Jigsaw Cooperative Learning in Physics: It's Impact on Secondary School Students' Achievement in Bukuru Metropolis, Nigeria

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Abstract

The study investigated the impact of Jigsaw cooperative learning on secondary school students' achievement in Physics. It employed the non-equivalent control group pretest-posttest type of quasi-experimental research design. One hundred and twenty eight (128) Senior Secondary Two (SS II) students from four co-educational secondary schools were used as sample for the study. A 50-item multiple-choice instrument called, "Heat Energy Achievement Test (HEAT)", was used to test students on the concepts of heat energy measurements. The internal consistency of HEAT was estimated at 0.83, using Kuder-Richardson formula 20. Three research questions were raised and answered using mean while two hypotheses were formulated and tested at α=0.05 using Analysis of Covariance (ANCOVA). Findings revealed, amongst others, that students taught using jigsaw cooperative learning achieve significantly higher than students instructed under conventional lecture method, irrespective of gender and the type of school they attend. Based on the findings, recommendations were made which included encouraging Physics teachers to employ jigsaw cooperative learning in teaching secondary school students, since the method has been found to enhance students' achievement in Physics and it is gender-friendly and independent of school type in terms of improving their achievement in the subject.

Keywords: Jigsaw cooperative learning, students' achievement in Physics, students' gender, school type, Bukuru metropolis, Nigeria

Introduction

Physics is a subject which studies matter and the behaviour of such matter in relation to energy. It is actually the study of inanimate matter, energy and their interactions. This signifies that a relationship exists between the behaviour of inanimate matter and energy which Physics explains. Young and Freedman (2008) defined Physics as an experimental science. This is because the phenomena of nature are usually observed by Physicists in an attempt to look for patterns and principles that relate and explain these phenomena. Physics plays an important role in the future progress of citizens of a nation. It does so by contributing to the technological infrastructure of the nation and providing trained personnel required to take advantage of scientific advances and discoveries. Furthermore, Physics is the most basic of sciences and its concepts underpin the understanding of other branches of science. This implies that the knowledge of Physics facilitates understanding of Physics-related disciplines. Therefore, the knowledge of its principles, laws and theories through Physics education is a necessity for the development of any nation. Moreover, Physics is a cross-cutting discipline whose application is found in many sectors of socio-economic development of any nation. For instance, its application is found in health, agriculture, energy and information communication sectors. In the health sector, the understanding of Physics is, indeed, necessary for developing new instrumentation and techniques. For instance, the x-ray machine which is used to take pictures of dense tissues such as bones and teeth is dependent on x-rays, a concept of Physics. X-rays are highly penetrating, ionizing radiation. In the agriculture sector, the various technologies of physics can reap great economic benefits for agriculture. For instance, Ginski, Horabik and Lipiec (2013) opined that energy transport (heat conduction, convection, radiation), thermal conductivity, thermal heat capacity, specific heat and permittivity, which are concepts in Physics, impact on agricultural products and food through drying, processing and cooking. In the area of information communication, computers are used to send and receive digital signals. They do so by working on principles of Physics. Analog radio waves are turned into digital signals represented by electrons whizzing along circuit boards. Digital signals can also be sent using electromagnetic radiation, usually achieved through a communication technology referred to as fiber optics.

In spite of the importance that Physics has to the socio-economic growth of a nation, results of students in Physics examinations such as the Senior School Certificate Examination (SSCE) organized by West African Examination Council (WAEC) and National Examination Council (NECO) have been unsatisfactory. The results of students in such examinations over the past years show poor achievement in Physics in some years and fluctuates on the average in the years past (NECO, 2016; WAEC, 2017). The fluctuation in students' achievement in Physics is worrisome as students who have been failing could not afford to study Physics or Physics-related courses in higher institutions of learning. The implication of this is that such students do not get the opportunity to contribute their quota to the socio-economic growth of Nigeria in the area of science and technology. Reports indicate that there are factors which have led to the unsatisfactory

results of Physics in the past years in Nigeria. These factors include ineffective methods of teaching Physics which are being used in secondary schools (Boyo, 2010; NECO, 2011, 2012; WAEC, 2015).

The conventional lecture method is viewed by Ojediran, Oludipe and Ehindero (2014) as a one-way traffic of teaching and learning, with the teacher being active and the students being passive, mere listeners, concentrating only on writing down information in form of notes. This method of teaching Physics which does not promote functional education, and which Boyo (2010) decried as being ineffective in the teaching-learning process, is a setback for sustainable development. In view of the reality of gross unemployment that stares the face of most developing nations, Physics should be taught using methods that enhance students' understanding of concepts and their achievement in the subject.

Jigsaw cooperative learning is a strategy of cooperative learning method of teaching which employs Jigsaw activities and aims at reducing learning conflict and enhancing positive educational outcome. In this strategy of teaching, students in a class are organized into 'jigsaw' groups, also called 'home' groups and are given portions of a task to accomplish. The students in the jigsaw groups are then re-organized into 'expert' groups containing one student from each jigsaw group. The students in the expert groups learn the portion of the task assigned to them and, after learning the task assigned, each student goes back to his/her original jigsaw group to contribute. This method of teaching can be used to teach students in both theory and practical aspects of Physics although, Maftei and Popescu (2012) were of the view that jigsaw cooperative learning yields better results in the practical aspects of Physics when students are taught using it. Aronson (2002) summarized the advantages of jigsaw cooperative learning as follows: 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 encourages listening, engagement and empathy by availing each member of a jigsaw group with an essential role to play in academic activities.

A study conducted by Lazarowitz, Hertz-Lazarowitz and Baird as cited in Hanze and Berger (2007) revealed that students taught using jigsaw cooperative learning score higher in their involvement in the classroom than their counterparts taught using conventional lecture method. Another study by Jurgen-Lohmann, Borsch and Giesen as cited in Hanze and Berger found out that no differences in achievement exist between students taught using jigsaw cooperative learning and those taught under conventional lecture method. They, furthermore, found out that jigsaw cooperative learning increases students' active involvement in classes. This is irrespective of the gender of the students.

Achievement in Physics is very important since it is the bedrock of science and technology; and, science and technology is an effective agent which propels the socio-economic development of the modern nation. Therefore, continuous poor achievement in Physics, or fluctuation in achievement, could spell doom for a nation. There are variables that influence students' achievement in Physics, some of which are gender and school type. Gender issues are contemporary and of universal concern and research works have

shown inconsistency in achievement of male and female students in Physics. For instance, in a study on effects of analogy instructional strategy, cognitive style and gender on achievement in secondary school Physics, Okoronka and Wada (2014) found out that gender has no significant effect on students' achievement in Physics. Other researches, such as those of Apata (2011), Aina and Akintunde (2013), revealed that male students achieve better in Physics than their female counterparts.

Another moderating variable which may affect achievement in Physics is school type. For the purpose of this research, school type is delineated into public and private schools. While public schools are the type of schools owned by Government (Local, State or Federal), private schools are the type owned by individuals, group of individuals, communities or religious bodies. Private schools vary widely and levels of involvement of parents vary from one private school to the other. Parents pay for the high cost of educating their children in private schools and therefore tend to be more involved in dictating what the schools offer than parents whose children are attending public schools (Olatoye and Agbatogun, 2009). Despite the differing characteristics between public and private schools, studies show inconsistency on the superiority of the schools in term of achievement in science. For instance, Lubienski and Lubienski (2014) held the view that public schools achieve just as well if not higher than private schools, demographic factors being constant. However, in the study conducted by Olatoye and Agbatogun (2009), a significant difference in mathematics and science achievement of public and private school pupils exists in which private school pupils performed better than public school counterparts in science.

Many research works on jigsaw cooperative learning have been conducted outside Nigeria, with only a few carried out within. However, there seemed to be none conducted in Bukuru metropolis, a town in Plateau State of Nigeria. It is pertinent, therefore, to investigate the impact of jigsaw cooperative learning on secondary school students' achievement in Physics in Bukuru metropolis. To achieve the objectives of the study, research questions were raised and hypotheses formulated and tested at $\alpha = 0.05$.

Research Questions

- What is the level of Secondary School Two (SS II) students' achievement in Physics before and after exposure to Jigsaw Cooperative Learning (JCL)?
- What is the level of SS II students' achievement in Physics, based on gender, before and after exposure to JCL?
- What is the level of SS II students' achievement in Physics, based on school type, before and after exposure to JCL?

Hypotheses

- There is no significant interaction impact of treatment and gender on Secondary School Two (SS II) students' achievement in Physics.
- There is no significant interaction impact of treatment and school type on SS II students' achievement in Physics.

Methodology

This study employed the non-equivalent control group pretest-posttest quasi-experimental research design. This implies that intact classes were used from four sampled co-educational secondary schools (two public and two private) for the study. Simple random sampling technique using the Table of Random Digits (two-digit column) was used to obtain the four schools. One of the two public schools was randomly assigned to experimental group while the second was assigned to the control group. Likewise, one of the two private schools was randomly assigned to experimental group while the second was assigned to the control group. The experimental group was taught Senior Secondary Two (SS II) aspects of heat energy measurements in the Physics curriculum using Jigsaw Cooperative Learning (JCL), while the control group was taught the same concepts using the conventional lecture method. The instrument used for the study was Heat Energy Achievement Test (HEAT) which enabled the researcher to measure students' achievement in heat energy measurements concept of Physics.

The test instrument HEAT was developed from secondary school Physics curriculum and past Senior Secondary Certificate Examination (SSCE) organized by West African Examination Council (WAEC), using a test blue print. The instrument was given to three experts in the University of Jos for face and content validity. Thereafter, the reliability of HEAT was obtained as 0.83 using Kuder-Richardson formula 20 (K-R 20) on the SPSS Software Version 23. An intact sample of a total of 128 SSII Physics students (66 male and 62 female) from four co-educational secondary schools (two from 50 co-educational public schools and two from 78 co-educational private schools) were used to gather data for the study. Pretest was administered on both the experimental and control groups using the developed test instrument HEAT, a week before treatment commenced. Thereafter, treatment was carried out on the experimental group for a period of four weeks on the topic heat energy measurements. The control groups were merely engaged on the same topic heat energy measurements by being taught using conventional lecture method during the same period of four weeks that the experimental groups were treated. After the four weeks treatment, a posttest was administered to all the students in both the experimental and control groups using HEAT. The mean, which is a descriptive statistic, was used to answer the raised research questions; while Analysis of Covariance (ANCOVA) was employed to test the formulated null hypotheses. Scheffe Multiple range test was used as post-hoc to ascertain the source of significant interaction effect of independent variables on the dependent variable.

Results

Research Question One

What is the level of Secondary School Two (SS II) students' achievement in Physics before and after exposure to Jigsaw Cooperative Learning (JCL)?

Table 1 shows data analysis of research question one.

Table 1: Achievement Mean Scores of SS II Students in Physics, Before and After Exposure to Jigsaw Cooperative Learning

Group		Before		After	
	N	□	SD	□	SD
Experimental	62	34.90	16.76	54.58	10.64
Control	66	32.70	18.23	37.67	15.06

The findings in Table 1 revealed respective achievement mean scores of 34.90 and 54.58 for students in the experimental group, before and after exposure to treatment using jigsaw cooperative learning; while those in the control group had respective mean scores of 32.70 and 37.67 before and after treatment.

Research Question Two

What is the level of SS II students' achievement in Physics, based on gender, before and after exposure to JCL?

Table 2 shows data analysis of research question two.

Table 2: Gender Achievement Mean Scores of SS II Students in Physics, Before and After Exposure to Jigsaw Cooperative Learning

Group	Gender		Before		After	
		N	□	SD	□	SD
Experimental	Male	31	26.26	7.33	54.39	11.51
	Female	31	26.97	6.96	54.77	9.89
Control	Male	35	28.97	7.71	37.31	13.35
	Female	31	28.39	8.91	38.06	17.01

The findings in Table 2 revealed that male students in the experimental group had a mean achievement score of 26.26 before exposure to treatment of teaching using jigsaw cooperative learning and 54.39 after exposure to the treatment respectively, while their female counterparts had respective mean scores of 26.97 and 54.77 before and after exposure to Jigsaw cooperative learning. Similarly, the results revealed that male students in the control group had respective mean achievement scores of 28.97 and 37.31 before and after treatment, while their female counterparts had respective mean scores of 28.39 and 38.06 before and after the treatment.

Research Question Three

What is the level of SS II students' achievement in Physics, based on school type, before and after exposure to JCL?

Table 3 shows data analysis of research question one.

Table 3: School Type Achievement Mean Scores of SS II Students in Physics, Before and After Exposure to Jigsaw Cooperative Learning

School Type	Group		Before		After	
		N	□	SD	□	SD
Private	Experimental	36	33.28	7.05	57.78	9.03
	Control	42	31.38	7.50	40.86	16.22
Public	Experimental	26	23.31	6.12	50.15	11.27
	Control	24	24.00	7.41	32.08	10.99

Table 3 showed that before treatment, students in experimental group of private schools had an achievement mean score of 33.28, while their counterpart in the control group had a mean of 31.38. Furthermore, the result showed that students in the experimental group of public schools had an achievement mean score of 23.31 and those in control group had a mean of 24.00 before the treatment. After treatment, the achievements mean score of students in the experimental group of private schools was 57.78, while that of their counterparts in the control group was 40.86.

Hypothesis One

There is no significant interaction impact of treatment and gender on Secondary School Two (SS II) students' achievement in Physics.

Table 4 shows ANCOVA results of interaction impact of treatment and gender on students' achievement in Physics.

Table 4: ANCOVA Results of Interaction Impact of Treatment and Gender on Students' Achievement in Physics

Sources of Variation	Type III Sum of Squares	Df	Mean Square	F	P
Corrected Model	13812.710[a]	3	230.212	22.790	0.019
Intercept	157.427	1	157.427	8.746	0.208
Treatment	50.065	1	50.065	2.778	0.048
Gender	78.456	1	97.864	0.876	0.467
Treatment*Gender	6592.025	3	412.002	22.889	0.013
Error	3960.286	125	188.585		
Total	2956.346	128	134.379		
Corrected Total	**13830.710**	**127**			

R Squared = .959 (Adjusted R Squared = .921)

The results from Table 4 indicates that F (3,125 = 22.790, p =.019).That is $p<0.05$, which implies that H_0 is rejected and inference drawn that there is a significant

interaction impact of treatment and gender on SSII students' achievement in Physics after exposure to Jigsaw cooperative learning.

Hypothesis Two

There is no significant interaction impact of treatment and school type on SS II students' achievement in Physics.

Table 5 shows ANCOVA results of interaction impact of treatment and school type on students' achievement in Physics.

Table 5: ANCOVA Results of Interaction Impact of Treatment and School Type on Students' Achievement in Physics after Exposure to Jigsaw Cooperative Learning

Sources of Variation	Type III Sum of Squares	Df	Mean Square	F	P
Corrected Model	6978.537[a]	3	64.616	11.778	0.075
Intercept	2909.365	1	2909.365	8.063	0.000
Treatment	41.235	1	41.235	3.887	0.036
School Type	1122.523	1	37.417	1.030	0.045
Treatment* School Type	2567.977	3	55.826	1.536	0.015
Error	690.431	125	36.338		
Total	106348.012	128			
Corrected Total	**7668.969**	**127**			

R Squared = .910 (Adjusted R Squared = .835)

Table 5 reveals that F (3, 125 = 11.778, $p<.05$). Based on this, H_o is rejected and conclusion drawn that there is a significant interaction impact of treatment and school type on SSII students' achievement in Physics after exposure to Jigsaw cooperative learning.

Discussion

Finding from Table 1 revealed that not much difference was observed in the achievement mean scores of students in the experimental and control groups before treatment was administered. The result, however, further indicated that students in the experimental group who were exposed to jigsaw cooperative learning had a higher achievement mean score (54.58) after the treatment than those in the control group (37.67) who were taught Physics using conventional lecture method. This agrees with the findings of Lazarowitz, Hertz-Lazarowitz and Baird as cited in Hanze and Berger (2007) that students taught using jigsaw cooperative learning score higher in their involvement in the classroom.

The findings further revealed that, though not much difference was observed in the mean achievement scores of male and female SS II Physics students in the two groups after treatment, female students in both groups achieved averagely higher than their male

counterparts (Table 2). The results also indicate that male and female students in the control group achieved lower, on the average, than their counterparts in the experimental group after exposure to treatment of teaching using jigsaw cooperative learning. This implies that for better achievement in Physics, students should be taught the subject using jigsaw cooperative learning. Table 3 revealed that students in the experimental group from private school who were exposed to the treatment of teaching using Jigsaw cooperative learning achieved much higher than their counterparts in the control group who were not exposed to the treatment. Further findings from Table 3 revealed that after treatment, the respective achievement mean score of students in the experimental and control groups from public school was 50.15 and 32.08. This implies also that public school students in the experimental group achieved more than their counterparts in the control group after exposure to the treatment of teaching using the Jigsaw cooperative learning. This finding is in line with that revealed by Olatoye and Agbatogun (2009) that learners in private schools achieve higher than their counterparts in public schools.

Although finding from Table 4 reveals that there was a significant interaction effect of treatment and gender on SSII students' achievement in Physics after exposure to Jigsaw cooperative learning, and Table 5 reveals that there was a significant interaction effect of treatment and school type on SSII students' achievement in Physics after exposure to Jigsaw cooperative learning, Scheffe's multiple range test did not reveal significant interaction effects between male and female students (gender) and between students in public and private schools (school type). The implication is that jigsaw cooperative learning, which was administered on the experimental groups (comprising both male and female students) in the private and public schools, was the source of interaction effect on SSII Physics students' achievement in Physics, and not students' gender or the type of school they attended. The implication of these results is that Jigsaw cooperative learning seems to have a great positive effect on secondary school students' achievement in Physics.

Conclusion

When jigsaw cooperative learning is used as an instructional method in teaching Physics, it improves students' achievement in the subject. Moreover, the achievement of students who learn Physics under the method of instruction does not depend on gender and school type.

Recommendations

Based on the findings of the study, the following recommendations have been proffered:

- Curriculum planners should plan Physics curriculum such that jigsaw cooperative learning is used by teachers to teach concepts in Physics. This is because the method inculcates leadership skills, tolerance and social cohesion needed for successful careers.

- Authors of secondary school Physics textbooks should write books in line with jigsaw cooperative learning. This will further make the use of the method popular in the teaching-learning environment.
- Workshops, seminars and conferences should be periodically organized by Ministry of Education and professional bodies for Physics teachers. This will equip the teachers towards effective implementation of jigsaw cooperative learning in their teaching.
- Physics teachers should employ jigsaw cooperative learning in teaching students in secondary schools, since the method has been found to enhance their achievement in the subject. Moreover, the method is gender-friendly and is independent of school type in terms of improving their achievement in the subject.

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