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Research Article

Effects of Jigsaw Cooperative Learning Strategy on Senior Secondary Two Chemistry Students' Understanding of Chemical Kinetics in Jos South LGA of Plateau State, Nigeria

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Abstract: This study determined the effects of jigsaw cooperative learning strategy (JCLS) on chemistry students' understanding of chemical kinetics in public and private secondary schools in Jos South LGA of Plateau state, Nigeria. The sample consisted of 78 students drawn from two co-educational schools. Random sampling technique was used to assign the students from each school into experimental and control groups. A rate of reaction understanding test, (RoRUT) with r = 0.79, was used as instrument for data collection. It contained five essay-type questions drawn from the senior secondary two chemistry curriculum on the topic, rates of chemical reactions. The data was analyzed using SPSS Statistics version 22. The findings revealed a significant difference between the posttest mean scores of students taught using JCLS and those taught using the lecture method with those taught with JCLS demonstrating better understanding of the concept. There was however, no statistically significant difference between the posttest mean achievement scores of male and female students taught the rates of chemical reactions using JCLS. The study also found out that the students from private schools demonstrated better understanding of the concept than students from public schools taught using JCLS. The study recommended that JCLS be used in the teaching of chemistry in secondary schools since the strategy influences both male and female students similarly. Necessary attention should be given to JCLS during teacher – training programs so as to equip chemistry teachers with the skills.

Keywords: Jigsaw, cooperative, learning, rates, reaction, strategy, lecture.

INTRODUCTION

The role of science and technology in the development of nations has been acknowledged worldwide. Science and technology have always been recognized as the basic tool of industrialization and national development and could bring economic and social happiness by providing employment and improving the welfare of the citizenry (Gongden, 2015). Science and technology is changing the world around us at an alarming rate such that any nation that chooses to ignore scientific literacy may find it difficult to fit into the world affairs seeing that science and technology has become an integral part of world culture. Any nation that ignores science and technology does not only do so at its own perils but will not develop. All over the world, governments at all levels have devoted large chunks of their annual budgets towards research and improvement in science and technology bearing in mind its importance for the progress and survival of the nations (Oak, 2011) .The need for a global awareness on the need to improve the quality of science and technology at all levels of education therefore becomes important.

The valuable role of science in the technological development of any nation is never in dispute. In Nigeria, some provisions of the National Policy on Education and the change to the 9-3-4 system all aim at providing sufficient opportunities are opened to citizens to get the best scientific education possible. The importance of science in this direction is however, anchored on chemistry – a basic science subject that is considered the pivot on which the wheel of science rotates. Chemistry is a branch of physical science that deals with the composition, properties and uses of matter. It also probes into the the principles governing the changes that matter undergo (Ababio, 2007). Gongden (2016) noted that chemistry has played a major role in science, technology and society and that it still does so today. He also noted that there is hardly

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anything in nature that chemistry has no impact or influence over hence the assertion that without chemistry there will be no life. It occupies a unique position in science education such that students offering courses such as medicine, biology, pharmacy, physics, biochemistry, microbiology and home economics are required to take chemistry. Several industries employ chemical principles for their successful operations. According to Ezeudu (2000), several activities that center on the management of natural resources, manufacturing, processing and storage of food and health facilities and a favorable living environment draw their basis from chemistry. Even though chemistry has its adverse effects such as pollution by chemical wastes, radioactive wastes from nuclear plants, abuse of drugs, studying chemistry will help us to control the above adverse effects. The usefulness of chemistry in the lives of nations and its citizens outweigh the disadvantages. Hence the need to intensify its learning and application at all levels of education.

The objectives of the revised edition of Nigeria's senior secondary school chemistry curriculum among other things are to enable the students to:

i. Develop interest in the subject of chemistry.
ii. acquire basic theoretical and practical knowledge and skills
iii. Develop interest in science, technology and mathematics.

In addition, the reviewed curriculum plans to, among other things:

i. Facilitate a smooth transition in the use of scientific concepts and techniques acquired in the new basic science and technology curriculum with chemistry.
ii. Provide students with the basic knowledge in chemistry concepts and principles through efficient selection of contents and sequencing.
iii. Show chemistry and its links with industry, everyday life activities and hazards.

Many researchers have expressed concern over the state of science teaching and learning in Nigerian secondary schools (Sowunmi and Aladejana, 2013). At a time when scientific and technological competence is vital to the nation's future, the weak performance of students in science examinations at the secondary schools is worrisome. Specifically, there has been a concern over the poor achievement of students in chemistry examinations, particularly in the West African Senior Secondary School Certificate Examination (WASSCE) and the National Examination Council (NECO).

Summary of WASSCE Chemistry Results from 2007 to 2016

Year	% Pass (Grade A – C)	% Failure (D - F)
2007	42.25	57.75
2008	44.35	55.65
2009	39.27	60.73
2010	36.27	63.50
2011	40.86	59.14
2012	41.27	58.73
2013	39.80	60.20
2014	50.94	49.06
2015	44.90	55.10
2016	40.39	59.61

Various reasons have been proposed for the dwindling (poor) performance of secondary school students in chemistry examinations in Nigeria among which is the difficulty of some concepts. WAEC chief examiners' reports for 2012-2018 identified other topics that are difficult to include chemical equilibrium, rates of chemical reactions, mole concept, thermochemistry, redox reactions and electrolysis. The general inability of students to tackle most of the numerical (problem solving) questions was also reported. This poor problem solving ability has led to the poor performance of chemistry students in the WAEC examinations (Jimoh, 2004; Njoku, 2007) with a general decline subsequently. Students' weakness as reported by the West African Examination Council, Chief examiners in chemistry include the following: inadequate practical exposure such as redox titration and rates of chemical reactions, inability to answer questions in electrolysis, inability to solve chemical problems involving the mole, lack of knowledge on balancing of chemical equation, lack of understanding of basic concepts and principles which includes chemical bonding, rates of reactions, lack of understanding of oxidation and reduction reactions and lack of knowledge on I.U.P.A.C. system of naming. There are other factors which also contribute to students' low achievement in chemistry. These include dearth of qualified and experienced chemistry teachers in secondary schools, poor environmental conditions for schooling, gender, poor funding and mismanagement of available resources, large class size in most public schools, teachers' inability to cover syllabus, reliance on examination malpractice by some schools, and poor studying habits amongst students (Boyo, 2010; Sule & Mankilik, 2015; Gongden & Gongden, 2018).

Many experts have called for a new approach to science education based on ongoing research on teaching and learning. These efforts were aimed at improving science teaching and learning. Gabel (2003) pointed out that the main reason why students are unable to perform well in science education lies with the method of instruction. In most science and chemistry classrooms, the main strategy used is the lecture method. Most of those who teach chemistry grew up learning chemistry through the lecture method

(Timberlake, 2009). Ojediran, Oludipe and Ehindero (2014) defined it as a one-way traffic process of teaching and learning with the teacher being active and the students being passive, mere listeners and note-writers. In this method, the teacher talks most of the times, leading to fleeting coverage of numerous topics but without understanding of concepts on which problems are based. It does not give room for inductive thinking, but almost completely deductive. Students simply play the role of passive listeners during the transfer of information by the teacher. Thomas and Israel (2013) identified it to be the most ineffective and the least performing method. However, despite the global shift from teacher-centered to student-centered strategies, the conventional lecture method of teaching is still the most frequently employed method of teaching chemistry in Nigerian secondary schools and has been identified by Boyo (2010).

In view of the glaring shortcomings of the conventional lecture strategy, several student-centred strategies of teaching were developed through research works. Among these are cooperative learning, collaborative learning, discovery/inquiry-based learning, use of analogies, problem-based learning, concept mapping, mind mapping, games and simulation and computer-assisted instruction among others. These have been considered as active learning strategies and have several advantages over the conventional lecture method. When students learn actively, they retain more course content for a longer time and are able to apply that material in a broader range of contexts (Morable, 2000; Pierre, 2011).

Jigsaw cooperative learning strategy is a form of cooperative learning strategy of instruction which uses jigsaw activities. It is a grouping method of teaching in which students in a class are organized into 'Jigsaw' groups. Each student in a jigsaw group is in charge of completing a part of the task/topic. The teacher allots a certain amount of time for students from different jigsaw groups who have the same task to work together temporarily in expert groups to become experts on their topic. Thereafter, original jigsaw group students come back together and each student presents his/her own information and provides an opportunity for the rest of the group students to ask questions for clarification. Each group then summarizes the presentations from their members and is presented by the group leader. The teacher's responsibility is to monitor their progress, answer any questions that may be asked about the topics and assess them on the materials they have learned through the jigsaw co-operative learning. Jigsaw cooperative learning strategy has been found to be effective, resulting in higher academic learning outcome according to a study by Lazarowitz and Baird in Hanze and Berger (2007). However, Moskowitz, Malvin, Schaeffer and Schaps in a study in Hanze and Berger (2007) found out that the jigsaw cooperative learning strategy does not influence students positively. The finding showed that though the method failed to have an effect on students' perceptions of classroom climate, attitudes towards peers or school, locus of control, school attendance, or reading and mathematics achievement, a positive effect on academic self-esteem for only female students was revealed. Aronson (2002) observed that students that learn concepts with the method do so faster and achieve higher in objective examinations than students who learn same concepts using expository methods; jigsaw cooperative learning strategy encourages listening, engagement and empathy by availing each member of a jigsaw group with an essential role to play in academic activities.

Among the factors that affect the academic achievement of students in science is school type. In this study, school type became an important consideration because studies have shown that there is inconsistency or conflicting report on the achievement of students in public and private schools. While Olatoye and Agbatogun (2009) asserted that students in private schools achieve significantly better in mathematics and science than their counterparts in public schools, Lubienski and Lubienski (2014) held the view that public schools achieve just as well, if not higher than private schools.

Another variable considered important in determining the students' achievement in science education is gender. While some researchers are of the view that male students achieve better than the females (Bot & Emefo, 2014; Nsofor & Ahmed, 2014), others opined that female students achieve better (Kathy, 2009); Adeniran, 2014). Yet still, some researchers (Mankilik & Agal, 2014) observed that both male and female students achieve equally. This shows that the contradiction between male and female students' achievement is far from been resolved.. Therefore, the situation calls for further investigation, more so that it has been opined that the instructional method used in the classroom may influence gender and students' academic achievement in science education. This study is therefore, sets to determine whether the use of jigsaw cooperative society in co-educational public and private secondary schools in Jos South LGA of Plateau state may enhance students' understanding of rates of chemical reactions and possibly enhance their performance in related subjects. There is a need for a study to establish the trend of achievement of male and female students in chemistry (chemical kinetics) in public and private schools in Jos South Local Government Area of Plateau state, Nigeria.

MATERIALS AND METHOD

The research design was the quasi-experimental design, specifically a pretest - 'posttest non-equivalent control group design. The population of the study comprised all the senior secondary two (SS2) chemistry students in .Jos South Local Government

Area of Plateau state. These were the students preparing to sit for the Senior School Certificate Examination, SSCE usually organized by the West African Examination Council (WAEC) and National Examination Council (NECO). The sample consisted of 78 students drawn from two schools – a private school and a public school in the Local Government Area. The two schools were obtained through purposive random sampling during which one school was picked from the public schools and another picked from the private schools. A senior secondary two chemistry class was randomly selected from each of the schools. The students from each class were also randomly assigned into control and experimental groups. Each school therefore had both a control and experimental group.

A rate of reaction understanding test, (RoRUT) was use to collect data from the students. It contained five questions drawn from the senior secondary two chemistry curriculum. Respondents answered the questions based on their understanding of the concept as presented to them during the period of instruction. Where any equation, illustration or formula is involved, they were expected to show clearly. Each question correctly answered attracted a total of six marks to take care of the methods, equations, formula and reasoning where applicable. The total marks obtainable were thirty (30) and was later converted to 100% for the sake of analysis. The questions were:

i. What do you understand by the term, 'rates of chemical reactions?' What is the rate of a reaction if 0.50 moles of the reactant are converted to products within two and half minutes?
ii. Briefly explain the following:
   - Activation energy
   - Collision theory
iii. Explain the effects of temperature on the rates of chemical reactions.
iv. With the aid of well-labeled diagram(s), show the effects of catalysts on rates of chemical reactions.
v. During collisions between hydrogen and iodine molecules in a closed system, it was discovered that no chemical reaction occurred. What are two possible explanations for this?

The instrument was validated appropriately by two chemistry experts and one expert in tests and measurements. In order to determine the reliability of the RoRUT, the inter-scorer method (Danjuma, 2005) for determining the reliability of an essay test was used and the Pearson Product-Moment Coefficient (PPMC) of correlation formula used to calculate the reliability coefficient which was found to 0.79.

Students were administered the instrument as pretest after which treatment was given them for three weeks. The control group in each case was taught the topic using the conventional lecture method while the experimental class was subjected to jigsaw cooperative learning strategy. The students in the experimental groups were re-grouped into jig saw groups, each having six students. Each student in a jigsaw group was given a task (one of the contents of the topic – rates of chemical reactions) to master. Students from different jigsaw groups who had the same task cooperated and worked together in expert groups to become experts on their topics. After a while they return, each to their original jigsaw group, presenting and sharing their information with others. After three weeks of instruction, they were given a posttest. This time, the questions were reshuffled. The researcher graded the students' responses and the scores were analyzed and used to answer the research questions and test the hypotheses. The data was analyzed using SPSS Statistics version 22 the most recent version and relevant other statistical tools.

RESULTS

The data collected were analyzed and the results used to answer the research questions and test the research hypotheses. The analyses were done using t-test for independent samples and decision taken at 0.05 level of significance. Where the P-value is less than 0.05, the null hypothesis is rejected in preference for the alternative hypothesis. However, where $P > 0.05$, the null hypothesis is not rejected.

Research Question One and Hypothesis One

Table 1: Group Statistics of Pretest Mean Scores of Control and Experimental Groups

Pretest Result	Group	N	Mean	Std Dev	Std Error Mean
	Control	36	26.19	9.715	1.619
	Exptal	42	25.93	10.103	1.559

Table 2: Independent Sample Test for Pretest Mean Scores of Control and Experimental Groups

	Levene's Test for Equality of Variances							95% Confidence	
Pretest Results	F	Sig	t	df	Sig (2-tailed)	Mean Diff	S. E Diff	Lower	Upper
Equal variances Assumed	.103	.750	.118	76	.906	.266	2.255	-4.224	-4.756
Equal variances not assumed			.118	74.969	.906	.266	2.248	- 4.212	-4.744

From Table 1, the pretest mean score of the experimental class is 25.93 while that of the control class is 26.19. The difference between the two is 0.26. This difference is negligible such that it can be concluded that there was no difference between the pretest mean scores of students taught using analogies and students in the control group. Table 2 revealed a P-value of 0.906 (equal variances assumed) greater than 0.05. The null hypothesis was not rejected. There is no significant difference between the pre-test mean scores of students taught rate of chemical reactions using jigsaw cooperative learning strategy and those taught using the lecture method at 5% level of significance.

Research Question Two and Hypothesis Two

Table 3: Group Statistics of Posttest Mean Scores of Control and Experimental groups

Posttest Result Achievement	Group	N	Mean	Std Dev.	Std Error Mean
	Control	36	53.89	9.818	1.636
	Exptal	42	61.90	10.566	1.630

Table 4: Independent Sample Test for Posttest Mean Achievement Scores of Control and Experimental Groups

	Levene's Test for Equality of Variances							95% Confidence	
Posttest Results Achievement	**F**	**Sig**	**t**	**df**	**Sig (2-tailed)**	**Mean Diff**	**S. E Diff**	**Lower**	**Upper**
Equal variances Assumed	.154	.656	-3.450	76	.001	-8.016	2.323	-12.643	-3.389
Equal variances not assumed			-3.470	75.483	.001	-8.016	2.310	-12.617	-3.415

Results presented in Table 3 show that the posttest mean achievement score of the control group in the mole achievement test is 53.89 while that of the experimental group is 61.90. The difference is 8.01. This shows that the experimental group achieved better than the control group. This indicates the effectiveness of jigsaw cooperative learning strategy in teaching rates of chemical reactions. Table 4 of the independent samples test shows that the P-value 0.001 < 0.05 (equal variances assumed). There is a statistically significant difference between the post-test mean scores of students taught rates of chemical reactions using jigsaw cooperative learning strategy and those taught using the lecture method at 5% level of significance. Those taught with jigsaw cooperative learning strategy achieved better than those in the control class.

Research Question Three and Hypothesis Three

Table 5: Group Statistics of Posttest Mean Achievement Scores of Male and Female Students Taught Using Jigsaw Cooperative Learning Strategy.

Posttest Achievement	Group	N	Mean	Std Dev.	Std Error Mean
	Male	25	64.28	10.557	2.111
	Female	17	58.41	9.856	2.390

Table 6: Independent Sample Test for Posttest Mean Achievement Scores of Male and Female Students in Jigsaw Cooperative Learning Strategy Class

	Levene's Test for Equality of Variances							95% Confidence	
Posttest Achievement	F	Sig	t	df	Sig (2-tailed)	Mean Diff	S.E Diff	Lower	Upper
Equal variances Assumed	.539	.467	-1.815	40	.077	-5.868	1.832	-.665	12.401
Equal variances not assumed			-1.840	36.070	.074	-5.868	3.189	-.600	12.336

Analysis presented in Table 5 revealed that the male students had a posttest mean achievement score of 64.28, while the female students had a mean score of 58.41. The difference between the mean scores of the male and female students is 5.87. This indicates that the use of jigsaw cooperative learning strategy slightly favors the male students above the female students when used to teach rates of chemical reactions. The independent samples test (Table 6) yielded a P-value of 0.077 > 0.05. The null hypothesis was not rejected. There is no statistically significant difference between the posttest mean achievement scores of male and female students taught the rates of chemical reactions using jigsaw cooperative learning strategy and those taught using the lecture method at 5% level of significance. This means that jigsaw cooperative learning strategy influence both male and female students similarly.

Research Question Four and Hypothesis Four

Table 7: Group Statistics of Posttest Mean Scores of Private and Public

Posttest Retention	Group	N	Mean	Std Dev.	Std Error Mean
	Private	20	59.48	8.078	1.616
	Public	22	52.76	6.648	1.612

Table 8: Independent Sample Test for Posttest Mean Scores of Private and Public Schools

Levene's Test for Equality of Variances 95% Confidence									
Posttest Retention	**F**	**Sig**	**t**	**df**	**Sig (2-tailed)**	**Mean Diff**	**S. E Diff**	**Lower**	**Upper**
Equal variances Assumed	.524	.474	-2.834	40	.007	6.715	2.370	1.926	11.505
Equal variances not assumed			-2.942	38.432	.006	6.715	2.283	2.096	11.334

The posttest mean scores of the students from the private and public schools were 59.48 and 52.76 respectively. This gives a difference of about 6.72. This shows that jigsaw cooperative learning strategy favored students from private schools than public schools.

From the Independent samples test above, it is observed that P = 0.007 (<0.05) when equal variance is assumed. Hence the null hypothesis was rejected in favor of the alternative hypothesis. There is significant difference between the achievement of chemistry students in private schools and those from private schools taught rates of reactions using jigsaw cooperative learning strategy. Students from private schools demonstrated better understanding of the topic than students from public schools taught using the same strategy.

DISCUSSION OF RESULTS

The study established a significant difference between the posttest mean scores of students taught rates of chemical reactions using jigsaw cooperative learning strategy and those taught using the lecture method. Those taught with jigsaw cooperative learning strategy demonstrated better understanding of the concept than those in the control class. This finding is in line with those of Azmin (2016) and Tukur, Nurulwahida and Madya (2018) who found out independently that students' performance is significantly enhanced when they are exposed to Jigsaw learning strategy. Sheikhi, Zainalipoor and Jamri (2012) had in an earlier study established similar findings when they investigated the effects of Jigsaw technique on the academic achievement of 2nd grade middle school students. Jigsaw cooperative learning significantly increased the achievement scores of the experimental group. Other studies that this finding agree with include those of Lazarowitz and Baird in Hanze and Berger (2007). The finding may be due to the advantage that Jigsaw cooperative learning strategy presents to students. Aronson (2002) observed that students that learn concepts with the method do so faster and achieve higher in objective examinations than students who learn same concepts using expository methods; jigsaw cooperative learning strategy encourages listening, engagement and empathy by availing each member of a jigsaw group with an essential role to play in academic activities. The finding however, differs from that of Moskowitz, Malvin, Schaeffer and Schaps (in Hanze and Berger, 2007) who found out that the Jigsaw cooperative learning strategy did not influence students positively.

The study also found out that there is no statistically significant difference between the posttest mean achievement scores of male and female students taught the rates of chemical reactions using jigsaw cooperative learning strategy and those taught using the lecture method at 5% level of significance. This means that jigsaw cooperative learning strategy influence both male and female students similarly. This finding is consistent with that of Anagbogu and Ezeliora (2007), Mankilik & Agal (2014) and Gongden and Gongden (2019) who found out variously that male and female students show no significant difference in their achievement in science education. The finding however, disagrees with those of Njoku (2005), Bot & Emefo (2014), and Nsofor and Ahmed (2014) who found out boys performed better than girls in science education. Kathy (2009) and Adeniran (2014) on the other established the superiority of females over males in their separate studies. The non-statistical significant difference may be due to the advantages of Jigsaw cooperative learning strategy which tends to eliminate or avoid many of the problems of other forms of learning in a group. Nwachukwu (2008) reports that exposing girls to small group cooperative interaction learning styles makes them to attain high cognitive achievement in chemistry, just as their male counterparts.

There is significant difference between the achievement of chemistry students in private schools and those from private schools taught rates of reactions using jigsaw cooperative learning strategy. Students from private schools demonstrated better understanding of the topic than students from public schools taught using the same strategy. The finding here agrees with earlier studies by Onah (2011) who found out that students from private schools who were taught chemistry using obtained higher mean achievement scores than those from public schools. It is also consistent with those of Alimi, Ehinola and Alabi (2012), who opined that private schools are better in terms of students' achievement than public schools. Deraney and Abdelsalam (2012) also, while studying on private versus public schools education found out that female students that graduated from private secondary schools in Saudi Arabia achieved higher in the preparatory level than those that graduated from public schools. The finding disagreed with that of Okorie and Ezeh (2016) who found out that school location has no statistically significant effect on students' mean achievement scores in chemistry. Lubienski and Lubienski (2014) also held the view that public schools achieve just as well, if not higher than private schools.

CONCLUSION

The study attempted to find the effects of jigsaw cooperative learning strategy on chemistry students' understanding of rates of reactions. The study showed that the strategy greatly improves students understanding (and hence achievement) of chemistry regardless their gender (whether male or female). The strategy proved to be one of the active learning techniques which generally shift the focus of instruction from the teacher and his/her delivery of course content to the student and his/her active engagement. In it, there is interaction between student with student, teacher with student and student with the materials. Based on the results of the study, the following recommendations were made:

i. Since the use of jigsaw cooperative learning strategy enhances academic achievement of students in chemistry, it is recommended that the strategy should be used in the teaching of chemistry in secondary schools. This is more so that the use of jigsaw cooperative learning strategy influences both male and female students similarly.
ii. Curriculum designers should be made aware of the effectiveness of jigsaw cooperative strategy and to take such into consideration when designing and revising chemistry and other curricula. This strategy should be recommended alongside other teaching strategies.
iii. Necessary attention should be given to jigsaw cooperative learning strategy during teacher – training sessions/programs so as to equip chemistry teachers with the skills of jigsaw cooperative learning strategy. Those who are already in the field should be trained in the art of jigsaw cooperative learning strategy through the use of in - service seminars related to this issue.

iv. Using jigsaw cooperative learning strategy in the chemistry classroom contributes to students' conceptual understanding since students have a chance to participate in discussions with one another, sharing with one another and providing explanations to one another.

v. The effectiveness of jigsaw cooperative learning strategy can be investigated with respect to students' achievement and understanding of other chemical concepts.

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