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# Two Puzzle Models-Based Instructional Strategies' Efficacy and Parental Educational Background of Junior Secondary School Students' Achievement in Selected Concepts in Basic Science

**Dr. Adodo, S. O**
Science and Technical Education Department, Adekunle Ajasin University, Akungba Akoko. P.M B 001, Ondo State, Nigeria.
E-mail: so_adodo@yahoo.com, and Sunday.adodo@aaua.edu.ng
**Ogundare, Samuel Akinola**
Department of Teacher Education University of Ibadan.

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**Abstract**

The persistent poor performance of students in basic science at junior secondary school has been traced to dated teaching methods. Hence, the constant recommendations from scholars and teachers of the subject for the use of game-like instructional strategies. Regardless of these recommendations, little attention has been paid to these strategies by basic science teachers. This study, therefore, determined the potency of maze puzzle-based instructional strategy (MPS) and logic mechanical puzzle-based instructional strategy (LMPS) on students' achievement in basic science in Ondo State, Nigeria. The pretest-posttest, control group, quasi-experimental design was adopted. Participants were randomly assigned to MPS, LMPS and conventional lecture method (CLM). The treatment was for 13 weeks which involved MPS, LMPS and Conventional Instructional Guide. Two instruments used were: Students' Achievement Test (r=0.81), al one hypothesis was tested at 0.05 level of significance. Data were analyzed using ANCOVA and Scheffe's post hoc test. There were significant main effects of treatments on achievement score ($F(2, 277)=197.93$, $\eta 2=0.588$). The LMPS (=18.28) performed better than MPS (=14.92) and CLM (=12.53). Logic mechanical and maze puzzle-based strategies enhanced students' achievement in basic science. Parental educational background had significant main effects on students' achievement ($F(2, 277)=78.60$, $\eta 2=0.356$) High PEB (=16.67) students performed better than their moderate (=15.40) and low (=13.67) counterparts. Logic mechanical and maze puzzle-based strategies enhanced students' achievement in basic science. Therefore, the two strategies should be adopted by teachers to enhance better performance in basic science.

**Keywords:** Instructional strategies, Achievement inbasic science, Basic science.

## Introduction

Integrated Science (Basic Science) as an approach to teaching and learning of science in which concepts and principles are presented so as to express the fundamental unity of scientific thought and avoid pre-mature or undue stress on the distinctions between the various scientific fields (Afuwape, 2004).

In Nigeria, the revised National Policy on Education (FRN, 2014) stated that the need for scientific and technological progress of Nigeria as a nation necessitates the inculcation of the spirit of enquiry and continuity in the child through the exploration of nature and local environment from the pre-primary level so that, by the time the child would have passed through the primary school, a solid foundation for scientific and reflective thinking would have been laid. In addition, the policy emphasizes the goals of science education to include the development of scientific literacy in the citizens.

Basic Science and Technology Curriculum is the production of a re-aligned, re-structured and revised curricula for Primary Science and Junior Secondary School Integrated Science. In selecting the contents, three major issues shaping the development of nations worldwide and influencing the world of knowledge today were identified. These are globalization, information/ communication technology and entrepreneurship education. The desire of Nigeria to be identified with contemporary development worldwide, called for the infusion of relevant contents of four non-school curriculum innovations in the area of: Environmental Education (EE),. Drug Abuse Education (DAE), Population and Family Life Education (POP/FLE), Sexually Transmitted Infection (STI) including HIV and AIDS. Another line of infusion of content occurred in every class from Basic 1-9. Also, some introductory technology topics have been introduced at the lower and middle levels, while leaving the upper level with purely science topics.

The overall objectives of this curriculum are to enable the learners to:

i. develop interest in science and technology,
ii. acquire basic knowledge in science and technology,
iii. apply their scientific and technological knowledge and skills to meet societal needs,
iv. take advantage of the numerous career opportunities offered by science and technology, and
v. become prepared for further studies in science and technology.

In order to achieve a holistic presentation of science and technology contents to learners, the thematic approach to content organization was adopted. Also in order to achieve the stated goals and objectives, a number of steps have been taken by science educators, governmental and non-governmental organizations and professional bodies to promote the quality of learning and teaching of basic science in junior secondary schools in Nigeria and other parts of Africa. These include: Inauguration of programmes for science development e.g. African Primary Science Programmes (APSP), the Nigerian Primary Science Project (NPSP), Science Education Programmes for Africa (SEPA), Nigerian Integrated Science Project (NISP) for JSS one to three.

Instead of experiencing good outcomes in terms of students' achievement and attitude to basic science, the results from different scientific studies in Nigeria and particularly in Ondo State have not been encouraging (Adeyemi, 2006, Ajagun, 2006). In 2002 and 2003 JSSC examination, the Commissioner for Ministry of Education, Ondo State announced 40% and 32% pass rate with credit respectively.

This implies that over 60% of the candidates failed and this has been the trend for the past ten years (Adeyemi, 2006). Learners continue to manifest weak understanding of science concepts, skills acquisition to solve problems among others, not only in external examinations, but in also in classroom activities (Awe, 2010). The overall performance of students in Basic Science in Federal Unity Junior Secondary Schools follows the same trend in spite of the increased number of trained basic science teachers in the schools.

Afuwape and Olatoye (2004) in their studies advocated enriched mastery and methodology in order to improve students' learning outcomes in Integrated Science. Similarly, Afuwape and Olatoye (2003), in their investigations on how to improve students' attitude towards Integrated Science, recommended effective treatment of students' attitude towards integrated science, with the hope that the resultant positive attitude of the students towards integrated science would in turn improve their achievement. This is in consonance with the views of Augustine (2006) that mastery of school subjects depended on the amount of practice from the learner. Awe (2010) was of the opinion that any strategy that could be provided through means of repeating the learning associated with stimuli until desired response is achieved should be encouraged. To this effect for improved learning outcomes of students in basic science and technology, NERDC (2007) recommended the use of guided inquiry method of teaching and learning so as to promote learning by doing and skill development.

Okebukola (1998) in his work, emphasized concept – mapping. Ajala and Kpangban (2000) gave hint on how to enrich the teaching and learning of biology, while Ajayi (2011) highlighted that instructional materials should be varied for better learning outcomes. In spite of all these teaching strategies, students' learning outcomes in terms of academic achievement, positive attitudes towards basic sciences and problem-solving abilities continue to dwindle and deteriorate yearly. This study takes cognizance of using puzzles as resource materials in teaching and learning some perceived difficult and abstract concepts in basic science and technology, to enhance better students' learning outcomes.

The primary goal of the use of puzzles in teaching is to promote students' achievement and mastery of any classroom content or concepts. It also enhances problem-solving ability of learners in science. Over the years, various educators, such as Bower (2005) and Gardner (2007) have discovered the use of puzzles and its advantages in teaching and learning, especially science discipline that enhance problem – solving.

Scott (2005) defines puzzle as problem that requires fun to solve. Becky (2010) describes puzzles as games or problems that require careful thinking in order to solve or answer them. Puzzle could be defined as a problem that seeks solution. In a basic puzzle, the learners piece together objects in a logical way in order to come up with the desired shape, picture, object or solution (Kendall, Parkers and Speorer, 2008). One of the most useful means of ferreting out students' intuition on a given topic is to present them with a paradox or puzzles involving the concepts under treatment and have them struggle towards a solution.

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Gardner (2006) maintains that puzzles are great ways to get students excited about learning new ideas. The two basic types of puzzle-based instructional strategies developed and employed to teach the selected concepts and skills are maze and logic mechanical puzzles.

Maze is a puzzle in which the learner must trace a path through complex networks of lines without touching or crossing any of them. Maze puzzles teach spatial concepts, logical progression, and deductive reasoning, as well as directionality. Mazes are often considered to be art themselves. The concepts are incorporated or fixed into the complex network of lines which learners are expected to locate. When students are able to solve this puzzle and keep on repeating solving it either in the class or at home, the concepts become part of the students. Maze puzzle-based instructional strategy involves learning activities designed to include brief introduction of the concepts by the teacher and allowing the learners to solve maze puzzles designed to explain the concepts further through continuous practice. The planned result of maze puzzle-based instruction is achieved when the learners discover the guidelines for solving maze puzzles as highlighted by Geddes and Grosset 2011. The learner should be aware that there is always a hidden path that leads home without getting to a dead end, study the paths very well, start from the starting point, trace a path from the starting point to specific given location and observe things or objects he comes across. After locating the specific given object, he should continue his journey until he gets to the end point and take note of all what he comes across on the way and write them down.

Logic mechanical puzzles consist of mechanically interlinked pieces. The puzzle challenges the learner to explore the interlocking pieces in order to assemble or disassemble the puzzle, put the puzzle in sequence, or use dexterity to move the pieces. Logic mechanical puzzles teach logical thinking, deductive and inductive reasoning, spatial concepts, motor coordination, among others (Bower, 2006). The interlocking pieces could be of different shapes marked with different colors or numbers, in which the learners are to study and examine the pattern of the arrangement of the interlocking pieces using dexterity to either disassemble or assemble the pieces to form a desired shape. The concepts are also fixed or incorporated into the pieces of the puzzles, which the learners are to find solution to, hence giving the learners ample opportunity of practice and repetition (Squire, 2005; Habialla, 2006). Gardner (2006) emphasize the effectiveness of logic mechanical puzzle at enhancing students' performance and problem solving in mathematics and physics in high schools, but there is dearth in research findings of its efficacy on students' achievement, problem solving in and attitude to basic science. Logic mechanical puzzle-based instructional strategy involves learning activities designed to include brief introduction of the concepts by the teacher and allowing the learners to solve logic mechanical puzzles designed to explain further the concepts through continuous practice (Bowe, 2006). Logic mechanical puzzles are good for all categories of learners, even the tactile learners who often cannot absorb traditional educational methods. The conventional methods of instruction have been employed as old as education itself. Conventional lecture method is a teaching method where by the teacher comes to the class and delivers his lecture to his students, thus making him the sole source of knowledge.

This approach has dominated the educational arena – whether in history, physics, geography or any other subjects – almost ensuring that students never learn how to think about solving problems. This commonly used method by basic science teachers is monotonous, makes students passive listeners and prevents students from active thinking and learning (Ogundare, 2008; Anany and Mary, 2010).

Scholars have different opinions on the use of conventional teaching instructional strategies in the teaching and learning of science. Ogundare (2008) and Ajagun (2006) observed in their different studies that the conventional chalk and talk method commonly used by science teachers is monotonous, making students passive listeners and prevent students from active thinking and learning. Consequently, students perceive science subjects as difficult and have negative attitude towards science. They further argued that it has always resulted to under achievement among students. Brenda & Robbert (2005) argued that the conventional lecture method cannot be totally ignored; any innovation of instructional strategies is to complement the convectional lecture method, hence traditional method is still very much useful and a powerful instructional strategy. Another significant factor that has been found to influence students learning outcomes, especially abstract and difficult concepts in science, is parental educational background. Parental educational background is one of the factors or variables that determine the socio-economic status of parents. The level of education determines other variables such as parent's education, type of environment or home lived in, number of children in the family, number of people living in the house, type of school the children attend, type of educational resources the children play with at home and language spoken at home etc. These variables collectively determine socio economic status of learners.

Research studies, such as those of Chukwuka, (2006) and Jacob (2006), have found that the higher the educational background of participants' parents, the better their performance in mathematics and science subjects. Among the reasons suggested were that most parents that are not educated are financially poor and could not provide learning resources such as mathematics kits, toys, puzzles and other materials for them. Also, children obtain many of their attitudes and values from their parents, and that the values placed upon education by their parents could influence students' attitude to school and parents' love of preparation and inspiration. However, Okafor (2010) observed in his study that there was no correlation between parental educational background and gain in attitude and no correlation between parental educational background and students' achievement in science subjects.

Added to this, Ogunmakinwa (2006) reported that students of different parental educational backgrounds performed about equally well in the posttest scores in his study of cognitive differences in Basic Science of JSS 1. There is therefore need to test the effects of two modes of puzzle-based instructional strategies on students' learning outcomes by parental educational background.

### Statement of the Problem

This study determined the effects of maze and logic mechanical puzzle-based instructional strategies on JSS students' achievement in basic science in Ondo State, Nigeria. The moderating effects of students' parental background on students' achievement in basic science was also determined.

### Hypotheses

Ho1: There is no significant main effect of parental educational background on students' achievement in basic science

### Methodology

Using a pretest, posttest control group, quasi-experimental design, a sample of 296 JSS II basic science students from six junior secondary schools stratified and purposefully selected from Six junior secondary schools located in three Local Government councils area in Ondo State, participated in the study. Each school was randomly assigned to treatment group from the selected schools. In all, two schools were involved in the control of 50 students per each class and four schools for the experimental groups (2 schools for maze puzzle-based of 50 students and 48 students per class respectively and 2 schools for logic mechanical puzzle-based instructional strategies) of 50 students and 48 students per class respectively. The instrument used was Students' Achievement Test in Basic Science (SATBS r=0.81). and Parental Educational Background Questionnaire (PEBQ)The treatment was for 12 weeks which involved Maze Puzzle Strategy (MPS), Logic Mechanical Puzzle Strategy (LMPS) and Conventional Instructional Guide (CIG). The Teachers' Instructional Packages (TIP) were the puzzle-based instructional Guides (Maze Puzzle-Based Instructional Package (MPBIP), Logic Mechanical Puzzle- Based Instructional Package (LMPBIP) and the Conventional Instructional Method Guide for the Treatment. Data collected were analyzed using mean and standard deviation inferential statistics such as Analysis of Covariance (ANCOVA) to determine the significant main effects. Estimated marginal mean (EMM) was used to determine the magnitude of the mean scores across the groups. Where significant difference was observed, Scheffe Post-hoc analysis was used to determine the direction of significance and to estimate the amount of variation due to independent variables.

### Results

**HO 1:** There is no significant main effect of parental educational background on students' achievement in basic science. In testing this hypothesis, ANCOVA was computed and the results are presented in table 1.

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**Table1: Summary of 3x2x3 Univariate ANCOVA of Post test Achievement Scores of Participants by Treatment and Parental Educational Background. (PEB)**

| Source | Type III Sum of Squares | Df | Mean Square | F | Sig | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 2526.586 | 18 | 140.366 | 50.141 | .000 | .765 |
| Intercept | 4349.646 | 1 | 4349.646 | 1553.7 | .000 | .849 |
| PREACHT | 57.894 | 1 | 57.894 | 70 | .000 | .069 |
| TREATMENT | 1108.155 | 2 | 554.078 | 20.681 | .000 | .588 |
| PEB | 428.871 | 2 | 214.436 | 197.92 | .000 | .356 |
| Error | 775.438 | 277 | 2.799 | 6* | | |
| Total | 69393.000 | 296 | | 76.600 | | |
| Corrected Total | 3302.024 | 295 | | * | | |

a. R Squared = .765 (Adjusted R Squared = .750) * Significant at p < .05

Table 1 shows that there was significant main effect of treatment on students' posttest achievement in Basic Science ($F_{(2,277)}$ = 197.93, p<.05), $\eta^2$ = 0.588). The effect of 58.8% was moderate. Hence, treatment accounted for 58.8% variation of student' achievement in basic science.

From Table 1, it was indicated that there was significant main effect of parental educational background on students' achievement in basic science ($F_{(2,277)}$, = 76.60, P < .05), $\eta^2$ = 0.356). The effect of 35.6% was moderate. Hence, parental educational background accounted for 35.6% variation of learners' achievement in basic science. Therefore, the hypothesis was rejected. Furthermore, the adjusted mean score for students' achievement across the divide of low, average and high parental educational background is shown in Table 2.

**Table 2: Estimated Marginal Means of posttest Achievement Scores of Participants by Parental Educational Background.**

| Parental Educational background. | Mean | Std Error | 95% Confidence Level | |
|---|---|---|---|---|
| | | | Lower bound | Upper bound |
| Low | 13.67 | .138 | 13.39 | 13.94 |
| Moderate | 15.40 | .230 | 14.95 | 15.86 |
| High | 16.67 | .208 | 16.26 | 17.06 |

Table 2 indicates that high PEB group obtained the highest adjusted mean score of 16.67, followed by those of moderate PEB who recorded adjusted mean score of 15.40 while those of low PEB recorded the least adjusted mean score of 13.67. The direction of the significant difference across the divide of low, moderate and high parental educational background is shown in Table 3 which presents the pairwise comparison of Scheffe post hoc analysis carried out.

**Table 3: Scheffe post-hoc analysis of posttest achievement scores by Treatment and Control group**

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| Parental Educational background | N | Mean | 1 | 2 | 3 |
|---|---|---|---|---|---|
| 1 Low | 105 | 13.67 | | | |
| 2 Moderate | 102 | 15.40 | * | | |
| 3 High | 89 | 16.67 | * | * | |

*Pairs of groups significantly different at p<.05

Table 3 indicates that the high group ($\bar{x}$ = 16.67) differs significantly from low average group ($\bar{x}$ = 13.67) and the average group ($\bar{x}$ = 15.40) also the average group differs significantly from the low group. Hence, the group's difference was responsible for the observed significant main effect of treatment on students' achievement in basic science among the three levels of students' parent backgrounds.

## Discussion

The study showed that there was significant main effect of parental educational background on students' achievement in basic science across the groups. The estimated marginal mean scores of PEB in Table 2 reveals that students from high PEB had the highest adjusted mean scores than both students from average and low PEB. This may be attributed to the fact that students from high PEB have more access to instructional resources, such as toys, educational puzzles, mathematics kits, among others, which they might have been familiar and interacted with than their counterparts from average and low PEB at home. Besides, those parents that are highly educated with high socio-economy status can afford to purchase them for their children and wards in order to enhance their learning. Probably they guide and give extra coaching to their children at home. This finding is in line with the findings of Chukwuka (2006) and Jacob (2006), who observed that there is significant positive relationship between PEB and students' achievement in chemistry. The finding negates the results of Okafor (2010) and Ogunmakinwa (2006) who found that PEB would make no noticeable contribution to students' achievement in mathematics.

## Conclusion

Conclusively, the study established that students' PEB had significant effects on students' achievement in basic science in favour of participants from high PEB. Some of the reasons that made this possible are that parents with high educational background could afford to buy toys, educational resources and educational puzzles for their children. It then becomes necessary for school management, government and parents to buy educational resources such as mathematical and science kits and educational puzzles for schools for students to interact with both at schools and at home.

## Recommendations

Based on the findings of this study, the following recommendations are made. The logic mechanical and maze puzzle-based instructional strategies are recommended for teaching basic science at junior secondary schools for improved performance in achievement in basic science.

Seminars, conferences, symposia among others, should be organized at federal, state and local government levels for service and in-service teachers on the technicalities of how to develop design and use maze and logic mechanical puzzle-based instructional strategies for lesson delivery.

School administrators in both public and private schools should adopt maze and logic mechanical puzzle-based instructional techniques by encouraging their teachers and students to use them. They should also purchase puzzle materials and keep them in resource room.

Curriculum planners and developers should incorporate educational resources such as games, computer and puzzles into the curricula at all levels in Nigeria. Teachers should be encouraged to use them.

Teachers should be more resourceful, creative and innovative so as to encourage students to learn on their own rather than making teachers to be reservoir of knowledge.

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