Effects of Crossword-Picture PuzzleTeaching Strategy and Mental Ability on Students' Achievement in Basic Science in Southwestern Nigeria

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Abstract: *This paper examined the effects of crossword-picture puzzle (CPP) and mental ability 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. Four instruments used were-Teachers' Instructional Guides for: Crossword-Picture Puzzle Teaching Strategy, Conventional Lecture Method; Basic Science Students' Achievement Test (r=0.70) and Australian Council for Educational Research Test (r=0.86) 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 ($F_{(2,389)} =202.16; p< 0.05; \eta^2 =.52$). Mental ability had significant main effect on achievement ($F_{(2, 389)} =5.04; p<0.05; \eta^2 =.03$). There was no significant two-way interaction effect of treatment and mental ability on achievement ($F_{(4,389)} =1.630; p>.05; \eta^2 =.017$). Crossword-picture puzzle strategy is therefore, recommended to be adopted by Basic Science teachers and curriculum planners.*

Word Count: *155*

Keywords: *crossword-picture puzzle, achievement, Basic Science, mental ability, southwestern Nigeria*

I.   Introduction

Basic Science is a core subject in junior secondary School Curriculum which has the potential role of laying the foundation for subject like Physics, Chemistry and Biology at the later stage of education. Reports from examination bodies have shown that students record low achievement in the subject (Federal Ministry of Education, Research Statistics and Planning Section, 2011). This has been attributed to the use of inappropriate method to teach this subject. Since academic achievement is still declining, scholars have thus recommended the use of other instructional strategies that could help students learn collaboratively, acquire problem solving skills and improve students' achievement.

Basic Science is one of the major subjects offered by all students in junior secondary schools in Nigeria. The number of students offering Basic Science is more than the number of teachers employed to teach the subject in various schools. Class size is large. This increases teachers' workload resulting in teachers' ineffectiveness. In addition, Basic Science has the perennial problems of lack of class activities, instructional resources and appropriate strategies to teach this subject.

However, the emphasis of educational researchers is on child-centred, active learning. This is the more reason why teaching-learning processes should be devoid of teachers dominating the class with ordinary mouth presentation of learning tasks. Multi-various teaching and learning approaches that attract students' attention, interest and most sense organs find their effectiveness in enhancing students' learning outcomes and also in the areas of science teaching and learning. One of these approaches that supports students' inclusive education and learning outcomes is the use of educational puzzles. Advocating for in-class activities and non-traditional teaching aids that can be effectively harnessed, researchers recommended the use of such activities and teaching strategy such as puzzle games to be adopted in the teaching and learning of science (Leong, 2005; Saunders and Christopher, 2003).

Educational games have inherent potential to: arouse and sustain interest in learning, excite learners, generate new ideas in learners, teach difficult science concepts, develop critical thinking, remove fatigue, foster social interaction, recall information easily and generally help learners with low achievement potential. Studies have shown the relevance of using puzzles to teach and learn science. As many studies reveal the use of puzzles being effective (Scott, 2006; Idowu and Ige, 2007; Kendall, Parks and Sperer, 2008), other study showed its limitation (Hill, 2003). As identified by Scott (2002), puzzles find their applications in science learning to introduce new ideas, test skills; pose problems that make learners ask challenging questions, help slow learners, can be used as classroom resources and develop students' manipulative skills. Bowers (2006) identified different types of puzzle. These are: Wooden puzzles, Jigsaw puzzles, Crossword puzzles, Logic Puzzles (Word puzzles or Mechanical puzzles), Pattern puzzles (which can be colors, shapes, numbers, letters or any combination of them), Riddles and Brain Teasers, Mazes and Picture puzzles while Cardenas-Nelson and Connolly (2011)

identified three types of picture puzzle: Spot-the-changes puzzles, Knot puzzles and Cut-Up puzzles. Out of these puzzle types, Crossword puzzle and Picture puzzle (Spot-the-changes puzzles) were used for the purpose of this study and this is called 'Crossword-Picture Puzzle Based Teaching Strategy'.

Studies revealed the effect of mental ability on students' learning outcomes. Aremu and Tella (2009) reported non-significant effect of mental ability on achievement. Mental ability has been found to have significant effect on learning outcomes (Raimi and Adeoye, 2002; Aremu and Sangodoyin (2010). There are differences in performance levels of students as a result of varying ability levels (Aremu and Sangodoyin, 2010). Students with higher mental ability tend to achieve highly in academic settings (Sophie,Benedikt, Chamorro-Premuzic and Tomas, 2011). Students with low mental ability tend to have low level of motivation towards learning and their attitude towards learning may be negative (Aremu and Sangodoyin, 2010). According to these researchers, methods and materials used for instruction play an active role in motivating students with low mental ability. This then implies that if students with low mental ability are exposed to appropriate method of instruction and relevant materials, their motivation to learn is likely to increase and this can invariably have a positive effect on their attitude and performance level as students with high mental ability also learn with ease. Since mental ability is an important construct that may determine the performance of students coupled with controversial research reports on this same variable, therefore mental ability was germane to this study.

Statement of Problem

Strategy that concentrates on talking about the problems instead of solving the problems is grossly inadequate for effective Basic Science delivery. Scholars have thus recommended other instructional strategies that help students learn collaboratively and encourage problem solving. One of such strategies is Crossword-Picture Puzzle teaching strategy. Therefore, this study sought to determine how Crossword-Picture Puzzle could as a teaching strategy improve junior secondary school students' achievement in Basic Science.

Hypotheses
1) There is no significant main effect of treatment on Students' achievement in Basic Science.
2) There is no significant main effect of Mental Ability on Students' achievement in Basic Science.
3) There is no significant interaction effect of treatment and Mental Ability 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 of Crossword-Picture puzzle-based Teaching 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 mental Ability on JSS 2 students' achievement in Basic Science.

II. 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 six 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.

III. Instruments for Data Collection

A Basic Science Students achievement test was designed by the researchers. 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.

Another instrument that was used in this study was Australian Council for Educational Research Test (ACERT). This is a standardized test and was adapted from Ehikhamenor (2012). It was a test used to classify the students into mental ability level (that is: high, moderate and low). The test consists of forty- two items (42) initially. The effectiveness of this test has been ascertained by Adekunle (2005). The test was observed to have

capacity in discriminating between high, moderate and low ability participants. The test was revalidated for its suitability by reviewing and critiquing in order to modify and detect technical errors. Thirty six (36) items survived scrutiny. The reliability was determined and the reliability index of 0.86 was obtained using Alternate/ Parallel forms of reliability. The participants who scored 60% and above in the ACER test were assigned to high mental ability group, those participants who scored within the range 40% to 59% were assigned to moderate ability group while those who obtained scores less than 40% were placed in low ability group.

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.

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.

Pre-treatment and Treatment Activities

The first one week was used for visitations to Ministries of Education and schools. The next 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 instruments- Australian Council for Educational Research Test (ACERT) administered first and followed by 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.

IV. Results

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

Table 1: 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	4.605			
Total	73955.000	390				
Corrected Total	6502.074	389				

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

Table 4.1 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 Crossword-Picture Puzzle Based teaching 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 2 is presented

Table 2: 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 2 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).

Hypothesis 2: There is no significant main effect of Mental Ability on Students' achievement in Basic Science. Table 1 revealed that mental ability of students had significant main effect on their achievement scores ($F_{(2,389)}$ =5.037; p<.05; partial eta squared=.026). The effect size of 2.6% was fair. Hypothesis 3 was therefore, rejected. This implies that there was significant difference in the achievement scores of students with high, moderate and low mental ability.

Table 4 Estimated marginal means of posttest achievement scores by mental ability.

Grand Mean=13.518

Treatment	Mean	Std.Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Low	12.963	.129	12.709	13.217
Moderate	13.440	.294	12.862	14.017
High	14.151	.378	13.407	14.895

Table 4 revealed that there was significant main effect of mental ability of students on their achievement scores. The magnitude of their contributions to the significance indicates that high ($\bar{x}$ =14.151) > moderate ($\bar{x}$ =13.440) > low ($\bar{x}$ =12.963).

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

Table 1 revealed that there was no significant two-way interaction effect of treatment and mental ability on students' achievement scores (F $_{(4,389)}$ =1.630; p>.05; partial eta squared=.017). The effect size of 1.7% was negligible, on the basis of this finding, hypothesis 5a was not rejected.

Summary of Findings
1) Basic Science mean achievement score of students exposed to Crossword-Picture Puzzle teaching strategy was significantly higher than that in the control group.
2) There was significant difference in the achievement scores of students with high, moderate and low mental ability.
3) There was no significant two-way interaction effect of treatment and mental ability on students' achievement scores

V.   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 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 Afuwape (2002) 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 a significant contributions of treatment on students' achievement in Integrated Science (Shaibu and Usman, 2002; Ige and Arowolo, 2003). The finding of this study was related to Bolorunduro (2005) that reported a significant contribution of puzzle-based teaching strategy to students' achievement in Integrated Science.

The results obtained revealed that mental ability of students was significant on their achievement scores. The study is consistent with Oshodi (2006) who found that ability was significant on learning outcomes in primary science. Students with high mental ability perform high, moderate mental ability students performed moderately while students with low mental ability obtained the least achievement score. This was in line with Aremu and Sangodoyin (2010) who found that students with high mental ability performed better than those with low mental ability but negates Ajila (2003) who found that students' academic ability was not significant on their achievement. Still in their study, these researchers had stated that there were differences in performance levels of students as a result of varying ability levels.

Result of the study revealed no significant 2-way interaction effect of treatment and mental ability on students' achievement in Basic Science. The results tend to suggest that treatment especially crossword-picture puzzle teaching strategy accounts 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 Aremu and Tella (2009); Oyeniran (2010) on Mathematics achievement and Agoro (2012) on Basic Science achievement and Ukoh (2012) on Physics achievement but at variance with others (Ajila, 2003; Oshodi, 2006) who worked on primary science and Patan, (2010) on Basic Mathematics respectively.

Educational Implications
a.   Students would be motivated when they see their teachers in school using game especially puzzle game to teach them.
b.   From the findings of this study, it is evident that it is possible to use crossword-picture puzzle as an alternative strategy of instruction at Junior Secondary school level.
c.   The curriculum planners could make use of Crossword-picture puzzle for effective Basic Science delivery in schools.
d.   The findings of the study also have implication for education sector in the area of training and retraining of teachers for professional developments

VI.   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.   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.

2. To improve students' achievement in Basic Science, crossword-picture puzzle should be adopted in secondary schools.
3. Teachers of Basic Science should find out about the mental abilities of their students and bearing these varied abilities in mind when planning and executing instruction in science classes.

Acknowledgment

References

[1]. Adekunle, M.O. (2005). Problem Solving and Concept Mapping Strategies as Determinants of Students' Achievement and Attitudes to Some Environmental Education Concepts in Social Science. Unpublished Ph.D Thesis, University of Ibadan.
[2]. Afuwape, M.O. (2002). Simulation game-Assisted Instruction, Students' cognitive style and numerical ability as determinants of learning outcomes in Integrated Science in Oyo State, Nigeria. An unpublished PhD Thesis, University of Ibadan.
[3]. Ajila, P.K. (2003). Comparative effects of explicit and Enhanced-explicit teaching on Learning outcomes in primary science in Ikere-Ekiti Locla Government Area, Nigeria. An unpublished PhD Thesis, University of Ibadan.
[4]. Aremu, A. and Sangodoyin, A. (2010). Computer Animation and the Academic Achievement of Nigerian Senior Secondary School Students in Biology. Journal of the Research Center for Educational Technology (RCET) 6(2): 148-161
[5]. Aremu,A. and Tella,A. (2009). The Relationship between Gender, Age, Mental Ability, Anxiety, Mathematics Self-Efficacy and Achievement in Mathematics. Journal of Educational Sciences 4, 113-124. www.world-education-center.org/index.php/cjes
[6]. Bolorunduro, O.M. (2005). The Impact of the Instructional Strategies of the Nigeria Integrated Science Teacher Education Project on Students' Learning Teacher Education Project on students'learning outcomes at Junior Secondary School Level. An unpublished Ph.D. Thesis, University of Ibadan.
[7]. Bowers, A. (2006). Teaching with Puzzles. http://www.education.more4kids.info
[8]. Cardenas-Nelson, E.J. and Connolly, J. (2011). Know the Types of Picture Puzzles.http://www.dummies.com/how-to/content/know-the-types-of-picture-puzzles.htm
[9]. Ehikhamenor,E.A.(2012). Effects of Two Modes of Problem Solving Models on Students' Achievement and Practical Skills in Practical Biology. A Post-Field Report Presented at the Joint Staff/Higher Degree Students' Seminar Series, Department of Teacher Education, Faculty of Education, University of Ibadan.
[10]. Federal Ministry of Education, Research Statistics and Planning Section .(2011)
[11]. Hill, J.M.D. (2003). Puzzles and Games: addressing different learning styles in teaching operating system concept. ACM Press. 182-186
[12]. Idowu, C.B. and Ige, A. (2007). Science Teachers' Assessment of Puzzle Games in the Teaching of Environmental Concepts of Integrated Science. Journal of Science Education 4(1)
[13]. Ige, T.A. and Arowolo, J.G. (2003). Effects of Hypothetico-Deductive Approach on J.S. III Students' Achievement in Integrated Science. Journal of the Science Teachers' Association of Nigeria 38(1&2): 39-45.
[14]. Kendalls, G., Parks, A. and Sperer. (2008). A Survey of NP-Complete Puzzles, International Computer Games Association Journal 31(1): 13-84
[15]. Leong, L. (2005). Improving Students' Interest in Learning: Some Positive Techniques. ournal of Information Systems Education 16 (2): 129-132.
[16]. Oshodi, O.O. (2006). Effect of the use of learning outcome specification on students' Achievement in Primary Science in Lagos, Nigeria. An Unpublished Ph.D Thesis, University of Ibadan.
[17]. Raimi, S.M. and Adeoye, F.A. (2002). Gender Differences Among College Students As Determinants of Performance in Integrated Science. African Journal of Educational Research 8(1&2),41-49
[18]. Saunders, G. and Christophers, J.E. (2003). Teaching outside the box: A look at the use of Some non-traditional teaching models in accounting principles courses. The Journal of American Academy of Business 3(1&2):162-165.
[19]. Scott, K. (2002). Ten Ways to Use puzzles in Math Education. http://www.scottkin.com/thinggames/index
[20]. _____ (2006). What is Puzzle? http://www.scottkin.com/thinggames/index
[21]. Shaibu,A.A.M. and Usman, I.A. (2002). Effects of NISTEP Mode of Teaching on Students' Academic Achievement in Integrated Science among Junior Secondary School Students. Journal of the Science Teachers' Association of Nigeria 37(1&2): 10-14
[22]. Sophie, V.S, Benedikt, H. and Chamorro-Premuzic, T. (2011). Hungry Mind: Intellectual Curiosity Is the Third Pillar of Academic Performance. Perspective on Psychological Science 6(6):574-588