

EFFECTS OF JIGSAW INSTRUCTIONAL STRATEGY ON CHEMISTRY STUDENTS' ACHIEVEMENT IN SOLVING ELECTROLYSIS PROBLEMS

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Abstract

Electrolysis as a concept in School Certificate Chemistry is considered abstract and researches have indicated that students find it difficult to understand. There is at present, a persistent poor achievement of Nigerian students in Senior School Certificate Chemistry Examinations, and this is partly traceable to ineffective classroom instructional strategies utilized by classroom teachers. This study sought to determine the effects of Jigsaw Instructional Strategy on Nigerian Senior School Chemistry students' achievement in solving electrolysis problems. The study adopted a non-randomized and non-equivalent pre-test, post-test, control group quasi-experimental design. Two intact classes of students were involved; one serving as the experimental group and the other serving as the control group. The instrument used for the study was the Electrolysis Achievement Test (EAT) which was duly validated and whose reliability coefficient (r) was found to be 0.87 using Pearson Product Moment Correlation Statistic. The data obtained from pretest and post-test were analyzed using mean scores, standard deviation and t -test statistics. The findings revealed significant difference in the achievement of students taught electrolysis using the Jigsaw instructional strategy and students taught using the conventional strategy ($t_{117} = 5.325, p = 0.005 < 0.05$). However, there was no significant difference in the achievement of male and female students taught electrolysis using Jigsaw ($t_{51} = 0.416, P = 0.486 > 0.05$). It is recommended among others that chemistry teachers should consider using Jigsaw instructional strategy to teach electrolysis.

Keywords: Jigsaw, Gender, Achievement, Electrolysis, Secondary school

Introduction

Chemistry is one important subject and discipline that has an overwhelming influence on the human life. Our body is Chemistry, so is our environment. Chemistry is a cornerstone to nearly every field of science and technology (Adebayo, 2007). Knowledge of chemistry is brought into play in the manufacturing of fertilizers, herbicides, insecticides drugs and fungicides. Also, the study of chemistry is necessary for the management of natural resources, provision of food, health facilities and adequate food supply (Ezendu, 2000). Besides, chemistry is one of the science subjects that provide the basic knowledge and understanding of principles that could be applied to improve the quality of life of man. Consequently, it stands in a central position among the basic sciences (Abubakar & Eze,

2010). It is also worthy of note that a credit pass in School Certificate Chemistry is a prerequisite for admission into any science and technology based course in higher institutions of learning. The knowledge of chemistry can be found in all types of manufacturing processes; for instance, the production of most consumer products are directly or indirectly dependent on chemical technology know-how and this covers a large spectrum (Okanlawon, 2004).

Electrolysis is the chemical decomposition of a compound brought about by direct current. The passage is through either a solution of the compound or the molten compound. Electrolysis as a concept is considered abstract, and students often find it difficult to explain or even solve problems involved in it (Oyelekan, 2006).

In Nigeria, secondary school students experience difficulty in solving electrolysis problems just like their counterparts worldwide (Oyelekan, 2006; Olorundare, 2014). According to Gabel (1996), the complexity of chemistry is viewed from both research on problem solving and misconceptions. These misconceptions are not only traceable to the complexity of the subject, but also to the manner in which the concepts are taught in the classroom. Available report also indicates that despite the fact that science (and chemistry in particular) is needed for technological development of the nation, the achievement of students was always poor (Abimbola, 2013). Olorundare (2014) described students' recent achievement in the sciences as worrisome. The figures presented showed undulating achievements in such a manner that we cannot affirm improvement in the students' general achievements.

The academic achievement of students has been of concern not only to parents and students but the wider society. Yusuf and Adigun (2010) stated that many parents believed that the academic achievements of students are determined by gender and consequently many consider the dominant gender of schools before enrolling their wards, with a majority of them preferring single sex schools to co-educational (mixed-sex schools). Many studies have been conducted to unravel factors influencing students' academic achievement. Kissau (2006) and Bosede (2010) asserted that gender and location of school do influence students' academic achievement in some subject areas. In most science-related fields, there are more males than females. Igboegwu and Okonkwo (2012) found that female anxiety level was higher than that of their male counterparts in educational statistics. The finding corroborates those of Clark and Gorski (2002) that females do not perform well in science because of their low level of confidence rather than their ability level.

The use of inappropriate instructional strategy is one of the causes of students' poor achievement in quantitative problems (O'Connor, 2000; Opolot-Okurot, 2005). Tran and Lewis (2013) observed that students offering chemistry courses did not have enough tutoring and sufficient inquiry skill. They therefore suggested that the use of cooperative instructional strategy could assist in assuaging this problem. Cooperative instructional

strategy is a method used by educators to help students develop necessary social skills (Johnson & Johnson, 1999). Zakaria, Chin and Daud (2010) concluded that, there were positive changes when a teacher changes his teaching approach from being teacher-centered towards a more student-centered approach. In cooperative learning for example, students work to maximize their own and others learning potentials to reveal new ideas and their solution. This is probably why Johnson and Johnson (1999) suggested that more can be obtained through group work and cooperative approaches to learning in chemistry.

Many kinds of cooperative learning techniques exist. They include Learning Together (LT), Teams-Games-Tournaments (TGT), Group Investigation (GI), Jigsaw grouping, Team Accelerated Instruction (TAI) and Student Teams Achievement Division (STAD). In order to encourage students to improve their achievement and promote more positive attitude to chemistry, there could be many alternatives to lecture-based teaching method.

Jigsaw as proposed in this paper is also a form of cooperative learning strategy in which individual students become experts in a particular aspect of a topic and teach those aspects to their fellow students. It utilises a concept called task specialization which demands that different students take up specialized roles in achieving the objectives of the lesson. In this strategy, students become experts on a particular aspect of a topic and teach their counterparts based on their knowledge of that particular expert.

The various stages involved in Jigsaw are listed as follows:

1. Identifying Topics and Specifying Learning Objectives
2. Designing Learning Materials
3. Identifying Topics and Specifying Learning Objectives
4. Forming Student Teams
5. Assigning Experts
6. Designing Assessments (Slavin, 1986)

The first stage involves the teacher selecting the topic of the lesson and formulating appropriate learning objectives that are expected to be achieved at the end of the lesson. These

objectives are best formulated in terms of what the students are expected to know, and be able to do at the end of the lesson. This is followed by selection of learning materials to be used to get the students to learn the topic at hand. During this stage, the teacher may design his own instructional materials as well as materials that students could use in their respective groups in carrying out the tasks that may be assigned to them. The teacher then divides the students into groups (teams), based on the class population. Each person is made an expert to master a particular aspect of the task assigned and explain it to the other members of the group. The teacher then designs the instruments he intends to use to assess the learners after the lesson, on the basis of the objectives set for the lesson.

Catapano (2017) also listed six simple steps to follow in using the Jigsaw instructional strategy.

1. Organize students into a group of 4-6 people.
2. Divide the day's reading or lesson into 4-6 parts, and assign one student in each group to be responsible for a different segment.
3. Give students time to learn and process their assigned segment independently.
4. Put students who completed the same segment together into an "Expert group" to talk about and process the details of their segment.
5. Have students return to their original "Jigsaw" groups and take turns sharing the segments they've become experts on.
6. Have students complete a task or a quiz that's reliant on them having understood the material from the contributions of all their group members (p.1).

Jigsaw strategy facilitates social interaction among students and provides opportunity for students to learn from one another. As an instructional strategy, Jigsaw expands the act of teaching beyond the teacher and gives opportunity for learners to express their talents. It is based on this student-centred nature of Jigsaw that this study sought to find out whether the Jigsaw instructional strategy would assist students in solving

electrolysis problems, having been identified as one of the problem areas in School Certificate.

Literature Review

Reports about the effectiveness of Jigsaw as an instructional strategy are mixed. According to Slavin (1996), the achievement outcomes of cooperative learning methods like Jigsaw in which tasks are specialized are unclear. Slavin (1995) asserted that research on the original form of Jigsaw has not generally found positive effects of the strategy on student achievement. Similarly, Johnson and Johnson (1994) did not find Jigsaw a better alternative to individualistic methods except only when group rewards were introduced. This was alluded to by Mattingly and Van Sickle (1991). Conversely, there are evidences that when Jigsaw is well implemented, students' achievement could be significantly improved (Al-Salkhi, 2015; Mbacho & Changeiywo, 2013; Maden, 2011).

Al-Salkhi (2015), researched into finding out the effectiveness of Jigsaw Cooperative Learning Strategy on the motivation and achievement of 7th primary grade students in Amman, Jordan. A total of 53 female students took part in the study, 26 of which were in the experimental group, while the remaining 27 were in the control group. The study utilized an achievement test and a Motivation Learning Scale on Islamic Education. The result showed that the experimental group achieved significantly more than the control group, and that a positive relationship existed between students' achievement and their learning motivation.

Maden (2011) sought to determine the effects of Jigsaw I instructional technique on Ataturk University Turkish teacher candidates in written expression. A total of 70 students of the Department of Turkish Teaching in the academic year of 2009-2010 were involved in the study. Two intact classes of students comprising of 34 and 36 students were assigned as experimental and control group respectively. Using a Success Test for Written Expression (STWE) as pre-test and post-test, the results obtained from the study indicated a non-significant difference in the academic achievement of the two groups, in favour of the Jigsaw group. Similar results in favour of Jigsaw were obtained by Burns (1984), Mbacho and Githua (2013) and Sharan and Shachar (1988).

Mbacho and Changeiywo (2013) sought to find out the influence of gender on the use of Jigsaw Cooperative Learning Strategy in Mathematics. One hundred and sixty students were randomly sampled from about twenty thousand Form III students from Laikipia East District in Kenya. Using a Mathematics Achievement Test, the results indicated that there was no statistically significant difference in Mathematics achievement of the students when they were taught using Jigsaw cooperative learning strategy.

Conflicting reports arise from research on practical classroom applications of Jigsaw without group reward. Some studies presented evidence that group processing activities could enhance the achievement effects of cooperative learning strategy like Jigsaw (Yager, Johnson, Johnson, & Snider, 1986). In contrast to this however, Rich, Amir, and Slavin (1986) found that team building activities had no effect on the achievement of students with Jigsaw. Slavin (1995) generalized that group strategies that did not make provision for specific group rewards based on the learning of all members of the group were not more effective than traditional instruction in increasing student achievement, although there was evidence that these methods could be effective when group rewards were incorporated into the strategy. These conflicting research reports necessitate further research into the use of Jigsaw instructional strategy.

The presence of high achieving students may be more threatening to boys than to girls (Schwalbe & Staples, 1991). It is therefore assumed that boys will react to high achieving students in a more competitive manner than girls do. Attribute such as warmth and sympathy are particularly preferred in girls (Seem & Clark, 2006). Gender role stereotypes are likely to attribute success of females to effort and the success of males to ability. Girls are thought to be more relationship oriented and expectedly should therefore be more interested in maintaining a good relationship with peers; even with high-achieving ones. This is expected to impact positively on their achievement with Jigsaw. This study sought to find out whether this could be true.

Theoretical Framework

Jigsaw is one of the major cooperative learning strategies, hence, the theoretical framework for

this study rests on the four major theoretical perspectives of cooperative learning and achievement as presented by Slavin (1996). These perspectives are: The motivational perspectives, the social cohesion perspectives, the cognitive perspectives and the motivational perspectives.

The main thrust of the motivational perspective is the motivation brought about by the reward system under which the Jigsaw strategy operates (Johnson & Johnson, 1992; Slavin, 1995). In this arrangement, individual success is dependent on group success, hence, members of a group are obliged to assist others in achieving a common goal. The overall success of the group is a combination of the efforts of individual members of the group. The social cohesiveness theoretical perspective holds that the cohesiveness of the group impacts significantly on the ability of the group to improve their achievement with cooperative learning strategy. This theoretical perspective is hinged on the believe that students can help one another to learn when engaging in group work since members of a group often comprise of students with various degrees of learning abilities. According to Slavin (1996), task specialisation is used in Jigsaw, Group Investigation, and Finding Out is used to facilitate interdependence among members of a group, with a view to enhancing social cohesion among the learners.

The cognitive perspectives holds that in cooperative learning, improvement in learners' achievement can be traceable to their mental processing resulting from interaction with members of their group. On the other hand, the developmental perspectives assumes that interaction among members of a group in solving an academic problem has the propensity to improve group and individual achievement. Members of a group, even though they belong to the same age group could differ slightly in their developmental status, hence, the more capable ones on the basis of development could impact positively on the learning of the less capable ones in the group.

Purpose of the Study

The main purpose of the study was to determine the effect of Jigsaw instructional strategy on chemistry students' achievement in solving

electrolysis problems. Specifically, the study aimed at finding the:

- (i) difference in the achievement of students taught electrolysis using Jigsaw instructional strategy and students taught using Conventional Lecture-Based Strategy (CLBS).
- (ii) difference in the achievement of male and female students taught electrolysis using Jigsaw instructional strategy.

Research Questions

Answers were sought to the following research questions:

- i. What is the difference in the achievement of students taught using Jigsaw instructional strategy and students taught using lecture method in solving electrolysis problems.
- ii. What is the difference in the achievement of male and female students taught using Jigsaw instructional strategy in solving electrolysis problems.

Research Hypotheses

Two research hypotheses were tested in the study:

HO₁ There is no significant difference in the achievement of students taught electrolysis using Jigsaw instructional strategy and students taught Conventional Lecture-Based Strategy (CLBS).

HO₂ There is no significant difference in the achievement of male and female students taught using the Jigsaw instructional strategy and those taught using Conventional Lecture-Based Strategy (CLBS).

Methodology

This study was a non-randomised, non-equivalent 2x2 quasi experimental research which utilized a pre-test and post-test. The design indicates two levels of independent variables (i.e. the Jigsaw instructional strategy and conventional lecture-based strategy), and gender at two levels of male and female. The population for the study was all senior secondary school II (SS II) chemistry students in Oyo, Nigeria. The choice of SS II was

based on their pre-requisite knowledge in basic chemistry concepts and especially electrolysis concept that is normally taught to the class. Two schools were purposively selected on the basis of having a minimum of 10 years of experience in fielding candidates for the West African Examinations Council (WAEC) and National Examinations Council's School Certificate chemistry; having chemistry teachers with teaching qualifications and who have taught chemistry in the school system for at least five years, and having a co-educational system of students' enrolment.

The two schools were randomly assigned to the experimental and control groups. An intact SSII class in each of the schools was selected for the study. 53 students were involved in the experimental group, while 66 students were involved in the control group, hence the sample consisted of 119 students.

The instrument used for the study was the Electrolysis Achievement Test (EAT). It consisted of twenty multiple choice objective questions with four options A – D and five theory questions of school certificate chemistry standard. The instrument was validated by two university chemistry lecturers, two experienced secondary school chemistry teachers as well as two chemistry educators in a university. The reliability of EAT was determined by using the test-retest method of two weeks interval, in which the EAT was administered to twenty senior secondary chemistry II students from non-participating but equivalent school. The data obtained were subjected to Pearson products moments correlation formula. A reliability coefficient of 0.87 was obtained for the instrument.

The Electrolysis Achievement Test (EAT) was of two types; Type A (test before the treatment) and Type B (test after the treatment). Both Type A and Type B consisted of the same 20-multiple choice items with four options (A-D), and five word problems except that the questions were scrambled so that they are not arranged in the same sequence. The EAT was used to determine students' achievement in chemistry. The duration for the tests was one hour thirty minutes. The multiple choice items were adopted from the West African Senior School Certificate Examination (WASSCE) Chemistry questions in the period

between 2005-2012. Each correct test item in the multiple choice was scored 5 marks to give a total of one hundred since there were 20 – multiple choice items. Also each word problem was scored 20 marks and a total of one hundred score again was obtained since there were 5-word problems. Then, the two scores were added together and an aggregate of one hundred marks was obtained.

Permission was sought from the authorities of the two schools and the consent of the students was sought through a students' consent form. The initial equivalence of the two groups was determined using the Students' Achievement Score (SAS) which consisted of students aggregate score in Chemistry for the first, second and third term examination for the immediate past session. This score was assumed to be the true reflection of the students' ability in Chemistry. The chemistry teachers in the schools cooperated by providing all necessary assistance, especially in the area of time tabling.

Data collection was in three main phases and it lasted for six weeks. The pretest was held during the first week, treatment lasted for the next four weeks and the post-test was conducted during the last week. The EAT was administered as pre-test to the students during the first week of the study

before treatment commenced. The main treatment was teaching using Jigsaw instructional strategy to an intact class of 53 students. The students in the experimental group were taught electrolysis by their regular chemistry teacher based on the training he had received from the researchers on Jigsaw. The teacher was also closely monitored but care was taken not to disrupt the lessons. The duration was two periods per week with each period lasting for 40 minutes. The control group was simultaneously taught using conventional lecture-based strategy (CLBS) to an intact class of 66 students by its regular teacher as well. By the sixth week, Type B of EAT was administered to the students as post-test. The data obtained were analyzed. The mean scores and standard deviations were calculated. The hypotheses were tested using t-Test at 0.05 level of significance.

Results

The data obtained are presented and interpreted as follows:

Research questions 1: What is the difference in the achievement of students taught using Jigsaw instructional strategy and students taught using conventional lecture-based strategy (CLBS) in solving electrolysis problems.

Table 1: The Mean of Pre-test and Post-test Scores of the Experimental and the Control Groups.

Strategy	N	Pre-test		Post-test		Mean Gain
		Mean	SD	Mean	SD	
Exp. (Jigsaw)	53	29.79	8.393	35.57	11.487	5.78
Control (CLBS)	66	22.85	6.907	25.76	8.60	2.91

Table 1 shows the mean scores of students who participated in the Electrolysis Achievement Test. The pretest and post-test mean scores of students taught using the Jigsaw instructional strategy were 29.79 and 35.57 respectively, while those of the students in the control group were 22.85 and 25.76 respectively. While the mean gain score of the experimental was 5.78, that of the control group was 2.91. This means that students taught

using Jigsaw performed better than those taught conventionally.

Research Question 2: What is the difference in the achievement of male and female students taught electrolysis using Jigsaw instructional strategy and those taught using the conventional lecture-based strategy (CLBS).

Table 2: The Mean of pre-test and post-test scores of male and female students taught using Jigsaw instructional strategy in solving electrolysis problem.

Gender	N	Pre-test		Post-test		Mean Gain
		Mean	SD	Mean	SD	
Male	17	30.12	7.705	36.53	11.248	6.41
Female	36	29.64	8.800	35.11	11.727	5.41

Table 2 shows the mean gain scores of male and female students taught using the Jigsaw instructional strategy. The pre-test and post-test mean scores of male students were 30.12 and 36.53 respectively. It gives a mean gain score of 6.41. The pre-test and post-test mean scores of the females were 29.64 and 35.11 respectively. It gives a mean gain score of 5.41. The male students had a slightly higher mean gain score than the females.

Hypothesis testing

Hypothesis 1: There is no significant difference in the achievement of students taught using Jigsaw instructional strategy and students taught using the conventional lecture-based instructional strategy in solving electrolysis problems.

Table 3: Independent samples t-test achievement of post-test scores of students taught using the Jigsaw Instructional Strategy and those taught using the conventional lecture-based strategy (CLBS).

Instr. Strategy	N	Mean	SD	Mean Diff.	df	t	p
Exper. (Jigsaw)	53	35.57	11.487	9.808	117	5.325	.005
Control (CLBS)	66	25.76	8.601				

Table 3 shows t-Test result of the comparison between the achievement of the experimental group and the control group. It reveals that the calculated p is less than 0.05 level of significance fixed for the t-Test. Hence the null hypothesis is rejected. This means that there was a significant difference in the mean scores of students in the post test when taught electrolysis using the Jigsaw instructional strategy as compared to when taught using CLBS ($t_{117} = 5.325$, $p=0.005 < 0.05$). The

significant difference is in favour of students taught using Jigsaw, an indication that Jigsaw facilitated better achievement of the students in electrolysis.

Hypothesis 2: There is no significant difference in the achievement of male and female students taught using the Jigsaw instructional strategy in solving electrolysis problems.

Table 4: Independent samples t-Test achievement of post-test scores of male and female students taught using Jigsaw instructional strategy in solving electrolysis problems.

Gender	N	Mean	SD	Mean Diff.	df	t	p
Male	17	36.53	11.248	1.418	51	0.416	0.486
Female	36	35.11	11.727				

Table 4 shows the post-test scores of male and female students taught electrolysis using Jigsaw instructional strategy. The calculated p-value is greater than 0.05 level of significance, hence, the hypothesis is retained. This means that there was no significant difference in the mean scores of male and female students taught using Jigsaw instructional strategy ($t_{51} = 0.416$, $P = 0.486 > 0.05$), hence, the influence of students' gender when taught electrolysis using Jigsaw instructional strategy was not significant.

Summary of the Findings

From the analysis and interpretations of the data collected for the study, the following are the major findings:

- i. Students taught electrolysis using Jigsaw instructional strategy achieved significantly better than those taught with conventional lecture-based strategy ($t_{117} = 5.325$, $p=0.005 < 0.05$).
- ii. There was no significant difference in the achievement of male and female students when Jigsaw instructional strategy was used to teach them electrolysis ($t_{51} = 0.416$, $p = 0.486 > 0.05$), hence gender had no significant influence with Jigsaw.

Discussion

The study found that students taught electrolysis using Jigsaw instructional strategy achieved better than those taught using the conventional lecture-based strategy. The finding is similar to that of Burns (1984), Mbacho and Githua (2013), Sharan and Shachar (1988), and Ogundiran (2013). This finding cuts across various school subjects. For instance, while Ogundiran (2013) found out that Jigsaw and Team game had significant effects on the achievements of students in Social Studies, Mbacho and Githua (2013) found out that learners taught Mathematics using Jigsaw cooperative learning strategy performed better than those taught using the conventional learning methods. Other studies (Johnson & Johnson, 1994; Mattingly & Van Sickle, 1991) found Jigsaw a better alternative to individualistic methods only when group rewards were introduced. This suggests that teachers intending to use Jigsaw should as part of the procedure incorporate some group reward mechanisms as a way of taking full advantage of the strategy.

Similar findings were also reported by Barrett (2005); Cadopi and Winnykamen (2002); Johnson and Ward (2001) and Ward and Lee (2005). A few other studies however (Slavin, 1995; Rich, Amir, & Slavin, 1996) found no significant difference in students' achievement with Jigsaw over the conventional learning strategy.

This study also revealed that gender had no significant influence on the post-test scores of students taught electrolysis using Jigsaw instructional strategy. This means that male students could achieve as much as female students in electrolysis when taught with the Jigsaw strategy. This finding is similar to previous research findings of Mbacho and Githua (2013) and Adebayo (2007). Both Mbacho and Githua (2013) and Adebayo (2007) found no significant difference in the achievement of male and female students when Jigsaw was used as the instructional strategy. Hence, no special treatment is required for either of the gender in using Jigsaw.

Conclusion

It is established in this study that Jigsaw instructional strategy could enhance students' achievement in electrolysis, thus making it possible to place the topic appropriately in the conflicting reports on the effectiveness of Jigsaw instructional strategy. The study therefore establishes the effectiveness of the Jigsaw instructional strategy in teaching electrolysis to students at the level of School Certificate Chemistry. Also established is the fact that emerged from the study that gender had no significant influence on students' achievement when Jigsaw was used to teach the topic. This is in spite of the fact that male students achieved slightly higher than their female counterparts when Jigsaw was used to teach them electrolysis.

Recommendations

On the basis of the research findings, the following recommendations are made:

1. Electrolysis as a topic in school Certificate chemistry should be taught using Jigsaw instructional strategy and teachers intending to use Jigsaw should as part of the teaching procedure, incorporate some group reward mechanisms as a way of taking full advantage of the strategy.

2. Teachers should be trained on how to utilize the Jigsaw instructional strategy to teach as a means of improving students' overall achievement in chemistry.
3. Jigsaw instructional strategy should be used as an instructional strategy for male and female students without discrimination.

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