

Effectiveness of Concrete-Pictorial-Abstract on Pupils' Academic Achievement in Mathematics in Ilorin West Local Government Area

Salamat Bolanle ISA

Department of Adult and Primary Education
Faculty of Education, University of Ilorin, Ilorin Nigeria
isa.sb@unilorin.edu.ng

Asmau Bolanle QUDUS

Department of Early Childhood and Primary Education
Faculty of Education, Kwara State University, Malete, Nigeria
asmauqudus@gmail.com

Abstract

Primary school mathematics instruction is a vital component of a pupils' educational journey; it serves as a vital cornerstone to the cognitive development of the pupils; however, it is accompanied by numerous obstacles that impede successful learning and academic achievement of pupils in mathematics. Based on this, the study investigated the effectiveness of concrete-pictorial-abstract on pupils' academic achievement in mathematics in Ilorin West Local Government Area. The study adopted a pre-test, post-test, non-equivalent control group quasi-experimental research design. The sample for this study consists of 89 pupils from two public and two private schools. Seven research hypotheses were formulated and tested at the 0.05 level of significance. Mathematics Achievement Test with two treatment packages: Instructional Guide for Concrete-pictorial-abstract and Instructional Guide for Conventional Teaching Strategy were used to collect data for the study. Data were analysed using the Analysis of Covariance (ANCOVA). The findings of the study revealed that there was a significant main effect of concrete-pictorial-abstract on pupils' academic achievement in mathematics in Ilorin west local government area of kwara state ($F_{(1; 80)} = 17.861; P < 0.05$). Based on these findings, it was concluded that there was a significant main effect of concrete-pictorial-abstract on pupils' academic achievement in mathematics in Ilorin west local government area of kwara state. It was recommended that teachers should use the concrete-pictorial-abstract strategy in teaching mathematics in order to enhance the problem-solving and reasoning skills of pupils.

Keywords: Concrete-Pictorial-Abstract Mathematics, Academic Achievement

Introduction

Mathematics instruction in primary school is a vital component of a pupils' educational journey; it serves as a vital cornerstone to the cognitive development of the pupils; however, it is accompanied by numerous obstacles that impede successful learning and academic achievement of pupils. Although mathematics plays a crucial role in cultivating fundamental cognitive abilities

and enhancing logical reasoning, a significant number of pupils encounter difficulties in this subject for several reasons. Such as lack of stimulating instructional resources, widespread anxiety related to the subject matter, and inadequate teacher preparation to teach the subject. Teachers' preparation in mathematics instruction includes lesson planning and selection of appropriate teaching method and materials. It has been observed that the majority of teaching methods utilized by teachers in primary schools fail to actively involve pupils in the learning process

Mathematics is the foundation of STEAM education (Science, Technology, Engineering, Arts, and Mathematics), offering critical tools and processes to drive innovation and discovery in nations around the world. According to Maxwell and Paulo (2022), mathematics is a language that may be utilized to represent, express, and solve computational problems. It is not a language that can only be presented symbolically. To effectively communicate its ideas, it must possess an organizational logic at a minimum. The logical structure that mathematics offers is crucial for effective interpretation of facts while solving problems. Hermund et al. (2023) asserted that mathematics acts as a theoretical language that enables us to define patterns, relationships, and systems in an accurate way. It offers resources for logic and cross-domain problem solving.

Yardav (2017) explained mathematics as the scientific study of quantities, including their relationships, operations, and measures expressed through numbers and symbols. Mathematics is frequently alluded to as the "language of science." It serves as the foundation for many scientific disciplines, including physics, chemistry, and biology, offering the structure for developing ideas and carrying out experiments (Hermund et al., 2023). Pupils need to have solid knowledge of mathematics theory right for the foundation stage in order to prepare for the task ahead. Mathematics is a form of creativity as well as a certain kind of thinking (mathematical thinking) in which individuals actively engage in. This shows that studying mathematics includes developing a creative and analytical attitude rather than just mechanical memory (Hjelte, Schindler & Nilsson, 2022).

Furthermore, Edwin et al. (2020) stated that mathematics is one of the most significant subjects in primary school and has a lot of potential to support the growth and development of children. It provides pupils with essential life skills like problem-solving, reasoning, measurement, and spatial understanding. Mathematics is an essential aspect of every individual's existence. It has an impact

on almost every aspect of human life, particularly on pupils in primary schools. An ordinary man needs mathematics to survive, regardless of how basic information he acquires (Tella & Olapade, 2024). This means that learning mathematics is essential to the improvement and sustainability of human life since the study of mathematics is centered on finding answers to issues pertaining to people and the physical realm.

For Nigeria to meet the global standard mathematics is made a core subject in primary school; the goal of these initiatives is to improve pupils' critical thinking and problem-solving abilities (National Policy on Education, 2013). The role of mathematics in any society cannot be underemphasized; it is what we use in domestic affairs, business transactions, and career advancement. At an early stage, pupils satisfy certain needs through mathematical skills such as counting and calculating numbers, understanding money, measuring, and recognizing shapes. Due to the role of mathematics in the cognitive development of pupils, the need to improve the academic achievement of pupils in mathematics has generated a concern among stakeholders in educational setting. This issue was demonstrated in the placement examination in Kwara State. According to the commissioner of Education and Human Capital Development, Kwara State, the 2024 placement examination result revealed that out of 62,031 pupils who sat for the examination, only 41,282 (67%) scored above 50% and above in mathematics. Perhaps this low academic achievement in mathematics is as a result of conventional method that is commonly used by the teachers (Sulyman et al., 2022).

Ekwueme, Ekon and Ezenwa-Nebife (2015) stated that teaching mathematics through hands-on and practical activities ensure pupils grasp mathematical concepts and develop their critical thinking and problem-solving skills. This can be achieved through a concrete pictorial-abstract (CPA) teaching strategy. Concrete pictorial-abstract is appropriate for pupils at this level since the learners at this stage enjoy learning in a fun way. The CPA, often ascribed as the Concrete-Semi-Concrete-Abstract or Concrete-Representational-Abstract (CRA) teaching strategy, is a teaching strategy rooted in Bruner's learning theory. It points out the stages of cognitive development, specifically the "enactive-iconic-symbolic" mode (Hafiziani et al., 2020).

Kathy (2024) stated that bruner's learning theory describes how children represent and understand the world through action, imagery, and language. Emma (2024) described CPA as a teaching

strategy that involves the use of physical and visual tools to help pupils acquire knowledge of abstract topics. Pupils can sometimes find mathematical concepts difficult to understand; the CPA approach works on pupils' previous knowledge by presenting abstract concepts in a tangible and concrete way. It entails progressing from concrete items to visual representations to abstract symbols and solving complex mathematical problems. (Maths—no problem, 2024)

Furthermore, Maths- no problem, (2024) stated that CPA involves three stages; the first stage is the concrete stage, also known as the doing stage. During this stage, pupils use tangible materials to represent problems. In contrast to conventional mathematics teaching methods in which the teacher illustrates how to solve a problem, the CPA method brings abstract concepts to life by enabling pupils to interact with and manipulate tangible objects. Pupils can find the abstract structure of mathematics difficult; however, with the utilization of tangible materials, they are able to visualize structure, which makes learning more meaningful (Emma, 2024). The second stage is the pictorial stage (seeing); this stage involves pupils drawing the concrete object. This enable the pupils to make a mental relation between the drawing of the concrete object and the tangible object used to represent the problem (Maths—no problem, 2024). Emma (2024) opined that without pictorial representation, pupils might find it difficult to visualize a problem. The third stage is the abstract stage, which is the symbolic stage; this stage involves representing abstract problems with numbers, figures, or symbols. The teacher presents mathematical concepts at a symbolic level, using only numbers, notation, and mathematical symbols (for example, +, x, -) to indicate addition, multiplication, or subtraction (Maths—no problem, 2024).

In addition, Andhin and Mela (2023) state that using tangible objects and visual tools can make teaching and learning mathematics more captivating for pupils, thus leading to greater motivation levels and encouraging pupils to actively participate in their learning process. Hafiziani et al. (2020) asserted that the CPA approach increases the problem-solving and reasoning skills of the pupils and pupils academic achievement in mathematics which enable them to gain self-confidence in solving any mathematical task. Al-Salahat (2022) reported that the CPA strategy enhanced the pupils' competency in solving mathematical word problems and calculating the perimeter of geometric shapes, and three weeks after the intervention, the pupils retained the learned skills.

Recently the issue of gender difference has become crucial to educational researchers; there is inconsistency in studies on the impact of gender on academic achievement in mathematics; hence, it is essential to examine the effect of gender on the mathematical achievement of pupils. Okpokwasili and Dukor (2023) explained gender as a characteristic associated with an individual's sex within a societal setting, shaped by the cultural and religious influences of the community. Jekayinfa et al. (2023) opined that gender is an attribute that distinguishes male and female in society; this attribute results in different roles and responsibilities as they progress in life. Alordiah et al. (2015) carried out research on the influence of gender on students' academic achievement in mathematics; they reported that the level of performance of the students in mathematics was average and male performance in mathematics was significantly different from the female performance.

Amatobi and Amatobi (2022) also reported that boys have a more favourable achievement in mathematics than girls, which was as a result of the positive attitude of boys toward mathematics. Also, Yaw and Sylvester (2023) also asserted that there is a significant in students' achievement in mathematics; the female performance was higher than the male performance. In addition, Kaigama and Madaki (2020) also reported a significant difference in academic achievement of male and female students; they opined that this difference in academic achievement could be a result of problems of calculation, and a lack of role models among female students.

Another factor that could affect pupils' achievement in mathematic is school type. School type is the different form of school in an environment, which could be a public or private school. Private schools are solely owned by private bodies, while public schools are established and controlled by the government. The establishment of these schools by different bodies has led to a wide spread disparity in infrastructural facilities and manpower available in public and private schools in Kwara State. Studies regarding the effect school type on pupils' achievement in mathematics have reported significant differences in public and private schools (Sule & Sunday 2024; Evans et al. 2019). Based on the foregoing, enhancing the academic achievement of pupils in mathematics through concrete pictorial instructional strategy remains a germane variable to explore. It is against this background that this study examined the effectiveness of concrete-pictorial-abstract on pupils' academic achievement in mathematics in the Ilorin West local government area.

Research Hypotheses

The following null hypotheses were postulated and tested at the 0.05 level of significance for the study.

H₀₁: There is no significant main effect of concrete-pictorial-abstract on pupils' academic performance in mathematics in Ilorin West Local Government Area of Kwara State.

H₀₂: There is no significant interaction effect of treatment and gender on pupils' academic achievement in mathematics in Ilorin West Local Government Area of Kwara State

H₀₃: There is no significant interaction effect of treatment and school type on pupils' academic achievement in mathematics in Ilorin West Local Government Area of Kwara State

H₀₄: There is no significant interaction effect of gender and school type on pupils' academic achievement in mathematics in Ilorin West Local Government Area of Kwara State

H₀₅: There is no significant interaction effect of treatment, gender and school type on pupils' academic achievement in mathematics in Ilorin West Local Government Area of Kwara State

Methodology

The study adopted a pretest posttest control group quasi-experimental research design with a factorial design of 2x2x2. The first two levels consist of one experimental group (concrete-pictorial-abstract) and one control group (conventional method). The second factorial level was based on gender, male (M) and female (F), while the third factorial level was on school type (public and private). The population for this study comprises all private and public school pupils' registered in schools in Ilorin West Local Government Area of Kwara State. There are sixty-one (66) public schools and two hundred and sixty-six (308) private schools, making a total of 374 schools (Annual School Census Report, 2022/2023). The study adopted a simple random sampling technique to select the schools that were used for the experimental and control groups, respectively; two (2) schools were selected for the experimental group, and another two (2) schools were selected for the control group. Purposefully, intact classes of primary three pupils were sampled for the study. The instruments that were used for this study are the Mathematics Achievement Test, which is titled (MAT) with two treatment packages, the Instructional Guide for Concrete-pictorial-abstract (IGCPA) and the Instructional Guide for Conventional Teaching Strategy (IGCTS), developed by the researcher on topics Addition, Subtraction, and

Multiplication. The instruments were validated by experts in mathematics and primary education. The data were analysed using Analysis of Covariance (ANCOVA) at the 0.05 level of significance.

Results

Hypothesis One: There is no significant main effect of concrete-pictorial-abstract on Pupils' academic achievement in mathematics in Ilorin West Local Government Area of Kwara State

Table 1: Summary of ANCOVA analysis showing the effect of concrete-pictorial-abstract on Pupil's academic achievement in mathematics

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	268.374 ^a	8	33.546	4.466	.000
Intercept	534.317	1	534.317	79.995	.000
Pretest	27.482	1	27.482	3.658	.146
Treatment	134.156	1	134.156	17.861	.000
Gender	2.756	1	2.756	.366	.546
School type	8.176	1	8.176	1.088	.300
Treatment * Gender	.319	1	.319	.042	.838
Treatment * School type	2.173	1	2.173	.289	.592
Gender * School type	13.589	1	13.589	1.809	.182
Treatment * Gender * School type	19.953	1	19.953	2.656	.107
Error	600.843	80	7.511		
Total	16062.000	89			
Corrected Total	869.217	88			

Table 1 shows the main effect of concrete-pictorial-abstract on pupil's academic achievement in mathematics. There was significant main effect of concrete-pictorial-abstract on pupils performance

($F_{(1; 80)} = 17.861$; $P < 0.05$). The hypothesis is therefore rejected. This implies that concrete-pictorial-abstract had a significant effect on pupils' academic achievement.

Hypothesis Two: There is no significant interaction effect of treatment and gender on pupils' academic achievement in mathematics in Ilorin West Local Government Area of Kwara State.

Table 1 also revealed the significant interaction effect of treatment and gender on pupil's academic achievement. There was no significant interaction effect of treatment and gender on pupils

academic achievement ($f(1; 80) = 1.088$; $P > 0.05$). The hypothesis is therefore not. This implies that the interaction of treatment and gender had no significant effect on pupils' academic achievement in mathematics.

Hypothesis Three: There is no significant interaction effect of treatment and school type on pupils' academic achievement in mathematics in Ilorin West Local Government Area of Kwara State

Table 1 also revealed the significant interaction effect of treatment and school type on pupil's academic achievement. There was no significant interaction effect of treatment and school type on pupils academic achievement ($f(1; 80) = .289$; $P > 0.05$). The hypothesis is therefore not rejected. This implies that the interaction of treatment and school type had no significant effect on pupils' academic achievement in mathematics.

Hypothesis four: There is no significant interaction effect of gender and school type on Pupils' academic achievement in mathematics in Ilorin West Local Government Area of Kwara State

Table 1 also revealed the significant interaction effect of gender and school type on pupil's academic achievement. There was no significant interaction effect of gender and school type on pupils academic achievement ($f(1; 80) = 1.088$; $P > 0.05$). The hypothesis is therefore not rejected. This implies that the interaction of gender and school had no significant effect on pupils' academic achievement in mathematics.

Hypothesis five: There is no significant interaction effect of treatment, gender and School type on pupils' academic achievement in mathematics in Ilorin West Local Government area of Kwara State.

Table 1 also revealed the significant interaction effect of treatment, gender and school type on pupils' academic achievement. There was no significant interaction effect of treatment, gender and school type on pupils' academic achievement ($f(1; 80) = 2.656$; $P > 0.05$). The hypothesis is therefore not rejected. This implies that the interaction of treatment, gender and school had no significant effect on pupils' academic achievement in mathematics

Discussion of Findings

This study investigated the effectiveness of concrete-pictorial-abstract on pupils' academic achievement in mathematics. A finding of this study revealed that there was significant main effect of concrete-pictorial-abstract on the academic achievement of pupils in mathematics in Ilorin West Local Government Area of Kwara State. This means pupils taught with concrete-pictorial-abstract perform better than those taught with conventional method. This finding corroborates the finding of Lumen et al (2023), who also reported that concrete-pictorial-abstract had a significant effect on pupils' performance in mathematics. Hafiziani et al (2020); Al-Salahat (2022) also asserted that CPA approach increases the problem solving and reasoning skill of the pupils which enable them to gain self confidence in solving any mathematical task.

This study also reveals that there was no significant interaction effect of treatments and gender on pupils' academic achievement in mathematics. This means male and female pupils responded similarly to the teaching strategy employed, showing that gender does not play a crucial role in how teaching strategy influence academic achievement in mathematics. This result is in line with the findings of Obafemi (2024); None (2022), who reported that there is no significant interaction effect of treatment and gender on students' performance in mathematics. This study negates the finding of Olajumoke and Erica (2024) that reveal that female students had a higher mean score than male students.

Another finding revealed that there is no significant interaction effect of treatment and school type on pupils' academic achievement in mathematics. This means the effect of treatment is uniform on the academic achievement of pupils regardless of the type of school. This finding corroborates the findings of Olarenwaju (2023) and Lukman et al. (2023), who reported there is no significant interaction effect of treatment and school type on pupils' achievement in mathematics. This finding negates the findings of Sulyman, Abdulkadir and Ebenezer (2022) who reported that there was significant interaction effect of treatment and school type on pupils' academic achievement in basic science.

This study also revealed that there is no significant interaction effect of gender and school type on pupils' academic achievement in mathematics. This denotes that the performance of both male and female pupils is the same regardless of the school type after the intervention of concrete-pictorial-abstract. This is in agreement with the finding of Okyere (2019); Sulyman and Dagunduro (2020), who reported that there was no significant interaction effect of school type and gender on self-concept and mathematics achievement.

Another finding revealed that there is no significant interaction effect of treatment, gender, and school type on pupils' academic achievement in mathematics. This indicated that the influence of the treatments on the academic achievement of pupils is uniform across different genders and school types. This is in line with the finding of Olarenwaju (2023); Lukman et al. (2023), who reported no significant interaction effect of treatment, gender, and school type on pupils' academic achievement in mathematics. This finding is in disagreement with the finding of Josiah and Mankilik (2021), who reported there was a significant interaction effect of treatment, gender, and school type on pupils' academic achievement in mathematics

Conclusion

Based on the findings of this study, it is evidence that concrete-pictorial-abstract is an effective teaching approach in enhancing the reasoning and problem-solving skills of pupils in mathematics. It was reported that concrete-pictorial-abstract has a significant effect on pupils' performance in mathematics. It was also concluded that there is no significant interaction effect of treatment, gender, and school type on pupils' academic achievement in mathematics.

Recommendations

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

1. Since concrete-pictorial-abstract is teaching strategy that increases the problem-solving and reasoning skills of pupils it is recommended that teachers should incorporate concrete-pictorial-abstract strategy into teaching and learning of mathematics in order to achieve meaningful learning of the abstract structure of mathematics.
2. Teachers should ensure that teaching practices in the classroom is inclusive regardless of the pupils' gender; all learners should be treated equally.

3. Teachers should attend seminars, conferences, and workshops in order to enable them to be well informed about the current trend in instructional approaches.
4. School administrators and the government should provide necessary materials and resources for the implementation of a concrete-pictorial-abstract approach. These include manipulative materials, pictorial tools, and technological tools to aid visualization of abstract concepts

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