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EFFECTIVENESS OF CONCRETE PICTORIAL ABSTRACT APPROACH IN ACHIEVING COGNITIVE INSTRUCTIONAL OBJECTIVES OF SEVENTH GRADE MATHEMATICS

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Abstract:

A quasi-experimental study was conducted to compare the efficacy of Concrete Pictorial Abstract Approach (CPA) and prevailing Activity Method of Teaching (AMT) in enabling seventh grade students to accomplish the instructional objectives of mathematics in various levels of cognitive domain. The experimental design utilized two intact divisions of seventh grade, one as control group (AMT-group) and the other as experimental group (CPA-group), from an elementary school affiliated to Kerala Board of Public Examination (KBPE), Govt. of Kerala. Three units from the mathematics textbook were taught to the control group by employing the AMT and the experimental group by using CPA-approach. Pre-intervention and post-intervention measures of achievement of instructional objectives in six different levels of cognitive domain, viz, knowledge, comprehension, application, analysis, synthesis and evaluation, was done with the help of an achievement test developed by the investigators. Covariate analysis revealed that no true difference between AMT and CPA in accomplishing knowledge level instructional objective. While the CPA was found significantly better than AMT in achieving understanding-, application-, analysis-, and synthesis level instructional objectives of mathematics, the AMT was found significantly more efficient than CPA in enabling the learners to attain evaluation level instructional objective of mathematics.

Keywords: Activity method of teaching, Concrete pictorial abstract approach, Instructional objectives, Cognitive domain, Mathematics.

1. Introduction

Mathematics learning during the formative years is essential for cognitive development, confidence building, problem-solving skills, and preparing for future academic and career success (Rabillas, Kilag, Cañete, Trazona, Calope & Kilag, 2023; Cowan, Hurry & Midouhas, 2018).

Maths learning provides children with the skills they need to steer the world effectively and lays the groundwork for lifelong learning and achievement (Baroody, Clements, & Sarama, 2019). Mathematics is fundamental to our comprehension of the cosmos and our own existence. The remarkable advancement of technology and the extensive expansion of science in the 20th and 21st centuries can undoubtedly be attributed to the use of mathematics. Despite its growing importance and popularity, many students struggle in mathematics (Akhter & Akhter, 2018). It still continues as the most difficult school subject where failure is highest (VaraidzaiMakondo & Makondo, 2020; Alwadood, Halim, Sulaiman & Noor, 2018). Researches have attributed selection of ineffective instructional strategies as the major reason for poor achievement of learners in mathematics (Dauda & Muhammad, 2024; Saha, Islam, Akhi & Saha, 2024; Mbedule, 2020).

Central to improving students' achievement in mathematics there is selection and use of instructional strategies appropriate to the content and instructional objectives (Morufat & Anayorchi, 2024; Mosimege & Winnaar, 2021). Attainment of cognitive instructional objectives are still regarded as vital in maths class as acquisition of instructional objectives in affective and psychomotor domains depends largely on the accomplishment of instructional objectives in the cognitive domain (Hui & Mahmud, 2023; Guy, Cornick & Beckford, 2015; Sonmez, 2017). The search for interesting and active methods of learning mathematics has brought out many innovative strategies in to classrooms, the Concrete Pictorial Abstract (CPA) approach is one among them. The CPA is grounded in Bruner's notion of transforming experiences into a cognitive representation through three distinct modes: enactive, iconic, and symbolic. The CPA technique has three distinct steps: (a) acquiring knowledge by the physical manipulation of tangible things, (b) acquiring knowledge through the representation of visual depictions of tangible manipulation, and (c) solving problems using an abstract notation (Putri, 2019). Studies are now available to show the success of CPA-approach in mathematics learning (e.g., Blas & Bernabe, 2023; Shafiee & Chew, 2023; Agustin, 2023; Yuliyanto, Turmudi, Agustin, Putri & Muqodas, 2019). None of the studies, however, has examined the success of the CPA-approach, in comparison to prevailing approach of instruction, in attaining teaching objectives of mathematics in different tiers of cognitive domain. In this context, this investigation is a modest attempt to study the effectiveness of CPA-approach in comparison to the prevailing Activity Method of Teaching (AMT) to achieve instructional objectives of seventh grade mathematics in various strata of cognitive domain.

2. Objective

The main objective of the study is to compare the efficacy of CPA approach and the prevailing Activity Method of Teaching (AMT) in accomplishing instructional objectives (IOs) of seventh grade mathematics in different levels of cognitive domain.

3. Hypotheses

The study tested six null hypotheses for answering the research questions. They are:

$H_0$1: CPA-approach is not significantly different from the AMT in achieving *knowledge* level instructional objectives of seventh grade mathematics.

$H_0$2: CPA-approach is not significantly different from the AMT in achieving *understanding* level instructional objectives of seventh grade mathematics.

$H_0$3: CPA-approach is not significantly different from the AMT in achieving *application* level instructional objectives of seventh grade mathematics.

$H_0$4: CPA-approach is not significantly different from the AMT in achieving *analysis* level instructional objectives of seventh grade mathematics.

$H_0$5: CPA-approach is not significantly different from the AMT in achieving *synthesis* level instructional objectives of seventh grade mathematics.

$H_0$6: CPA-approach is not significantly different from the AMT in achieving *evaluation* level instructional objectives of seventh grade mathematics.

4. Methodology

a) *Population:* Students of grade seven studying in elementary schools recognised by KBPE, Govt. of Kerala (India), comprise the population of the study. An approximate size of the population is 3.74 lakhs.

b) *Participants (Sample);* A convenient sample of two divisions of grade seven classes from a government aided elementary school were drawn for the study. One of the classes was designated arbitrarily as control group (n = 46) and the other as experimental group (n = 43) by lottery method.

c) *Research design:* Since intact classes were taken for the study, shuffling and random assignment of the students into control group and experimental group was not possible. A quasi-experimental method was, therefore, employed for the investigation. The study employed a control group design with pre-test and post-test.

d) *Variables:* Achievement of instructional objectives of mathematics in six different levels (Knowledge, Understanding, Application, Analysis, Synthesis and Evaluation) of cognitive domain constituted the dependent variables. Two instructional strategies, viz., Activity Method of Teaching (AMT) and Concrete Pictorial Abstract Approach (CPA), constituted the independent variables of the study.

e) *Tools:* A teacher made achievement test in mathematics, developed by the investigators, was used to assess the pre-intervention and post-intervention achievement of different instructional objectives in cognitive domain. The achievement test administered was of two hours duration and for a maximum of 50

marks. The pedagogic intervention was done with the help of lesson transcripts based on AMT and CPA-approach, developed by the researchers, based on three selected units (Money Math, Numbers and Algebra, and Squares and Right Triangles) from the mathematics textbook prescribed for seventh grade students.

f) *Pedagogic intervention:* A total of 21 classes each of 35 minutes duration was given to the control class and the experimental class, the former by adopting AMT strategy and the later by adopting CPA-approach. The classes were given to both the groups on the same day at the same class period. The teaching interventions were done by two equally qualified lady teachers having equal experiences in teaching mathematics. Pre-testing was done one day before the pedagogic intervention, and the post-testing was done one day after the experimental teaching.

g) *Statistical techniques:* The null hypotheses were by using one-way ANCOVA with the help of SPSS.

5. Analysis and Interpretation

To find out the relative success of AMT and CPA in accomplishing knowledge *(ke)* level instructional objectives of mathematics in cognitive domain, the control group (AMT) and the experimental group (CPA) were compared regarding the post-test scores of knowledge level achievements after adjusting for the effect of corresponding pre-intervention scores. Table 1 gives the results of the ANCOVA done in this context.

Table 1: Summary of ANCOVA: Achievement of knowledge level instructional objectives

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5.387[a]	2	2.694	1.196	.307
Intercept	616.948	1	616.948	273.896	.000
Pre-test *(ke)*	2.302	1	2.302	1.022	.315
Groups	2.903	1	2.903	1.289	.259
Error	193.714	86	2.252		
Total	2296.000	89			
Corrected Total	199.101	88			

[a.] R Squared = .027 (Adjusted R Squared = .004)

The F-ratio calculated for the groups is not significant (F = 1.289; p>.05), showing that the control group and experimental group do not differ significantly in their achievement of knowledge level instructional objectives. In another words, AMT and CPA are almost equally effective strategies in accomplishing knowledge level instructional objectives of seventh grade mathematics.

The AMT and CPA were compared regarding the post-intervention scores of understanding level attainment of instructional objectives after adjusting for the pre-intervention scores of the groups. Table 2 presents the result of the one-way ANCOVA carried out incidentally.

Table 2: Summary of ANCOVA: Achievement of understanding level instructional objectives

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	271.977[a]	2	135.989	32.645	.000
Intercept	1470.169	1	1470.169	352.925	.000
Pre-test (ug)	10.548	1	10.548	2.532	.115
Groups	248.380	1	248.380	59.626	.000
Error	358.247	86	4.166		
Total	5614.000	89			
Corrected Total	630.225	88			

[a.] R Squared = .432 (Adjusted R Squared = .418)

The F-ratio computed on comparing AMT and CPA regarding the post-intervention scores of understanding level instructional objectives in mathematics is significant ($F = 59.626$; $p<.001$). The mean estimated for the control group (AMT) is 5.83 and that for the treatment group (CPA) is 9.26, exposing that the CPA-approach is better than activity method in accomplishing understanding level instructional objectives of mathematics.

Covariate analysis was used to compare the AMT and CPA classes to explore the significant difference, if any, between the strategies in enabling the students to achieve application (ap) level instructional objectives of mathematics. The result of ANCOVA is presented in Table 3.

Table 3: Summary of ANCOVA: Achievement of application level instructional objectives

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	38.425[a]	2	19.212	7.577	.001
Intercept	1235.330	1	1235.330	487.177	.000
Pre-test (ap)	4.300	1	4.300	1.696	.196
Groups	33.310	1	33.310	13.136	.000
Error	218.069	86	2.536		
Total	2813.000	89			
Corrected Total	256.494	88			

[a.] R Squared = .150 (Adjusted R Squared = .130)

The F-ratio calculated for the groups is significant at .001 level. It indicates that AMT and CPA differ significantly ($F = 13.136$; $p<.001$) in their efficacy to accomplish application level

instructional objectives. The mean scores of achievements in application-level questions for AMT and CPA classes are in the order of 4.76 and 6.00 respectively. It shows that CPA is more effective than AMT in enabling the students to attain application level instructional objectives in mathematics.

The post-intervention scores of achievements in analysis *(ay)* level instructional objectives for the CPA and AMT classes were compared after adjusting for the effect of the covariate (pre-intervention scores) so as to find out the relative efficacy of the methods. The summary of the covariate analysis is shown in Table 4.

Table 4: Summary of ANCOVA: Achievement of analysis level instructional objectives

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	450.309[a]	2	225.155	49.125	.000
Intercept	3287.334	1	3287.334	717.244	.000
Pre-test (ay)	11.513	1	11.513	2.512	.117
Groups	437.384	1	437.384	95.430	.000
Error	394.163	86	4.583		
Total	6783.000	89			
Corrected Total	844.472	88			

[a.] R Squared = .533 (Adjusted R Squared = .522)

The obtained F-value is significant at .001 level ($F = 95.430$; $p<.001$), revealing the existence of an actual difference between AMT and CPA groups in the attainment of analysis level instructional objectives. The mean scores for the AMT and CPA classes are 6.02 and 10.47 respectively. It demonstrates that CPA is effective than AMT in empowering the learners to achieve analysis level instructional objectives of mathematics.

The relative effectiveness of AMT and CPA in accomplishing the synthesis (sy) level objectives of mathematics, the post-intervention scores of the groups were subjected to covariate analysis after controlling the effect of their pre-intervention scores. The summary of the ANCOVA is presented Table 5.

Table 5: Summary of ANCOVA: Achievement of synthesis level instructional objectives

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	18.759[a]	2	9.380	14.329	.000
Intercept	437.136	1	437.136	667.777	.000
Pre-test (sy)	.559	1	.559	.853	.358
Groups	17.756	1	17.756	27.125	.000
Error	56.297	86	.655		
Total	744.000	89			
Corrected Total	75.056	88			

[a.] R Squared = .250 (Adjusted R Squared = .232)

The F-ratio gained on comparing the AMT and CPA groups concerning the post-intervention scores of synthesis level achievement in mathematics is significant beyond .001 level ($F = 27.125$; $p<.001$). The mean estimated for the AMT and CPA groups are 2.30 and 3.21 respectively. It denotes that CPA is effective than AMT in realizing synthesis level objectives of teaching mathematics.

Covariate analysis for the comparison of CPA and AMT classes was done regarding the post-intervention scores of Maths achievement at evaluation *(ev)* level, after controlling the effect of pre-intervention scores as covariate. The result of ANCOVA done incidentally is shown in Table 6.

Table 6: Summary of ANCOVA: Achievement of evaluation level instructional objectives

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.370[a]	2	1.185	2.254	.111
Intercept	275.732	1	275.732	524.333	.000
Pre-test (ev)	.229	1	.229	.435	.511
Groups	2.232	1	2.232	4.244	.042
Error	45.225	86	.526		
Total	428.000	89			
Corrected Total	47.596	88			

[a.] R Squared = .033 (Adjusted R Squared = .010)

The F-ratio estimated on comparing AMT and CPA groups regarding the post-intervention scores of evaluation level attainment in mathematics is significant at .05 level ($F = 4.244$; $P<.05$). The mean post-test scores calculated are 2.22 and 1.91 respectively for the AMT class and CPA class, revealing that AMT is more successful than CPA-approach in accomplishing evaluation level instructional objectives in Maths.

6. Conclusion

The analysis revealed that Concrete Pictorial Abstract (CPA) approach is not significantly better than prevailing Activity Method of Teaching (AMT) in enabling the seventh-grade students to achieve knowledge level instructional objectives in mathematics ($F = 1.289$; $p>.05$). The hypothesis H_01 *(CPA-approach is not significantly different from the AMT in achieving knowledge level instructional objectives of seventh grade mathematics)* is, therefore, accepted. The CPA-approach was found significantly better than the AMT in enabling seventh graders to attain understanding level instructional objectives in mathematics ($F = 59.626$; $p<.001$). Th hypothesis H_02 *(CPA-approach is not significantly different from the AMT in achieving understanding level instructional objectives of seventh grade mathematics)* is, hence, rejected. Significant difference was noticed between CPA and AMT in their efficacy in empowering students to accomplish application level instructional objectives of Maths ($F = 13.136$; $p<.001$), the difference being in suuport of the CPA-approach. The hypothesis-H_03 (CPA-approach is not significantly different from the AMT in achieving *application* level instructional objectives of seventh grade mathematics) is, subsequently, rejected. In facilitating the accomplishment of analysis level instructional objectives of Maths to learners of Class-7, CPA is significantly more effective than the prevailing AMT ($F = 95.430$; $p<.001$). The hypothesis-H_04 *(CPA-approach is not significantly different from the AMT in achieving analysis level instructional objectives of seventh grade mathematics)* is, consequently, rejected. Significant difference exists between activity method of teaching and concrete pictorial abstract approach in their success in enabling seventh grade students to attain synthesis level instructional objectives in Maths ($F = 27.125$; $p<.001$). The CPA is more effective than AMT in helping the learner to achieve synthesis level instructional objectives. The hypothesis-H_05 *(CPA-approach is not significantly different from the AMT in achieving synthesis level instructional objectives of seventh grade mathematics)* is, hence, rejected. The AMT is significantly more successful than CPA in facilitating the accomplishment of evaluation level objectives of teaching mathematics to seventh class students ($F = 4.244$; $P<.05$). The hypothesis-H_06 (CPA-approach is not significantly different from the AMT in achieving *evaluation* level instructional objectives of seventh grade mathematics) is, therefore, rejected.

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