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EFFECT OF PUZZLE LEARNING STRATEGY ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT AND RETENTION IN CHEMISTRY IN ZONE B AREA OF BENUE STATE, NIGERIA.

***[1]Infancy. T. M., [1]Dr. Adzape. N. J., [2]Prof. Adejoh. J. M., [2]Prof. Okwara. K. O.**

[1]Department of Chemistry Education, Joseph Sarwuan Tarka University, Makurdi.

[2]Department of Biology Education, Joseph Sarwuan Tarka University, Makurdi.

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***Corresponding Author: Infancy. T. M.**

Department of Chemistry Education, Joseph Sarwuan Tarka University, Makurdi.

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ABSTRACT

The study investigated the effect of puzzle learning strategy on secondary school students' achievement and retention in Chemistry in Zone B area of Benue State, Nigeria. The study was guided by 2 research questions and 2 hypotheses. A quasi-experimental, non-randomised, pre-test post-test control group design was adopted for the study. The population of the study comprised 6740 SS11 Chemistry students (3960 males and 2780 females) in the seven local government areas of Zone B, Benue State. A multistage sampling procedure was used to sample 346 Chemistry students (195 male and 151 female) from 8 public co-educational schools. The instruments for data collection were the Chemistry Achievement Test (CAT) and Chemistry Retention Test (CRT). The reliability of CAT was determined using Kuder-Richardson KR-21, which yielded a reliability coefficient value of 0.87. The CAT was reshuffled to have the CRT. Data collected were analyzed using descriptive statistics of mean and standard deviation to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. The findings of the study revealed a significant difference in the mean achievement and retention scores of students taught Chemistry using the puzzle learning strategy and those taught using the lecture method ($P=0.000 < 0.05$), in favour of those taught using the puzzle learning strategy. It was concluded that puzzle learning strategy enhances students' achievement and retention in Chemistry. Based on the findings, the study recommended, among others, that Curriculum planners should incorporate puzzle learning strategy into the school curriculum for effective

teaching and learning. Teachers should adopt puzzle learning strategy as an effective approach of passing instruction to learners.

INTRODUCTION

Developing nations are investing resources in the teaching and learning of science and technology to improve the standard of living of their citizens and are also providing solutions to global challenges. It is imperative, therefore, that Nigeria, as a developing country, must not be left out of this deliberate effort to invest in science and technology to improve the standard of living of its citizens and provide solutions to its problems. For science and technology to thrive in Nigeria, innovative teaching strategies need to be employed in teaching science subjects, as noted by Orhii (2018). The core science subjects that students are taught at secondary school and expected to pass before furthering their career in science at tertiary institutions include Chemistry, Physics, Biology, and Mathematics.

The teaching and learning of science subjects, especially Chemistry, may be difficult because of the subject's abstract nature. Most teachers in Zone B area of Benue State Nigeria teach the subject abstractly, which can make it difficult to understand. Chemistry is important as it deals with the study of everything around us. Ababio (2016) defines Chemistry as a branch of pure science that deals with the composition, properties, and uses of matter. Chemistry is the scientific study of matter, its properties, and its interactions with other matter and energy (Möller, 2022). Chemistry teachers are expected to adopt innovative and learner-centred instructional approaches that actively engage students during learning, this can enhance students' academic achievement and retention, rather than relying completely on the traditional methods.

The traditional teaching approaches, according to Lammers & Murphy (2018), are long-established, teacher-centred approach to instruction that focuses on transferring knowledge from the teacher to the students. In this approach, the teacher is the primary authority while students primarily listen, take notes, and memorise. The lecture approach, as noted by Apine (2022), is a traditional teaching method in which the teacher verbally conveys information while students listen and take notes. It involves a facilitator presenting information verbally to a group of learners, often with limited interaction during the session. Other traditional teaching methods include: Demonstration method, discussion methods, Chalk and Talk, Recitation/Drill, Storytelling, and the Question-and-Answer approach. Most of these approaches are not learner centered and activity-based. Hence, the need to adopt innovative

teaching approaches like the puzzle learning strategy which is learner centered (Adewumi,2023)

Puzzle learning approach is a learner-centred and activity-based approach that requires learners to use logic and critical thinking skills to provide solutions to tasks (Costa, 2017). According to Whitton (2017) Puzzle Games are categorised into: traditional puzzles, logic puzzles and digital puzzles with examples such as word search puzzles, crossword puzzles, jigsaw puzzles, definition builder puzzles can be used by teachers and learners to meet learning goals in Chemistry. The use of this approach, according to Hussein, Elaish, and Jensen (2022), helps improve learners' critical thinking skills and prepare them for higher learning. The use of this strategy in learning is referred to as edutainment, because students are entertained in the process of learning. Puzzle-learning approach can be a suitable replacement for the traditional approach because the traditional approach is purely teacher-centred and renders learners passive, the students are likely to lose interest during lessons due to a lack of engagement. This lack of engagement makes learning bored resulting in poor achievement.

Achievement is the extent to which a student, teacher, or institution fulfils their intended learning objectives, goals, and outcomes in a particular subject, course, or program (Hellas, Ihantola, Petersen, Lister, & Simon, 2018). Achievements is reflected in grades, test scores or even the completion of certain levels of educational tasks. Puzzle learning strategy influences students' achievement by promoting active engagement and deeper cognitive ability during learning. Through problem-solving and pattern recognition, students can develop critical thinking skills that enhance their achievement (Hsu & Wang,2018). The ability of students to manipulate subject-based puzzle games while learning significantly sustains their understanding (Anjurin-Ojewole, 2023). The approach serves as a motivation strategy that plays a central role in students' achievement, as highly motivated learners show persistence and are consistent in solving complex problems and retaining knowledge.

Retention refers to the ability of learners to remember, recall, and apply knowledge, skills, or concepts acquired during instruction over a period of time. Tanner (2017) defines retention as the long-term storage and retrieval of information from memory. Students' ability to retain knowledge is closely tied to their ability to understand and apply the knowledge in problem situations (Blaich, Wise, & Pascarella, 2020). Students do not merely memorise facts when they use puzzle learning strategy; they actively connect concepts while solving puzzles. This promotes deeper understanding and longer-lasting learning. The enjoyable and challenging nature of puzzles can sustain students' attention during Chemistry lessons, thereby increasing

the likelihood that what they learn will be retained. Students who learn Chemistry using puzzle games are required to recall chemical concepts, terms, symbols, and relationships while solving problems. Repeated retrieval strengthens memory and makes information easier to recall later.

Statement of the Problem

The needs of learners remain the central focus of any educational system. In recent times, there has been a shift in learning from teacher-centred to learner-centred in most educational institutions. This shift has given rise to innovative instructional strategies which may help to improve students' engagement and learning outcomes. Puzzle learning strategy, being an innovative and learner-centred approach, has gained attention in different parts of the world (Ajayi & Ogbeba, 2017). However, in Zone B Area of Benue State, the traditional approach is the method commonly in used, and innovative strategies are rarely in used by Chemistry teachers, which may be the reason why students record poor achievement and retention in Chemistry. This poor achievement and retention can be seen in the examiners' reports of the West African Secondary School Certificate Examination (WASSCE) from 2015 to 2023. The trend of failure is worrisome and underscores the need for the adoption of innovative instructional strategies that may improve students' achievement and retention in Chemistry. Furthermore, poor academic achievement in Chemistry has serious implications for students' admission into higher institutions, as it limits their eligibility for science-related programmes, reduces their competitiveness in admission processes coordinated by the Joint Admissions and Matriculation Board, and often compels them to pursue alternative fields or remedial programmes, thereby delaying their academic and career progression. It is on this premise that this study investigated the effect of puzzle learning strategy on secondary school students' interest, achievement, and retention in Chemistry in Zone B Area of Benue State, Nigeria.

Purpose of the Study

The purpose of this study was to investigate the effect of puzzle learning strategy on secondary school students' achievement and retention in Chemistry in Zone B Area of Benue State. Specifically, the study sought to:

1. ascertains the effect of puzzle learning strategy on the achievement of secondary school students in Chemistry in Zone B area of Benue State.

2. find out the effect of puzzle learning strategy on the retention of secondary school students in Chemistry in Zone B area of Benue State.

Research Questions

The following research questions guided the study:

1. What is the difference in the mean achievement scores of secondary school students taught Chemistry using puzzle learning strategy and those taught using the lecture method?
2. What is the difference in the mean retention scores of secondary school students taught Chemistry using puzzle learning strategy and those taught using the lecture method.

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance.

HO_1. There is no significant difference in the mean achievement scores of secondary school students taught Chemistry using puzzle learning strategy and those taught using the lecture method.

HO_2**:** There is no significant difference in the mean retention scores of students taught Chemistry using puzzle learning strategy and those taught using lecture method

METHODOLOGY

This study adopted quasi-experimental nonequivalent pre-test post-test research design, where intact classes were randomly assigned. The experimental design explored the cause-and-effect relationship between the independent and the dependent variables. The use of the intact classes ensured that school programmes were not disrupted. The study was carried out in seven local government areas of Zone B Area of Benue State. The population of this study consisted of 6740 (3960 males and 2780 females) SS11 Chemistry students across 85 secondary schools in seven local government areas of Zone B area of Benue State (Benue State Teaching Service Board, 2025). A sample size of 346 (195 males and 151 females) Chemistry students from 8 public co-educational schools in the four educational zones of Zone B was selected using a multistage sampling technique. The educational zones were Gwer-West/Gwer-East, Makurdi/Guma, Gboko/Tarka, and Bukuru. 8 schools were purposively selected to ensure equal representation from the four zones. Two instruments were adopted, which are Chemistry Achievement Test (CAT) and Chemistry Retention Test (CRT). Both instruments had sections A and B. Section A was used to collect personal data of students, while section B consisted of 30 items multiple choice questions with four options

(A, B, C and D). The items in CAT and CRT were the same except that they were reshuffled. Face and content validity were carried out on the instruments and the lesson plan. Copies of the instruments were given to five experts, alongside the objectives of the study, research questions, hypotheses, lesson plans, and marking schemes. Two of the experts were in the Department of Chemistry Education from Moses Orshio Adasu University, Makurdi (MOAUM), one was in Physics Education, another in Integrated Science and the other in Test and Measurement from Joseph Sarwuan Tarka University, Makurdi. Periodic table and Chemical Reactions were the topics used for constructing the CAT. The experts in Chemistry Education, Integrated Science, Physics Education and Test and Measurement checked the face and content validity of the instruments. They also checked the instruments in terms of clarity of items and ambiguity of words, content coverage, and relevance of the test items to the objectives of the study. The rationale for the check was to ensure that the instruments accurately measure what they were intended to measure. After validation, the instruments were trial-tested on 40 students from the School for the Gifted and Talented Makurdi, Benue State, who were not part of the research but exhibited similar characteristics to the subjects in the main study. The reliability of CAT was found to be 0.87 using Kuder-Richardson KR-21.

RESULTS

Research Question 1: What is the difference in the mean achievement scores of students taught Chemistry using puzzle learning strategy and those taught using lecture method?

Table 1: Mean and Standard Deviation of Achievement Scores of Students Taught Chemistry using Puzzle Learning Strategy and those Taught Using Lecture. (N= 346)

Method	N	Pre-interest		Posttest		Mean gain
		Mean	SD	Mean	SD	
Puzzle learning strategy	174	21.21	5.47	25.49	3.76	**4.28**
Lecture Method	172	21.29	5.64	22.42	5.75	**1.13**
Mean difference		**-0.08**		**3.07**		**3.15**

Source: Field Study, 2025(N = Sample size, SD = Standard Deviation**)**

Table 1 showed the mean achievement scores of students taught Chemistry using puzzle learning strategy and those taught using lecture method. Students taught using puzzle learning strategy had a pre-test mean score = 21.21 with a standard deviation (SD)=.5.47 and post achievement mean =25.49 and SD=3.76. while students taught using lecture method had mean achievement = 21.29 and SD= 5.64 for pre-interest and post-interest mean rating = 22.42 and SD=5.57 respectively. The Table further showed the mean gain of 4.28 for Chemistry students taught using puzzle learning strategy and mean gain of 1.13 for students

taught using lecture method. The mean difference between the groups was 3.15 in favour of Chemistry students taught using puzzle learning strategy.

Research Questions 2: What is the difference in the mean retention scores of students taught Chemistry using puzzle learning strategy and those taught using lecture method?

Table 2: Mean and Standard Deviation of Retention Scores of Students Taught Chemistry using Puzzle Learning Strategy and those Taught using Lecture Method. (N=346)

Method	N	Post-test		Retention		Mean gain
		Mean	SD	Mean	SD	
Puzzle learning strategy	174	25.49	3.76	28.19	3.06	**2.70**
Lecture Method	172	22.42	5.75	23.61	5.58	**1.19**
Mean difference		**3.07**		**4.58**		**1.51**

Source: Field Study, 2025(N = Sample size, SD = Standard Deviation**)**

Table 2 showed the mean and standard deviation of retention scores between students taught Chemistry using puzzle learning strategy and those taught using lecture method. Students taught Chemistry using puzzle learning strategy had a post-test mean score of 25.49 with a corresponding standard deviation (SD)=3.76 and retention mean scores =28.19 and SD=3.06. while students taught using the lecture method had post-test mean score of 22.42 with SD =5.75 and retention mean score of 23.61 and SD=5.58 respectively. The Table further showed the mean gain of 2.70 for Chemistry students taught using puzzle learning strategy and mean gain of 1.19 for students taught using lecture method. The Table shows mean retention difference of 1.51 in favour of Chemistry students taught using puzzle learning strategy.

Hypothesis 1: There is no significant difference in the mean achievement scores of students taught Chemistry using puzzle learning strategy and those taught using lecture method.

Table 3: ANCOVA Test of Mean Achievement Scores of Students Taught Chemistry using Puzzle Learning Strategy and those Taught using Lecture Method.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	824.751[a]	2	412.376	17.501	.000
Intercept	11972.426	1	11972.426	508.116	.000
PretestAchievement	9.613	1	9.613	.408	.523
Treatment	816.346	1	816.346	34.646	.000
Error	8081.899	343	23.562		
Total	207675.000	346			
Corrected Total	8906.650	345			
Source: Field Study, 2025(P<0.05)					

Table 3 revealed that, F (1,345) =34.646, P=0.000 < 0.05. Since the P value (0.000) was less than the alpha level (0.05), the null hypothesis which state that there is no significant difference in the mean achievement of students taught Chemistry using puzzle learning strategy and those taught using lecture method was rejected. This implied that there was a significant difference in the mean achievement of students taught Chemistry using puzzle learning strategy and those taught using lecture method in zone B area of Benue State. The difference is in favour of students taught using puzzle learning strategy.

Hypothesis 2: There is no significant difference in the mean retention scores of students taught Chemistry using puzzle learning strategy and those taught using lecture method

Table 4: **ANCOVA Test of Mean Retention Scores of Students Taught Chemistry using Puzzle Learning Strategy and those Taught using Lecture Method.**

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	3318.768[a]	2	1659.384	135.599	.000
Intercept	1622.586	1	1622.586	132.592	.000
Posttest Achievement	2745.962	1	2745.962	224.390	.000
TREATMENT	48.429	1	48.429	3.957	.047
Error	4197.454	343	12.237		
Total	222219.000	346			
Corrected Total	7516.223	345			
Source: Field Survey, 2025(P<0.05)					

Table 4 revealed that, F (1,345) =3.957, p = .047 < 0.05. since the p value (.047) was less than the alpha level (0.05) the null hypothesis which state that there is no significant difference in the mean retention scores of students taught Chemistry using puzzle learning strategy and those taught using the lecture method is rejected. This implied that there was a significant difference in the mean retention scores of students taught Chemistry using puzzle learning strategy and those taught using the discussion method in favour of those taught using puzzle learning strategy.

DISCUSSION OF FINDINGS

The findings reveal that there is a significant difference in the mean achievement scores of students taught Chemistry using puzzle learning strategy and those taught using lecture method. This means that SS II students who learned Chemistry using puzzle learning strategy achieved higher scores than those taught using the lecture method, highlighting the effectiveness of the puzzle learning instruction strategy in improving academic achievement in Chemistry. This finding is in agreement with Ebizie, Oraelosi, and Nwodo (2024), who

found that school pupils exposed to puzzle learning approach achieved significantly better than those exposed to the conventional method of instruction. Also, the study is consistent with the findings of Joshua and Okoli (2019), who found that students who were taught using crossword puzzle achieved significantly higher scores than those taught using the conventional method. The consistency in the result is because puzzle learning strategy encourages students to think critically, analyze information, and solve problems, which can lead to better academic achievement in Chemistry. This implies that puzzle learning is an effective instructional approach for improving students' understanding and academic achievement in Chemistry. The findings provides an answer to the corresponding research question by establishing that students taught using puzzle learning strategy have higher achievement than those taught using the lecture method.

The third finding showed that, there is a significant difference in the mean retention scores of SS II students taught Chemistry using puzzle learning strategy and those taught using lecture method. The findings imply that SS II students taught using puzzle learning strategy achieved higher retention scores than those taught using the lecture method. This demonstrates the effectiveness of the puzzle learning strategy in improving long-term retention in Chemistry. The finding aligns with the findings by Idika and Oluwaseyi (2024), who found that students exposed to puzzle instructional learning showed higher retention scores than those in the control group. The consistency in the findings is because puzzle learning strategy involves activities that often require students to concentrate and exercise multiple times with the aim of getting the solution. This culture of repeating exercise or activities improves long-term retention of concepts. Students are also tasked with the responsibility of relating the puzzle activity to the content, which facilitates their retention ability. The findings provide an answer to the corresponding research question by establishing that students taught using puzzle learning strategy have higher retention ability than those taught using the lecture method.

CONCLUSION

Based on the findings obtained from the data collected, it was concluded that students taught using puzzle learning strategy have better achievement and retention than those taught using the lecture method. This indicated that puzzle learning strategy is an effective instructional strategy for enhancing students' achievement and retention in Chemistry.

RECOMMENDATIONS

1. Curriculum planners should incorporate the Puzzle Learning Strategy into the Chemistry curriculum to promote effective teaching and learning and improve students' achievement and retention in Chemistry.
2. Chemistry teachers should incorporate the Puzzle Learning Strategy into the teaching and learning of Chemistry, particularly for concepts that students perceive as abstract or difficult.
3. School administrators should provide Chemistry teachers with adequate instructional materials and other resources required for the effective implementation of puzzle-based learning activities.
4. Colleges of Education, universities, and other teacher professional development institutions should incorporate practical training on the design and implementation of puzzle-based instructional strategies into Chemistry teacher-training programmes to equip teachers with the skills needed to effectively use puzzles in teaching and learning Chemistry.
5. Further research should be conducted on the effectiveness of the Puzzle Learning Strategy across other Chemistry topics, class levels, school types, and geographical areas to provide additional evidence on its effectiveness in Chemistry education.

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