A Comparative Study of Jigsaw and Guided Inquiry Strategies on Senior Secondary Two Students' Achievement in Electrolysis in Plateau State, Nigeria

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Abstract

The study investigated the effects of jigsaw and guided- inquiry method on senior secondary two student's achievement in Chemistry in Bokkos, Plateau State. Three research questions and three hypotheses guided the study. The study adopted the quasi- experimental non-equivalent pre-test, post-test control group design. A sample size of 187 senior secondary two (SS II) Chemistry students from three public senior secondary schools in Bokkos was involved in the study. The instrument for data collection was the Electrolysis Achievement Test (EAT). The validity of the instrument was established by three experts. The reliability of the instrument was established using Kuder-Richardson formula (KR- 21) which yielded coefficient of internal consistency of 0.70. Data was collected by administering the Electrolysis Achievement Test (EAT) instrument as pre-test and post-test. The data obtained was analyzed using mean, standard deviation, and Analysis of Covariance (ANCOVA). The findings of the study showed that there was a significant difference between the pre-test and post-test achievement mean score of the students taught Chemistry using jigsaw teaching strategy and lecture method. The study also found a significant difference between the pretest and post-test achievement mean score of the students taught Chemistry using guided inquiry teaching strategy and lecture method. The study recommended that teachers in senior secondary school should incorporate good and appropriate approaches such as jigsaw and guided inquiry strategies in the teaching of Chemistry because when the three methods were compared, it was discovered from the study that students achieved more using jigsaw ii teaching method, followed by guided inquiry method and lastly by lecture method.

KEYWORDS: Achievement, Jigsaw strategy, Guided Inquiry, Electrolysis

Introduction

Education plays a pivotal role in the social and economic development of any nation. In Nigeria, the government has prioritized education as a tool for national progress, with a particular emphasis on science and technology. Science education is regarded as the cornerstone of innovation and technological advancement, which are crucial for national growth. Chemistry, a core subject in the science curriculum, is central to the development of a scientifically literate society. The study of Chemistry provides students with critical knowledge and skills that are essential for understanding natural processes, industrial production, and technological applications. The objectives of Chemistry at the senior secondary school level include: to show

Chemistry and its link with industry, everyday life benefits and hazards, and to provide a course which is complete for individuals not proceeding to higher education (Federal Ministry of Education, 2015). Therefore, Chemistry is important in developing both the individual and the entire society. Chemistry as a core science subject that requires students to learn through hand on activities should be taught at three levels of content representations: macroscopic, microscopic and symbolic for meaningful understanding of the chemical concepts. It is pertinent that Chemistry students at all levels of education have adequate knowledge of scientific concepts at the three levels and should be able to integrate the knowledge across the levels with ease (Sokrat, Tamani & Radid, 2016).

Despite its importance, students' achievement in Chemistry, particularly in complex topics such as electrolysis, has been persistently low in Nigeria, raising concerns among educators and policymakers. Several misconceptions have been identified in some topics in Chemistry such as the mole concept and chemical thermodynamic (Sokrat, Tamani & Radid, 2016), periodicity (Satilmis, 2015) and redox reaction (Shehu, 2015). The commonly reported difficult Chemistry topics in Nigeria context are redox reactions, electrolysis, chemical equilibrium, chemical kinetics, mole concepts and stoichiometry (WAEC, 2012-2019).

Electrolysis, the process of using electrical energy to drive chemical reactions, is a fundamental concept in secondary school Chemistry. Understanding electrolysis is crucial for students, as it has applications in various fields, including energy storage, metallurgy, and chemical manufacturing. However, Nigerian students often struggle with this topic, resulting in poor achievement levels in both internal and external examinations. The reasons for this low achievement are multifaceted, ranging from insufficient laboratory resources to the use of ineffective teaching strategies. Traditional teaching methods, particularly the lecture-based approach, have been widely criticized for their inability to engage students and promote deep understanding of scientific concepts. As a result, there has been a growing interest in exploring alternative teaching strategies that can enhance students' achievement in Chemistry.

Among the innovative teaching strategies that have been introduced to improve students' achievement in science subjects are the Jigsaw teaching strategy and the guided-Inquiry-based teaching method. Jigsaws Cooperative Learning Strategy is defined by Ahmad (2019), as a teaching strategy that involves students learning in small groups with different ability levels in order to comprehend a subject matter. The students engage in interactions with their peers, teachers and other experts. The Jigsaw strategy, a cooperative learning approach, promotes active student participation by dividing the class into small groups and assigning each student a specific task or topic to become an expert in. This strategy encourages students to work together, share knowledge, and teach one another, which can lead to improved understanding and achievement of the material. Inquiry based method was defined as the strategy of teaching in which learners seek information or knowledge of certain phenomena with minimal guidance from their teacher (Ghumdia & Adams, 2017). In contrast, the Inquiry-based teaching method involves guiding students through the process of scientific inquiry, where they formulate questions, conduct experiments, and draw conclusions based on their observations. Inquiry-based learning (IBL) is a widely used and highly recommended teaching strategy within the science curricula and across education (Aldahmash et al., 2016; Dunne et al., 2013; Wang et al., 2014). This method fosters critical thinking, problem-

solving skills, and a deeper comprehension of scientific concepts, making it a powerful tool for improving student achievement in chemistry.

Student achievement is often measured by their ability to demonstrate mastery of key concepts and apply them in solving problems. In the context of chemistry, achievement is reflected in students' performance in assessments, practical examinations, and their overall understanding of the subject matter. Improving students' achievement in chemistry is particularly important in Nigeria, where poor performance in science subjects has been a persistent issue. The use of interactive and student-centered teaching strategies, such as Jigsaw and Inquiry-based methods, has the potential to address this problem by making learning more engaging and relevant to students. These strategies encourage active participation, collaboration, and critical thinking, which are essential for achieving success in chemistry.

The issue of gender differences in students' achievement in chemistry has also garnered attention in recent years. Studies have shown that male and female students may have different learning preferences and may respond differently to various teaching strategies. For example, some research suggests that female students tend to excel in collaborative learning environments, such as the Jigsaw strategy, where cooperation and communication are key components. On the other hand, male students may perform better in inquiry-based settings, where they can engage in hands-on experimentation and independent problem-solving. However, the evidence on gender differences in achievement is not conclusive, and more research is needed to understand how these differences can be addressed through effective teaching strategies.

This study sought to compare the effects of the Jigsaw teaching strategy and the guided-Inquiry-based teaching method on the achievement of senior secondary two students in electrolysis in Nigeria. By examining how these strategies impact student achievement, the study aims to provide valuable insights into the most effective methods for teaching complex Chemistry topics in Nigerian secondary schools. The findings of this research will contribute to the broader efforts to improve science education in the country, with the ultimate goal of enhancing students' academic achievement and preparing them for future careers in science and technology.

Objectives of the study

Specifically, the objectives of this study sought to;

1. determine the mean achievement scores of Senior secondary two students taught electrolysis using Jigsaw teaching strategy (JTS) and those taught using Lecture Teaching Method (LTM)
2. determine the mean achievement scores of Senior secondary two students taught electrolysis using guided- inquiry teaching method (ITM) and those taught using Lecture Teaching Method (LTM)
3. find out the difference in the mean score achievement of Senior secondary two students taught electrolysis using JTS and those taught using GITM.

Research questions

The following questions were asked to guide the study

1. What is the difference between the mean achievement scores of Senior secondary two students taught electrolysis using Jigsaw teaching strategy (JTS) and those taught using lecture Teaching Method (LTM)?

2. What is the difference between the mean achievement scores of Senior secondary two students taught electrolysis using guided- inquiry teaching method (GITM) and those taught using Lecture Teaching Method (LTM)?

What is the difference in the mean score achievement of Senior secondary two students taught electrolysis using JTS and G ITM?

Hypotheses

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

1. There is no significant difference between the mean achievement scores of Senior secondary two students taught electrolysis using jigsaw teaching strategy (JTS) and those taught using the Lecture Teaching Method (LTM).
2. There is no significant difference between the mean achievement scores of Senior secondary two students taught electrolysis using guided- inquiry teaching method GITM) and those taught using the Lecture Teaching Method (LTM).
3. There is no significant difference in the mean score achievement of Senior secondary two students taught electrolysis using JTS and those taught using (G ITM)?

Methodology

The study adopted quasi-experimental design, with pre -test post-test control group design. The design involved three groups (two experimental groups and one control group) where subjects were note randomly assigned to different groups by the researchers instead intact classes was used. The target population of this study was 1505 Senior secondary two students from 21 government senior secondary schools in Bokkos Local government that offer Chemistry as one of the core subjects. A total of 187 students were randomly selected from the population. Three senior secondary schools were selected randomly among the list of public secondary schools to serve as sample for the study. The sample for experimental group I comprise 65 students. Similarly, 65 students form the experimental group II while the control group has 57 students respectively. The study adopted simple random sampling technique to select the sample for the study.

The Electrolysis Achievement Test (EAT) consist of sections A, B and C. Section A was the student's biodata while the Section B was twenty-five multiple choice objectives test questions on electrolysis. Section C was five essay questions on electrolysis. Moreover, Electrolysis achievement test instrument was reshuffled and used for the data collection in the post-test of the research study. The Electrolysis achievement test (EAT) instrument items were developed based on the electrolysis concepts involving ionic theory, faradays laws of electrolysis and electrochemical cells that was taught during the research study. The twenty-five items with options numbered A, B, C, and D were carefully drawn from the standardized WAEC past question papers from 2000 to 2023. This was done to ensure that the relevant items are included in the test and that each content area listed above is given an adequate number of questions based on the behavioral objectives, Chemistry curriculum and WAEC syllabus on the concept of electrolysis

Results

Research Question One: What is the difference between the mean achievement scores of Senior secondary two students taught electrolysis using Jigsaw teaching strategy (JTS) and those taught using lecture Teaching Method (LTM)?

Table 1: Achievement Scores of the Students' taught Electrolysis using Jigsaw Teaching Strategy and Lecture Method

Group	Test	N	$\overline{X}$	SD	Mean Gain	Mean Difference
JTS	Pre-test	65	37.98	8.685	27.85	
	Post-test	65	65.83	10.539		22.33
	Pre-test	57	38.23	9.046	5.52	
LTM	Post-test	57	43.75	9.603		

Table 1 shows that the students' taught Chemistry using Jigsaw teaching strategy and those taught using lecture method had pre-test mean scores of 37.98 and 38.28 with standard deviation scores of 8.69 and 13.9.05, respectively. The post-test mean scores of the those taught with JTS and LTM are 65.83 and 43.75, with standard deviation scores of 10.54 and 9.60, respectively. The mean gains were 27.85 and 5.52 for the students' taught electrolysis using JTS and those taught with LTM respectively with a mean difference of 22.33. This implies that JTS do help improve students' achievement in electrolysis than LTM.

Research Question Two: What is the difference between the mean achievement scores of Senior secondary two students taught electrolysis using guided- inquiry teaching method (GITM) and those taught using Lecture Teaching Method (LTM)?

Table 2: Achievement Mean Scores of Students taught Electrolysis using Guided- Inquiry Teaching Method and Lecture Teaching Method

Group		Pre-test		Post-test			
	N	Mean	SD	Mean	SD	Mean Gain	$\bar{x}$- difference
GITM	**65**	38.25	6.92	63.35	11.60	**25.1**	
							19.58
LTM	**57**	38.23	9.05	43.75	9.60	**5.52**	

Table 2 shows the pre-test and post-test achievement mean score of students taught electrolysis using guided- inquiry teaching method (GIM) and those taught using Lecture Teaching Method (LTM). From the result, those taught using guided- inquiry teaching strategy have a post-test achievement mean score of 63.35 and standard deviation of 11.60 higher than the pre-test mean score of 38.25 and standard deviation of 6.92 with a mean gain of 25.1, indicating that there was improvement in the achievement of students after treatment using G ITM. Also, for the those taught using LTM, the mean score was 38.23 and a standard deviation of 9.05 at the pre-test. At

the post-test the mean score of students was 43.75 and standard deviation of 9.60. The finding shows that students taught using guided-inquiry teaching method had a higher mean score (63.35) than those taught using LTM (43.75) with a mean difference of 19.58. This means that at the pre-test the students in both groups were almost at the same level of achievement, but after intervention, those taught using guided- inquiry teaching method achieved better than those taught using LTM. This implies that guided- inquiry teaching method improved students' achievement in electrolysis than lecture teaching strategy.

Research Question Three: What is the difference in the mean score achievement of Senior secondary two students taught electrolysis using JTS and G ITM?

Table 3: Achievement Scores of the Students' taught Electrolysis using Jigsaw Teaching Strategy and guided - inquiry Teaching Method

Group	Test	N	$\overline{X}$	SD	Mean Gain	Mean Difference
JTS	Pre-test	65	37.98	8.685	27.85	
	Post-test	65	65.83	10.539		2.75
	Pre-test	65	38.25	6.919	25.1	
GITM	Post-test	65	63.35	11.597		

Table 3 shows that the students' taught Chemistry using Jigsaw teaching strategy and those taught using guided- inquiry teaching method had pre-test mean scores of 37.98 and 38.28 with standard deviation scores of 8.69 and 13.9.05, respectively. The post-test means scores of the those taught w using JTS and G ITS are 65.83 and 43.75, with standard deviation scores of 10.54 and 9.60, respectively. The mean gains were 27.85 and 25.1 for the students' taught electrolysis using JTS and those taught using G ITS respectively with a mean difference of 2.75. This implies that JTS improved students' achievement in electrolysis than GITM.

Hypothesis One: There is no significant difference between the mean achievement scores of Senior secondary two students taught electrolysis using jigsaw teaching strategy (JTS) and those taught using the Lecture Teaching Method (LTM).

Table 2: ANCOVA Result on Achievement Mean Scores of Students Taught Electrolysis using JTS and LTM

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	14805.233[a]	2	7402.616	71.798	.000	.547
Intercept	19032.042	1	19032.042	184.593	.000	.608
Covariate	4.465	1	4.465	.043	.835	.000
Group	14790.827	1	14790.827	143.457	.000	.547
Error	12269.234	119	103.103			
Total	403087.000	122				
Corrected Total	27074.467	121				

a. R Squared = .547 (Adjusted R Squared = .539)

Analysis of Covariance (ANCOVA) was conducted to determine if a significant difference exists in the mean achievement scores of Senior secondary two students taught electrolysis using jigsaw teaching strategy (JTS) and those taught using the Lecture Teaching Method (LTM). Table

4 shows that F(1,119) =143.46, p < 0.05, since the p-value of 0.000 is less than 0.05 level of significance, the null hypothesis was rejected, indicating that there was a significant effect of jigsaw teaching strategy on students achievement in electrolysis. The result further reveals an adjusted R squared value of .539 which means that 53.9 percent of the variation in the dependent variable which is achievement in electrolysis is explained by variation in the treatment of JTS, while the remaining is due to other factors not included in this study.

Hypothesis Two: There is no significant difference between the mean achievement scores of Senior secondary two students taught electrolysis using guided- inquiry teaching method (GITM) and those taught using the Lecture Teaching Method (LTM).

Table 3: ANCOVA Result on Achievement Mean Scores of Students Taught Electrolysis using G ITM and LTM

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	11970.600[a]	2	5985.300	52.890	.000	.471
Intercept	18771.267	1	18771.267	165.875	.000	.582
Covariate	304.745	1	304.745	2.693	.103	.022
Group	11670.139	1	11670.139	103.125	.000	.464
Error	13466.678	119	113.165			
Total	383786.000	122				
Corrected Total	25437.279	121				

a. R Squared = .471 (Adjusted R Squared = .462)

Analysis of Covariance (ANCOVA) was conducted to determine if a significant difference exists in the mean achievement scores of Senior secondary two students taught electrolysis using inquiry teaching strategy (GITM) and those taught using the Lecture Teaching Method (LTM). Table 5 shows that F(1,119) =103.13, p < 0.05, since the p-value of 0.000 is less than 0.05 level of significance, the null hypothesis was rejected, indicating that there was a significant effect of inquiry teaching strategy on students achievement in electrolysis. The result further reveals an adjusted R squared value of .462 which means that 46.2 percent of the variation in the dependent variable which is achievement in electrolysis is explained by variation in the treatment of ITS, while the remaining is due to other factors not included in this study.

Hypothesis Three

There is no significant difference in the mean score achievement of Senior secondary two students taught electrolysis using JTS and those taught using G ITM.

Table 6: ANCOVA Result on Achievement Mean Scores of Students Taught Electrolysis using JTS and G ITS

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	640.566[a]	2	320.283	2.663	.074	.040
Intercept	28246.695	1	28246.695	234.852	.000	.649
Covariate	441.174	1	441.174	3.668	.058	.028
Group	189.507	1	189.507	1.576	.212	.012
Error	15274.826	127	120.274			
Total	558297.000	130				
Corrected Total	15915.392	129				

a. R Squared = .040 (Adjusted R Squared = .025)

Analysis of Covariance (ANCOVA) was conducted to determine if a significant difference exists in the mean achievement scores of Senior secondary two students taught electrolysis using jigsaw teaching strategy (JTS) and those taught using the guided- inquiry teaching method (GITM). Table 6 shows that F (1,127) =1.58, $p > 0.05$, since the p-value of 0.212 is greater than 0.05 level of significance, the null hypothesis was retained, indicating that there was a significant effect of jigsaw teaching strategy (JTS) and guided- inquiry teaching method on students' achievement in electrolysis. The result further reveals an adjusted R squared value of .025 which means that 2.5 percent of the variation in the dependent variable which is achievement in electrolysis is explained by variation in the treatments of JTS and GITM, while the remaining is due to other factors not included in this study. This implies that there is no significant difference in the mean achievement score of Senior secondary two students taught electrolysis using JTS and those taught using GITM.

Discussion of findings

The study investigated the effectiveness of jigsaw and guided- inquiry teaching method on senior secondary two student's achievement in Chemistry in Bokkos, Plateau State. The results of the analysis of data from field showed that exposure to jigsaw teaching strategy was found to be more effective in improving the achievement of secondary school students in Chemistry as indicated in the result that there is a significant difference between the post -test achievements scores of students taught Chemistry using jigsaw strategy and lecture method. The effectiveness of jigsaw strategy could be because it is a strategy that centers on discussions with peers, and exchange of ideas in groups which gives opportunity for all to sit and listen, contribute, reflect and think, thus allowing the students to think critically, evaluate ideas, concept and principles within the group thereby promoting meaningful learning in students. In other words, students in a jigsaw class are not passive listeners neither is the teacher a sole performer. Students are allowed to develop critical thinking ability, work on problems and find solution to them while the teacher is acting as a guide to the students. The findings is in line with the work of Samuel (2018) who conducted a study on Effects of Jigsaw IV, Group Investigation and Reversed Jigsaw Cooperative Instructional Strategies on Basic Science Students' Achievement and Retention among senior secondary students and found the jigsaw strategy was effective in improving students' achievement and retention in secondary school. In a similar study Adjibolosoo, (2019) found that

students performed better when taught with jigsaw strategy than when taught with lecture teaching method. He went further to recommend that adequate consideration be given to jigsaw teaching strategy by teachers when teaching science based causes in secondary schools.

The study also found that inquiry teaching strategy was helpful in improving student achievement in chemistry as indicated in the result that there is a significant difference between the posttest achievements scores of students taught chemistry using inquiry teaching strategy and lecture method. The effectiveness of inquiry teaching strategy could be because it is a strategy that centers on questioning students, which gives room for the students to search for meaning themselves, thus allowing the process of reflective thinking and critical evaluation of ideas, concept and principles in the students' thereby promoting meaningful learning. In other words, students in an inquiry class are not passive listeners rather are engaged in the teaching and learning process. The teacher does not relay information directly to the student rather, the students are asked to work on a particular concept while teacher acting as a facilitator of knowledge and encourager of learning. The findings are in line with the work of Ikeoluwa (2018) who conducted a study on Effects of Inquiry-Based Learning Strategies on Chemistry Students' Conceptions in Chemical Kinetics and Equilibrium and found that inquiry strategy was helpful in solving the problem of misconception among students in chemistry in senior secondary schools.

The findings of the study also revealed that student taught electrolysis using jigsaw teaching strategy achieved slightly better than those taught with inquiry teaching strategy as indicated by the posttest achievement mean score of the student. The difference could be as a result of variation in the treatments of JTS and G ITM, while the remaining could be due to other factors not included in this study. This finding concurs with Lawan (2019) who conducted a study on effects of jigsaw ii co-operative learning strategy on academic performance in mensuration among secondary school students and found that jigsaw strategy was helpful in improving students' achievement in mensuration.

Conclusion

The study investigated the effectiveness of jigsaw and guided- inquiry teaching method on senior secondary two student's achievement in Chemistry in Bokkos, Plateau State. This was prompted by the observed problem of defective methodology employed during classroom instruction by teachers in chemistry which result in poor achievement of students in external examination. The result of the study showed that the achievement level of both groups of students before treatments were low in Chemistry. The result further showed that students taught using jigsaw and inquiry teaching strategies performed significantly better than their counterparts who were taught using lecture method. Jigsaw strategy was found to be more effective in improving the achievement of secondary school students in Chemistry when compared to guided- inquiry teaching method.

Recommendations

In view of the findings of this study, the following recommendations were made:

i. Jigsaw strategy should be incorporated into the secondary Chemistry curriculum as a medium of instruction than lecture method.
ii. Guided-Inquiry method should also be incorporated into the secondary Chemistry curriculum as a medium of instruction than lecture method.

iii. Chemistry teachers should be re-trained through series of workshops, seminars and symposium on how to incorporate effectively jigsaw and guided - inquiry teaching method during Chemistry lessons.

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