

EFFECTS OF CROSSWORD-PICTURE PUZZLE TEACHING STRATEGY AND GENDER ON STUDENTS' ACHIEVEMENT IN BASIC SCIENCE

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Abstract

This paper examined the effect of Crossword-Picture Puzzle (CPP) Teaching Strategy and gender on students' achievement in Basic Science. A pretest-posttest quasi experimental design was employed. The sample consisted of 389 JSS II Basic Science Students from nine schools randomly selected in three States in Southwestern Nigeria. Three instruments used were-Teachers' Instructional Guides for: Crossword-Picture Puzzle Teaching Strategy ($r=0.76$), Conventional Lecture Method ($r=0.74$); Basic Science Students' Achievement Test ($r=0.70$). Three hypotheses were tested at 0.05 level of significance. Data were analysed using ANCOVA and mean scores. Results showed that treatment had significant main effect on achievement score ($F_{(2,389)} = 202.16$; $p < 0.05$; $\eta^2 = .52$). Gender had significant main effect on achievement score ($F_{(1, 389)} = 3.99$; $p < 0.05$; $\eta^2 = .01$). The two-way interaction effect of treatment and gender was not significant on achievement score ($F_{(2,389)} = .980$; $p > .05$; $\eta^2 = .005$). Crossword-picture puzzle strategy is therefore, recommended to be adopted by Basic Science teachers and curriculum planners.

Keywords: Puzzle, Game, Effect Size, Southwestern Nigeria

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Introduction

The instructional approach recommended by the Nigerian Integrated Science Teacher Education Project (NISTEP) for effective teaching and learning of Basic Science is strongly activity-based. Basic Science which is the 'inter-link' among science subjects (Physics, Chemistry, Biology, Agricultural Science and Geography) presents various concepts from these different fields as a body of knowledge but not science in compartment. For the teaching and learning of Basic Science to be meaningful and effective, a number of concepts in Basic Science which have their origin from different science disciplines require appropriate instructional strategies for adequate understanding of these science concepts. The main objective of teaching and learning Basic Science is for the learners to acquire holistic, scientific knowledge, attitude and skills through well-organized and meaningful activities

coupled with appropriate methods that are activity-based such as crossword-picture puzzle based teaching strategy. Basic Science should be presented in a way that science will be viewed as a single entity and interesting endeavor through carefully selected activities and instructional strategies but not science in isolation or dogma.

Unfortunately, the way Basic Science is taught influences students' academic achievement. According to studies such as ^[15, 3], academic achievement in science especially Biology and Basic Science is declining. This has been attributed to lack of appropriate method to teach the subject. Experts are in their research efforts and recommendations advocating for more proven instructional strategies to teach Basic Science effectively ^[8, 16]. One of such strategies is the use of puzzle game.

The use of puzzle in science lessons has attracted the attention of educational researchers in their various studies ^[23, 9]. Game and picture appeal so much to children that they like to be engaged with them. These concepts (game-crossword puzzle and picture puzzle) in conjunction with science process skills (observing, recording, inferring, etc), that is, inquiry method, have been found effective in teaching and learning of Basic Science. Concerted effort to make social science lessons and social science related activities and concepts interesting and participatory has always being the major focus of educational research ^[4]. Interest prepares learners mind for science learning. But, unfortunately, interest of students in science tasks is disappearing and almost graduating into extinction. This reason may be the way science is taught. One of the possible ways to make science teaching and learning effective is the use of game (crossword puzzle and picture puzzle). ^[22] Writing on the potential of game said:

It's been information time and again that children retain more information when they're stimulated by and actively involved in the learning process. Interactive teaching has become increasingly popular and new tools and ideas for enhancing lesson plans are appearing every day. A great way to get students interested in learning is to bring the fun back into it by using educational games.

Children have some background experiences that can easily be incorporated into classroom situation. These children have been using toys to play game which have scientific implications.

Table 1: Varieties of Toys Used by Nigerian Children to Play Game

S/N	Item	Related Concept
1.	Catapult (*ofa)	Gravity, projectile and translational motion
2.	Mammalian Trap	Elastics and strings
3.	One string toy "guitar"	Sound-vibration curves and shapes
4.	Spinning snail shell (*okoto)	Motion, circular motion
5.	Kite (paper)	Air and motion
6.	Toy Telephone	Air and sound
7.	Spinning bottle top (*kanna-kanna)	Energy (motion changed to sound). Motion to and from straight line. Motion converted to rotational motion as in the working car engine.
8.	Paper drum and stick	Sound
9.	Music box (*Agidigbo)	Sound
10.	Air gun	Air motion and translational motion
11.	Pawpaw stick toy gun (*lbon)	Elastic, springs, gravity, motion accuracy and precision
12.	Bow and Arrow (*ofa)	Gravity, motion, shape, curves, muscular energy and parabola
13.	Pawpaw stalk gun	Variation of sound with air column being altered. Also, mechanical to sound energy
14.	*Ayo	Counting and reasoning
15.	Ballon filled with air	Force (Air force pushing up, balloon works like rocket)

(Source: [1])

Table 1 reveals that learners already have background knowledge of the concept of game. They can have a misconception that if any of these toys for playing game is brought to the school environment, there is tendency for their teachers to punish them. Therefore, using game as instructional strategy will correct such a misconception and harness game as a means of learning science effectively. Educational games have inherent potential to: arouse and sustain interest in learning, excite learners, generate new ideas in learners, teach difficult science concepts, remove fatigue, foster social interaction, recall information easily and generally, help learners with low achievement potential. To ascertain the alternative means of instructional strategy different from traditional modes of instruction, there is the need to examine effects of crossword-picture puzzle teaching strategy and gender on students' achievement in Basic Science.

Mixed reports abound from fields of research on gender issue. Some researchers reported a decline in gender differences in science achievement ^[2, 27]. Others found significant main effect of gender on subjects' learning outcomes in science. ^[13,16], found in their studies that male students achieved significantly better than female students in science subjects while in the studies carried out by ^[21, 25], girls performed better than boys in science subjects. Research reports from different dimension, ^[14, 11] found no significant difference in students' achievement in science. Since the reports from various studies on gender are inconsistent, gender was germane to this study.

Statement of Problem

Basic Science is a subject joining several subjects into a single course and offered by all students at junior secondary schools in Nigeria as a compulsory subject. Students that offer science as their career derive their foundational scientific knowledge from Basic Science. As important as the subject is, reports from examination bodies have shown that students record low achievement and problem solving skills in the subject. This has been attributed to the use of Conventional Lecture Method which concentrates on talking about problems rather than solving problems. Scholars have thus recommended the use of instructional strategies that could help students learn; engage in thought-provoking activities and acquire problem solving skills. One of such strategies is Crossword-Picture Puzzle Teaching strategy. This strategy has been proved in literature to be effective in teaching science subjects mostly in Northern Nigeria but there is paucity of research on their effects on students' achievement in Basic Science especially in South-Western Nigeria. Therefore, this study determined the effects of Crossword-Picture Puzzle and gender on students' achievement in Basic Science in South-Western Nigeria. The moderating effect of gender was also examined.

Hypotheses

1. There is no significant main effect of treatment on Students' achievement in Basic Science.
2. There is no significant main effect of Gender on Students' achievement in Basic Science.
3. There is no significant interaction effect of treatment and Gender on Students' achievement in Basic Science.

Scope of the Study

The study covered nine junior secondary schools in Southwestern Nigeria (Oyo, Ogun and Ondo). The study focused on the effect Crossword-Picture Puzzle teaching strategy and gender on students' achievement in Basic Science. Only public junior secondary schools in Oyo, Ogun and Ondo; South-western Nigeria used for the study. The content coverage was limited to six concepts in the JSS 2 Basic Science curriculum following thematic approach to content organization: You and The Environment (Drug Abuse); Living things and Non-living things (Habitat, Respiration, changes in matter); Science and Development (Information and Communication Technology); You and Energy (Heat Energy). The study was delimited to the effect of gender on JSS 2 students' achievement in Basic Science.

Methodology

A pretest, posttest, control group, quasi-experimental design was used to collect data for this study. The treatment operated at two levels-one experimental and one control group. The sample consisted of 389 JSS 2 Basic Science students randomly

selected from nine schools in Southwestern Nigeria. The intact classes of students were randomly assigned to two treatment groups-Crossword-Picture Puzzle teaching strategy group and Control group.

Instruments for Data Collection

The researchers prepared Basic Science Students achievement test. The instrument consisted of twenty (20) multiple choice items with five options (A-E) from which participants selected the correct alternative. The initial draft of forty multiple choice items was given to peer review and experts in the field of Science Education. This was done to ascertain the face and content validity of the instrument. Thirty (30) items survived scrutiny. It was later trial-tested in a secondary school that was not selected for the main study. It was the 20 items with discrimination indices between 0.4-0.6 that were used. The data collected were analysed using Kuder-Richardson formula 20 (Kr_{20}). The reliability coefficient of 0.70 was obtained.

The researchers prepared Teachers' Instructional Guide for Crossword-Picture Puzzle-Based Teaching Strategy (TIGCPP). This instrument contained the lessons for the eight weeks of treatment. The specific features of this guide are: small group experiment, individual experiment, the use of laboratory apparatus, the use of game with picture puzzles and crossword puzzles. To ascertain the face and content validity of the instrument, two lecturers from Science unit in the department of Teacher Education, Faculty of Education, University of Ibadan, Ibadan, were given copies of the instrument for close examination. Their suggestions and ratings were used to produce the final copy of the instrument and the inter-rater reliability was estimated using Scott's π and inter-rater reliability index of 0.76 was obtained.

The researchers also prepared Teachers' Instructional Guide for Conventional Lecture Method (Control) (TIGCLM). This instrument was a traditional teaching method. The instrument was given to two experienced junior secondary school teachers in the field of Basic Science to ensure its face and content validity. The instrument was made valid subject to their necessary corrections and approval. The inter-rater reliability estimated using Scott's π statistic and the inter-rater reliability index of 0.74 was obtained.

Pre-treatment and Treatment Activities

The researchers visited Ministries of Education and schools for the first one week. Two weeks for training of research assistants. Training was done step by step using the teaching guides on: Crossword-Picture Puzzle-Based Teaching Strategy and Conventional Lecture Method (Control). Next one week for pretest. All the students in the class involved in all the nine (9) representative schools were used for the experiment and were given a pretest on the evaluative instrument-Basic Science Students' Achievement Test (BSSAT). The treatment lasted for eight weeks. The

treatment was carried out on the experimental and control groups. During this period, students were taught six selected concepts in Basic Science using a double period with each single period lasting 40 minutes. The last one week was used for the administration of posttest after treatment using Basic Science achievement test. This makes a total of thirteen (13) weeks.

Experimental Group

The treatment here involved two phases (following Teachers' Instructional Guide for Crossword-Picture Puzzle-Based Teaching Strategy, TIGCPPTS) -inquiry, question and answer and games (crossword and picture puzzles). For inquiry, question and answer, questions were asked from students to help students understand a given idea, concept, principle, etc. Students were divided into small groups of 4-5 members. Students followed written instructions, manipulated apparatus, and classified quantities, took measurements of quantities, recorded observations, inferred from results and reported activities individually. In phase 2 which was game (Crossword and Picture Puzzles), students were divided into small groups of 4-5 members, followed verbal instruction on games, manipulated games, recorded score in games and winner of games recognized.

There were rules for playing the game.

Rules for Playing the Game-Picture Puzzle (Group Work)

There were two pieces of picture puzzle. One was labeled and the other one not labeled. A member of group was asked to pick a number. The picture pieces (from students' content note) that corresponded to this number would be given to the group to solve the puzzle. Five (5) minutes was given to the group to study the labeled piece after which it was withdrawn and was given the other piece which was not labeled to complete the puzzle by fixing the labels on the picture using another Five (5) minutes.

Rules for Playing the Game-Crossword Puzzle (Individual Work)

Individual student was given crossword puzzle on the given topic. Individual student was asked to form specific number of words (e.g. at least 10 words) in a specific time (e.g. 5 minutes) using the crossword puzzle.

Control Group

The treatment here involved conventional method (lecture method). The teacher followed Teachers' Instructional Guide for Conventional Lecture Method, TIGCLM.

Method of Data Analysis

Data collected were analyzed using ANCOVA and estimated marginal means of posttest scores to detect the differences in performance level.

Results

Hypothesis 1: There is no significant main effect of treatment on Students' achievement in Basic Science.

Table 2: Posttest Achievement Scores of Students by Treatment, Gender and Mental Ability

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4793.665	18	266.315	57.833	0.000	0.737
Intercept	5188.588	1	5188.588	1126.759	0.000	0.752
Pretest*	33.367	1	33.367	7.246	0.007	0.019
Treatment	1861.848	1	930.924	202.160	0.000*	0.521
Gender	18.363	1	18.363	3.988	0.047*	0.011
Mental ability	46.390	2	23.195	5.037	0.007*	0.026
Treatment*Gender	9.022	2	4.511	0.980	0.376	0.005
Treatment*Mental ability	30.020	4	7.505	.630	0.166	0.017
Gender*Mental ability	20.325	2	10.163	2.207	0.111	0.012
Treatment*Gender*Mental ability	11.707	4	2.927	0.636	0.637	0.007
Error	1708.409	371				
Total	73955.000	390	4.605			
Corrected Total	6502.074	389				

R Squared=0.737 (Adjusted R Squared=0.725) *significant at $p < .05$

Table 2 revealed that treatment had a significant main effect on students' posttest achievement scores ($F_{(2,389)} = 202.160$; $p < .05$; partial eta squared=.521. The effect size of 52.1% was fair. The hypothesis is therefore rejected. This means that there was a significant difference in the mean achievement scores of students exposed to Enhanced Explicit Teaching strategy and Conventional Lecture Method. On the basis of this finding, hypothesis 1 was rejected. To find out the magnitude of the mean scores of the groups' performance, Table 3 is presented

Table 3: Estimated Marginal Means of Posttest Achievement Scores by Treatment and Control Group.

Grand Mean=12.869

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Crossword-Picture Puzzle	16.921	.323	16.286	17.556
Conventional	8.817	.286	8.254	9.380

Table 3 revealed that students in the Crossword-Picture Puzzle Based Teaching treatment group had the highest adjusted posttest mean achievement scores ($\bar{x} = 16.921$) followed by students in the Conventional Lecture Method group ($\bar{x} = 8.817$). The grand mean being 12.869

Hypothesis 2: There is no significant main effect of Gender on Students' achievement in Basic Science.

Table 4: Estimated Marginal Means of Posttest Achievement Scores by Gender.

Grand Mean=13.518

Gender	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Male	13.848	.239	13.378	14.318
Female	13.188	.228	12.740	13.636

Table 4 revealed that male students had higher mean=13.848 while the female students had lower mean=13.188. It shows that the male achievement score was significantly different from their female counterpart.

Hypothesis 3: There is no significant interaction effect of treatment and Gender on Students' achievement in Basic Science.

Table 2 revealed that the two-way interaction effect of treatment and gender was not significant on students' achievement scores ($F_{(2,389)} = .980$; $p > .05$; partial eta squared=.005). The effect size of 0.5% was negligible. Therefore, hypothesis 3 was not rejected.

Summary of Findings

1. There was a significant main effect of treatment on students' achievement in Basic Science.
2. Posttest achievement mean score of male students was significantly higher than their female counterparts
3. The two-way interaction effect of treatment and gender was not significant on students' achievement.

Discussion of Findings

The result obtained revealed that there was a significant difference in the mean achievement scores of students exposed to Crossword-Picture Puzzle Based teaching and Conventional Lecture Method. Students in the Crossword-Picture Puzzle Based Teaching treatment group had the highest adjusted posttest mean achievement scores ($\bar{x} = 16.921$) followed by students in the Conventional Lecture Method group ($\bar{x} = 8.817$). The results from this study departed from earlier study by [1] that revealed no significant effect of treatment on students' achievement in Integrated Science. However, the result of this study lends credence to most researchers that recorded significant contributions of treatment on students' achievement in Integrated Science [24, 12]. The finding of this study was related to [8] that reported a significant

contribution of puzzle-based teaching strategy to students' achievement in Integrated Science.

The results obtained showed that male students had higher mean=13.848 while the female students had lower mean=13.188. It showed that the male achievement score was significantly different from their female counterpart. This means that the result of this study was in favour of male students. The result is consistent with the studies of ^[16, 7] who reported males' achievement in Integrated Science significantly better than their female counterparts. Although, ^[10] finding revealed that gender had significant main effect on achievement, the result was in favour of female students. Converse results of several studies showed that gender had no significant effect on achievement ^[6, 17]. Males having higher performance than their female counterparts in this work could be probably attributed to males' domineering tendencies during instructional process, discussions; always to lead and not ready to be led, their confidence and enthusiasm to approach new situation while the reason for females' underachievement in this study could be that they are easily discouraged and depressed when they are exposed to new situation.

Results of the study showed no significant 2-way interaction effect of treatment and gender on students' achievement in Basic Science. The results tend to suggest that treatment especially crossword-picture puzzle teaching strategy account for the improved performance of students in Basic Science and then should be adopted by the practicing teachers. The result is consistent with some previous studies of ^[19] on Mathematics achievement and ^[3] on Basic Science achievement and ^[26] on Physics achievement but at variance with others ^[5, 18] who worked on primary science and ^[20] on Basic Mathematics respectively.

Educational Implications

1. Students are familiar with game on mobile phones; they watch their parents and peers when playing with all sorts of game in their respective home. They would be motivated when they see their teachers in school using game especially puzzle game to teach them to overcome the tendency in hating Basic Science and the perception that some science concepts are difficult to learn.
2. The curriculum planners and Basic Science Teachers could make use of Crossword-picture puzzle for effective Basic Science delivery in schools.
3. The findings of the study also have implication for education sector in the area of training and retraining of teachers for professional developments

Conclusion and Recommendations

The study found that Crossword-Picture Puzzle-Based Teaching strategy was more effective than the Conventional Lecture Method in teaching the selected concepts in

Basic Science. Based on the findings of this study, the following recommendations are made.

1. To improve students' achievement in Basic Science, crossword-picture puzzle should be adopted in secondary schools.
2. Because of the potential benefits of educational game to foster learning during classroom instructional process, teachers should incorporate the use of game especially puzzle game for effective Basic Science delivery.

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