teach them using this manipulative because of its characteristics of portability, detachability and coloration (Anyim, 2022).

The application of the principles of meaningful learning at every level of the children's education at the primary level of education even up to secondary school level is capable of ensuring teaching preparedness and learning readiness to the mathematics teachers and pupils

respectively. With appropriate instructional method employed the numeracy fluency of the learners can be raised. The use of the multi-base arithmetic blocks approach is one of the most suitable strategies which can be used to lay a good foundation for subsequent manipulation of numbers and future mathematics education. The requisite foundation in the use, relationship between numbers and relating number to real life measures or quantities acquired from school or home determine the extent a child will handle number and numerals in performing computations. It is against this backdrop that the researchers delved into this study.

### Statement of the problem

Concerns are high from different stockholders in education over poor teaching and learning of mathematics because mathematics is a subject where doing (practice) is more prominent than reading. The researcher's observation has shown that most mathematics lessons in the public primary schools (especially the middle basic) are devoid of hands-on, learners' centered approach. Some pupils do not possess the basic numeracy skills expected at that level of education and thus find it difficult to handle mathematics computations with flexibility.

Furthermore, the inappropriate teaching methods used by most mathematics teachers in public primary schools translate to pupils' poor achievement and inability to retain and put into practice what is learnt which further resulted to consistent low performance in public examinations. Consequently, the issue of poor performance in mathematics examination was due to problem of teaching methods for mathematics in the primary schools. One begins to wonder if there is a better instructional strategy that will reduce these errors and increase students' flexibility in handling mathematics computations. Among existing methods and strategies, the researcher wishes to find the answer to the question: how does Dienes' base ten block manipulative enhance middle basic pupils' performance and retention in mathematics in Obio/Akpor local government area of Rivers State.

### Aim and objectives of the study

The aim of this study was to investigate the effectiveness of Dienes base ten block manipulative on pupils' performance and retention in mathematics in primary schools in Obio/Akpor local government area of Rivers State. In specific terms, the study sought to:

1. Find out if there is any difference in the performance mean score of pupils taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method.
2. Find out whether any difference exist in the performance mean score of the high ability pupils taught

mathematics with Dienes base ten block manipulative and those taught using deductive teaching method.

3. Ascertain if there is any difference in the performance mean score of the low ability pupils taught mathematics with Dienes base ten block manipulative and those taught using deductive teaching method.

### Research questions

The following research questions were answered.

1. What is the difference in the performance mean score of pupils taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method?
2. What is the difference in the performance mean score of the high ability pupils taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method?
3. What is the difference in the performance mean score of the low ability pupils taught mathematics with Dienes base ten manipulative and those taught using the deductive teaching method?

### Hypotheses

The following hypotheses were tested at 0.05 level of significance.

H0<sub>1</sub>: There is no significant difference in the performance mean score of pupils taught mathematics with Dienes base ten block manipulative and those taught using deductive teaching method.

H0<sub>2</sub>: There is no significant difference in the performance mean score of high ability pupils taught mathematics with Dienes base ten block manipulative and those taught using deductive teaching method.

H0<sub>3</sub>: There is no significant difference performance mean score of low ability pupils taught mathematics with Dienes base ten manipulative and those taught using deductive teaching method.

## METHODOLOGY

### Research design

The study employed quasi-experimental design which involved pretest and posttest. A quasi –experimental design is a design in which the researcher cannot properly control some of the threats to the validity of the study being carried out (Nwankwo, 2013). Intact classes were used which do not allow for randomization of the subjects on whom pretest were administered to cushion the effect of the extraneous variables. This design was adopted by the researchers since the study used pupils in schools as subjects. The design used two groups namely the experimental group and control group.

The experimental group (EG) was exposed to treatment on number sense using Dienes Multi-base Arithmetic Block (MAB) and the control group (CG) was exposed to the same topics using the conventional lecture method. A pretest (Q1) was administered to the two groups to determine their respective levels of performance prior to the treatment. This was followed by a post test (Q2) administered after the treatment. The schematic illustration of the study design is presented in (Table 1).

**Table 1: Schematic Illustration of Study Design**

Group	Pretest	Treatment	Post test
Experimental group	Q1	X <sub>1</sub>	Q2
Control group	Q1	X <sub>2</sub>	Q2

where,

Q<sub>1</sub> = Pretest for experimental and control groups

Q<sub>2</sub> = Posttest for experimental and control groups

X<sub>1</sub> = Dienes Base Ten Block Manipulative

X<sub>2</sub> = Deductive Teaching Method

### Population of the study

The population of this study consisted of 4,503 (2,069 males and 2,434 females) basic five pupils in all the 55 public middle basic schools in Obio/Akpor local government area of Rivers Nigeria.

**Source:** Research, Planning and Statistics Department; Rivers State Universal Basic Education Board, 2022.

### Sample and sampling technique

A sample of one hundred and ninety three (193) basic five pupils was drawn from two public primary schools in Obio/Akpor local government area. Multi-stage and simple random sampling techniques were employed to select the sample for the study. In the first stage, two primary schools were selected using the simple random sampling technique; the second stage involved the selection of basic five among the middle basic classes. Finally, two arms were randomly selected from basic five classes of the selected schools into the experimental and control group. Two arms were selected from each school. The sample were also grouped into ability levels based on their performance in previous school internal examination results. Those with scores of average of less than 60 were grouped as low ability pupils while those with scores of average 60 and above were grouped as high ability pupils.

### Instrument for data collection

A 20-item multiple choice test, Mathematics Performance Test (MPT) was adapted from the Rivers State Common Entrance Examination past questions in mathematics. The multiple-choice responses were four options (A-D) for each test item (question). Each correct answer carries 5 marks, while a wrong answer does not have any mark.

Two types of lesson plans were prepared and used (lesson plan using manipulative and lesson plan using deductive teaching method) to teach the selected topics to the sampled pupils. The topics that were taught to both experimental and control groups were; Lowest Common Multiples (L.C.M); Highest Common Factors (H.C.F); and types of fractions. The academic performance of the pupils was ascertained by using pre-test and post-test; comparing the mean differences of the experimental group with those of the control group. Similarly, pupils' retention was measured by using post-test and post-posttest; comparing the mean differences of the experimental group with those of the control group. Table 2 shows the table of specification that was used to prepare the instrument, Mathematics Performance Test (MPT).

**Table 2:** Table of specification.

Topics	Remembering	Understanding	Applying	Total
L. C. M	1	6		7
H. C. F	1	5		6
Types of Fractions	2	2	3	7
<b>Total</b>	<b>4</b>	<b>13</b>	<b>3</b>	<b>20</b>

### Validation of the instrument

The 20-item multiple-choice test and the lesson plans were given to three mathematics educators to assess the suitability of the items in the instrument by matching the research questions and the school curriculum of the level. The inputs of these mathematics educators helped to establish the face and content validity of the instrument; their advice and constructive criticism were also taken into consideration for the improvement of a better and final draft of the performance test and lesson plans for the study.

### Reliability of the instrument

The reliability of the instrument, MPT, was determined through the test retest method for a measure of stability of the instrument. Through a random sampling technique, the instrument was administered to 30 pupils in basic five of a school in Obio/Akpor local government area that was not part of the sample. The instrument was then retrieved and re-administered to the same set of pupils, after a period of two weeks and the result of the test were marked and correlated using Pearson Product Moment Correlation with the aid of (SPSS) software package (version 25.0). The reliability coefficient was found to be 0.77 which indicated that MPT was reliable enough to conduct the study.

### Method of data collection

The 20-item multiple choice test (Mathematics Performance Test) was administered as pretest to each group of students in the control and experimental groups,

in the sample schools before delivering the lessons. The scripts of the students were marked, scored and recorded over 100. The experimental group was taught L.C.M, H. C.F; and types of fraction using the Dienes base ten block while the control group was taught the same topics using the deductive teaching method. The researcher used teachers in the sample schools as instructors during the exercise after coaching and talking to them about the purpose and topic(s) of the lessons.

During the teaching of the experimental group, the instructor counted and applied the principle of repeated addition of cubes to determine the multiples of numerals; applied division operations by grouping the cubes to determine the factors of numerals; and made the pupils to consider some collections of cubes or longs as a whole(s) with others being distinct (colours) from the rest to determine the part of the whole (as in fractions) prepared chalk board summary. To the control group, the instructor applied the deductive teaching method to present multiples, factors and fractions using the logical process. After teaching both groups, posttest was administered on the same sample; marked, scored and recorded. The experiments were conducted during the school hours in order to avoid absenteeism and to ensure that the students are put under check. The pretest items were re-shuffled to form the posttest before subsequently administering them on the sample.

### Method of data analysis

Scores and records generated from pretest and posttest administered on the students were analyzed in order to answer the posed research questions, and also test the hypotheses. Mean and standard deviation were used to determine the difference in performance mean scores of the control and the experimental groups. Analysis of Covariance (ANCOVA) was employed to test all the hypotheses at 0.05 level of significance

## RESULTS

**Research Question 1:** What is the difference in the performance mean scores of pupils taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method?

Table 3 shows the performance mean scores of the students taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method. The experimental group had pretest mean score of 33.58 with standard deviation of 11.16, and 63.14 posttest mean score with standard deviation of 14.47; the mean gain was 29.56. The control group had pretest mean score of 29.61 with standard deviation of 9.14, and 42.69 posttest mean score with standard deviation of 15.68; the mean gain was 13.08. The performance mean difference between the experimental

**Table 3:** Mean ( $\bar{X}$ ) score, standard deviation and mean difference of the performance of students taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method.

Group	N	Pre test		Post test		Mean Gain	Mean Difference
		$\bar{X}$	SD	$\bar{X}$	SD		
Experimental	102	33.58	11.16	63.14	14.47	29.56	
Control	91	29.61	9.14	42.69	15.68	13.08	16.48

and the control groups taught mathematics with Dienes base ten block manipulative and deductive teaching method, respectively, was 16.48.

**Research Question 2:** What is the difference in the performance mean scores of the high ability pupils taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method?

In Table 4 which showed the difference in the performance mean score of the high ability students taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method, it was indicated that the experimental group had pretest mean performance score of 38.95 with standard deviation of 11.79, and a posttest mean performance score of 58.95 with standard deviation of 15.81; the mean gain was 20.00. On the other hand, the control group had a pretest mean performance score of 32.06 with standard deviation of 10.67, and a posttest mean performance score of 53.97 with standard deviation of 17.35; the mean gain was 21.91. The performance mean difference between the high ability students in the experimental and the control groups that were taught mathematics with Dienes base ten manipulative and deductive teaching method, respectively, was 1.91.

**Table 4:** Means ( $\bar{X}$ ) score, standard deviation and mean difference of the performance of the high ability students taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method.

Group	N	Pretest		Posttest		Mean Gain	Mean Difference
		$\bar{X}$	SD	$\bar{X}$	SD		
Experimental	38	38.95	11.79	58.95	15.81	20.00	
Control	34	32.06	10.67	53.97	17.35	21.91	1.91

**Research Question 3:** What is the difference in the performance mean scores of the low ability pupils taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method?

In table 5 which showed the difference in the performance mean score of the low ability students taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method, it was indicated that the experimental group had pretest performance mean

**Table 5:** Means ( $\bar{X}$ ) score, standard deviation and mean difference of the performance of the low ability students taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method.

Group	N	Pretest		Posttest		Mean Gain	Mean Difference
		$\bar{X}$	SD	$\bar{X}$	SD		
Experimental	67	31.88	10.48	64.14	13.64	32.26	
Control	54	27.81	7.26	35.96	9.70	8.15	24.11

score of 31.88 with standard deviation of 10.48, and posttest performance mean score of 64.14 with standard deviation of 13.64; the mean gain was 32.26. On the other hand, the control group had a pretest performance mean score of 27.81 with standard deviation of 7.26; and a posttest performance mean score of 35.96 with standard deviation of 9.70; the mean gain was 8.15. The performance mean difference between the low ability students in the experimental and the control groups that were taught mathematics with Dienes base ten manipulative and deductive teaching method, respectively, was 24.11.

Table 6 shows the summary of ANCOVA on the difference between the performance of students taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method. The  $F = 79.150$  at  $Df (1,190)$  and partial eta squared  $0.294$  is statistically significant as  $p < 0.05$ , thus, the null hypothesis one was rejected. Therefore, there is a significant difference in the performance mean score of students taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method.

Table 7 shows the summary of ANCOVA on the difference in the performance of high ability students taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method.

The  $F = 2.181$  at  $Df (1, 69)$  and partial eta squared  $0.031$ , is not statistically significant as  $p > 0.05$ , thus, the null hypothesis two was upheld. Therefore, there is no significant difference in the performance mean score of high ability students taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method.

Table 8 shows the summary of ANCOVA on the difference in the performance of low ability students taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method. The  $F = 156.360$  at  $Df (1,118)$  and partial eta squared  $0.570$ , is statistically significant as  $p < 0.05$ , thus the null hypothesis two was rejected.

Therefore, there is a significant difference in the performance mean score of low ability students taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method.

## DISCUSSION

### Academic Performance of Pupils taught with Dienes Base Ten Block Manipulative and those taught with the Deductive Teaching Method

The finding of the study revealed that the difference in the performance mean scores of the basic five pupils taught mathematics with Dienes base ten manipulative and those taught using the deductive teaching method was high. This is an indication that the innovative teaching method which is Dienes base ten instructional strategy yielded a mean difference in favour of the experimental group. The Dienes base ten manipulative was better than the deductive teaching method which has been found to be more of teacher centred. With the Dienes base ten manipulative teachers focus is to make instruction in mathematics (L.C.M, H.C.F and fractions) more learners centred since it help the pupils/students to understand mathematical concepts from the simple the complex, thus increasing their procedural understanding.

Further finding revealed that the difference in the performance mean scores of the pupils was significant. There was a significant difference in the performance mean scores of the students taught mathematics with Dienes base ten manipulative and those taught using the deductive teaching method. By this finding, it means that using the Dienes base ten manipulative caused a significant positive change and improvement in the students' performance in mathematics (L. C. M, H. C. F and fractions). The mean difference was very clear and outstanding as revealed by the analysis. This finding was in line with those of Ligget (2017) and Larbi and Mavis (2016) that stunts taught using manipulative or any other intervention strategy performed significantly better in comparison to their classmates that were not using the same teaching method.

### Academic Performance of High Ability Pupils taught with Dienes Base Ten Block Manipulative and those taught with the Deductive Teaching Method

It was found in the study that no much difference exists in the performance mean scores of the high ability basic five pupils taught mathematics with Dienes base ten manipulative and those taught using the deductive teaching method. This finding revealed the performance mean gain between the pupils/students already classified as the high ability students when taught with two different instructional methods and the finding slightly favoured the high ability pupils/students taught topics in mathematics using the Deductive teaching method. The high ability pupils/students in the experimental group taught with Dienes base ten manipulative had a slightly lower mean gain score than their counterparts in the control group taught using the deductive teaching method. This also implies that those high ability pupils/students who

**Table 6:** Summary of ANCOVA on the performance of students taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method.

Source	Type III Sum of Squares	Df	Mean Squares	F	Sig	Partial eta squared
Corrected model	21514.430	2	10757.215	48.838	.000	.340
Intercept	36119.489	1	36119.489	163.984	.000	.463
Pretest	1411.644	1	1411.644	6.409	.012	.033
Group	17433.743	1	17433.743	79.150	.000	.294
Error	41849.819	190	220.262			
Total	6157 25.000	193				
Corrected Total	63364.249	192				

**Table 7:** Summary of ANCOVA on the effect on the performance of high ability students taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method.

Source	Type III Sum of Squares	Df	Mean Squares	F	Sig	Partial eta squared
Corrected model	2473.257	2	1236.629	4.817	.011	.123
Intercept	13156.459	1	13156.459	51.247	.000	.426
Pretest	1470.123	1	1470.123	5.726	.019	.077
Group	559.904	1	559.904	2.181	.144	.031
Error	17714.243	69	256.728			
Total	261700.000	72				
Corrected Total	20187.500	71				

**Table 8:** Summary of ANCOVA on the performance of low ability students taught mathematics with Dienes base ten block manipulative and those taught using the deductive teaching method.

Source	Type III Sum of Squares	Df	Mean Squares	F	Sig	Partial eta squared
Corrected model	23952.401	2	11976.201	83.220	.000	.585
Intercept	24159.527	1	24159.527	167.878	.000	.587
Pretest	18.181	1	18.181	.126	.723	.001
Group	22501.840	1	22501.840	156.360	.000	.570
Error	16981.483	118	143.911			
Total	354025.000	121				
Corrected Total	40933.884	120				

performed better took advantage of their previous knowledge and attainments to do well even under the deductive teaching method; on the other hand, those in the experimental (intervention strategy) had over confidence in their high ability.

It was further revealed that the existing difference in the performance mean scores of the high ability pupils in both groups was not significant. Therefore, there was no significant difference in the mean performance mean scores of the high ability pupils/students taught with Dienes base ten manipulative and those taught using the deductive teaching method. This finding showed that using Dienes base ten manipulative in teaching mathematics did not improve performance of those in the experimental group as expected than the others in the control group. The insignificant mean score suggests that the pupils/students were actually high performers as those of them taught with the intervention strategy performed slightly below their counterparts in the control group. Furthermore, it is also obvious that continuing with the conventional teaching method, which is more of teacher-centered may or may not lead to the expected performance. The finding may not consistent across board because of the students' factor of readiness on the part of some high ability students. This finding agrees with those

of Tambaya (2018) and Lin et al. (2017) that high ability student generally perform well in any type of instructional strategy whether conventional or innovative/interventional strategy; but runs contrary to the finding of Anyanwu et al. (2019).

#### **Academic Performance of Low Ability Pupils/Students taught with Dienes Base Ten Block Manipulative and those taught with the Deductive Teaching Method**

Another finding of the study showed that a high difference exist in the performance of low ability pupils taught mathematics with Dienes base ten manipulative and those taught using the deductive teaching method. This means that among the low ability pupils/students in the different groups that is experimental and control group, performance varies considerably as indicated by the mean difference. In other word, using the Dienes base ten manipulative caused more performance than the deductive teaching method. Teaching mathematics (L. C. M, H.C. M and fractions) was effective with the innovative/intervention approach, Dienes base ten manipulative, and this is capable of raising the performance of students with low ability better in other to do well in numeracy works and procedural skills.

Based on the above finding, it was obvious that the existing difference in the performance mean scores of the low ability pupils in both groups was significant. It was therefore affirmed that there was a significant difference in the performance mean scores of the low ability pupils/students taught mathematics (L. C. M, H. C. F and fractions) with Dienes base ten manipulative and those taught using the deductive teaching method. This suggested that the mean gain between the performance scores of the experimental group and that of the control group was significant enough so that the positive difference was attributable to Dienes base ten manipulative. The finding of Noreen and Rana (2019) indicated that innovative/intervention instructional strategy always results to higher and better performance compared to the conventional instructional strategy.

## Conclusion

Based on the findings of this study, it was concluded that the use of Dienes base ten block manipulative was effective on the improvement of pupils' academic performance in number sense which is a sensitive aspect of mathematics at the foundational level. The use of Dienes base ten block to teach high and low ability pupils also improved the performances of pupils when compared to the use of deductive teaching methods.

## Recommendations

Based on the findings of this study the following recommendations were made;

1. The Dienes base ten block manipulative should be procured and used in public primary schools to inculcate number fluency in the young children at the primary level to consolidate learnt number concepts/unlearn misconceptions as they go through the lower, middle and upper basic levels.
2. Greater percentage of the questions/items in the first school leaving certificate examination, common entrance examination at the primary education should focus of number sense, computational and procedural abilities of the high ability learners in order to enhance their mathematical skills and sharpen teachers' focus in teaching.
3. Dienes base ten block manipulative should be used as instructional material to teach low ability pupils in primary school mathematics in particular for teaching basis arithmetic operations, and other complex procedures in mathematics.

## REFERENCES

- Adeniji, S. M., Ameen, S. K., Dambatta, B. U., & Onlonise, R. (2018). Effect of mastery learning approach on senior school students' academic performance and retention in circle geometry. *International Journal of Instruction*, 11(4), 951-962.
- Ambreen, S. (2017). Analysing the nature of pupils' interactions in different fixed and mixed groups in the primary classroom. A Doctorate Degree Dissertation of University of Leeds.
- Anyanwu, C. R., Ezenwa, V. I., & Gambari, A. I. (2019). Bridging the gap between low, medium and high ability students through the use of computer-based multimedia instruction. *Journal of Information, Education, Science and Technology*, S1 (1), 105-117.
- Anyim, T. N. (2022). *Mathematics basics*. Rollers Press.
- Centre for Educational Resources- John Hopkin University (2021). Four major educational philosophies. <http://www.cerjhu.edu>.
- Edoho, E. A., Asuquo, I. M., Anditung, P. A., & Abasi, A. U. (2020). Improving senior secondary school students' academic achievement and retention in mathematics and basic science using collaborative concept mapping instructional strategy. *European Journal of Scientific Research*, 156(1), 108-117.
- Federal Republic of Nigeria (2014). National policy on education. NERDC Press.
- Findley, W. G., & Bryan, M.M. (1971). Ability grouping: Status, impact and alternatives. Education Research and Information Centre.
- Gamoran, A. (2022). Standards, inequality and ability groupings in schools <http://www.ces.ed.ac.uk>.
- George, N. R., & Charles-Ogan, G. I. (2023). *Essentials of mathematics teaching and learning*. UlchDigi Prints & Services.
- Kelley, R.D. (2018). Ability grouping and students' achievement in four rural elementary schools in the southern United States. Doctoral Dissertation of Walden University.
- Kim, R., & Albert, L. R. (2014). The history of base ten blocks: Why and who made base ten block? *Mediterranean Journal of Social Sciences*, 5(9), 356-365.
- Kulik, J.A. (1992). An analysis of the research on ability grouping: Historical and contemporary perspectives. The National Research Centre on the Gifted and Talented.
- Larbi, E., & Marvis, O. (2016). The use of manipulative in mathematics education. *Journal of Education and Practice*, 7(36), 53-61.
- Liggett, R. S. (2017). The impact of use of manipulatives on the math scores of grade two students. *Brock Educational Journal*, 26(2), 87-101.
- Lin, W., Tseng, C., & Chiang, P. (2017). The effect of blended learning in mathematics course. *EURASIA Journal of Mathematics Science and Technology*, 13 (3), 741-770.
- Loveless, T. (2013). The resurgence of ability grouping and persistence of tracking: Part II of Brown Center report on American education. Brookings Institution Press.
- Mark, R. (2013). The blue table means you don't have a clue: The persistence of fixed ability thinking and practices in primary mathematics in English schools. *Forum Quantitative Social Research*, 55, 31-44.
- Noreen, R., & Rana, A. M. K. (2019). Activity based teaching versus traditional method of teaching mathematics at elementary level. *Bulletin of Education and Research*, 41(2), 145-159.
- Nwankwo, O. C. (2013). A practical guide to research writing for students of research enterprise. University of Port Harcourt Press.
- Ononogbu, B. I. C. (2003). Creative and effective mathematics teaching. In S. B. Nwideduh (Ed.). *Focus on effective teaching in schools* (pp 157-166). Paragraphics
- Paga, D. (2013). The effect of a grouping by tens manipulative on children's strategy use, base ten understanding and mathematical knowledge. Doctorate Thesis of Columbia University.
- Selah, M., Lazonder, A. W., & Jong, T.D. (2007). Structuring collaboration in mixed-ability groups to promote verbal interaction, learning and motivation of average-ability students. *Contemporary Educational Psychology*, 32, 314-331.
- Steenbergan-Hu, S., Makel, M.C., & Olszewski-Kubilius, L. (2016). What one hundred years of research says about the effect of ability grouping and acceleration of K-12 students' academic achievement: Findings of two second-order meta-analysis. *Review of Educational Research*, 86(4), 849-899.
- Tahidu, Y. (2018). Training teachers on the use of Dienes multi-based blocks to teach basic six pupils place value at Nabulugu D/A primary schools in West Mamprusi District. Master's Dissertation of University for Development Studies.
- Tambaya, I. S. (2018). Impact of 5E teaching cycle on retention of pre-

- NCE Biology students with varied abilities in North-West zone, Nigeria. *International Journal Strategic Research in Education, Technology and Humanities*, 5(1), 15-23.
- Uttal, D. H., Schydder, K. V., & Deloache, J. S. (1997). Manipulatives as symbols: A new perspective on the use of concrete objects to teach mathematics. *Journal of Applied Developmental Psychology*, 18, 37-54.