EFFECT OF JIGSAW IV COOPERATIVE INSTRUCTIONAL STRATEGY ON ACADEMIC PERFORMANCE IN MATHEMATICS AMONG POST-BASIC SCHOOL STUDENTS IN ADAMAWA STATE, NIGERIA

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Abstract

This study investigated the effect of Jigsaw IV Cooperative Instructional Strategy (J4CIS) on students' academic performance in mathematics in post-basic schools in Adamawa State, Nigeria. The study was guided by two research questions and two hypotheses. A quasi-experimental, pre-test, post-test, non-equivalent research design was adopted for the study. The population of the study was 40976 SSII students in Adamawa State. A total of 240 SSII students served as a sample size from 4 intact classes using multistage sampling technique; 125 (63 male and 62 female) SSII students were in the experimental group, while 115 (62 male and 53 female) were used as the control group. The instrument for data collection was the Student Mathematics Performance Test (SMPT), which was validated by experts in mathematics and mathematics education in the Modibbo Adama University Yola. The reliability coefficient of 0.74 was obtained using Kuder-Richardson's formula (KR-21). Data collected were analyzed using mean and standard deviation to answer research questions, while hypotheses were tested using Analysis of Co-variance (ANCOVA). The findings of the study showed that the mean performance score of students taught mathematics using Jigsaw IV cooperative instructional strategy was significantly higher than those taught with the Conventional method (P<0.05). Female students had a higher mean performance score difference than male students after being taught using Jigsaw IV cooperative instructional strategy, though the difference was not statically significant (P > 0.05). The study concluded that the Jigsaw IV cooperative instructional strategy enhanced the academic performance of students in mathematics, irrespective of gender. The study recommended that the Adamawa State Post-Primary Management Board should embark on training mathematics teachers on how to use Jigsaw IV cooperative instructional strategy as a mode of teaching mathematics to the students so as to improve their academic performance in mathematics.

Keywords: Jigsaw IV cooperative instructional strategy, academic performance, mathematics, gender.

Introduction

Science is the bedrock of modern technology because the world depends greatly on it, while mathematics is the foundation of science and technology, and the functional role of mathematics in science and technology is so multifaceted and multifarious that no area of science, technology, or business enterprise can be studied without its application. Mathematics is the science that deals with the arrangement

and logic of shape and quantity (Alshatri, Wakil, Jamal, & Bakhtyar, 2019). The place of mathematics in any national development cannot be overemphasized. This justifies the compulsion of the study of the subject by all students who go through basic and post-basic schools in Nigeria. It is regrettable, however, that in contemporary times, many students still struggle with mathematics and perform abysmally low in their internal and external examinations. Among science and technology courses, according to the National Policy on Education of the Federal Republic of Nigeria (2014), mathematics is one of the core subjects to be offered by all students up to the tertiary levels of education. Mathematics is widely regarded as one of the most important subjects in the school curriculum. The problem of learning mathematics in Nigerian schools at all levels has continued to be topical and attracted the attention of researchers in the field of education. Several factors have been identified as major problems in teaching and learning mathematics. For instance, Harries and Bourne (2017) identified ineffective teacher-centered methods that are employed in classrooms as having negative impacts on the teaching and learning of mathematics, implying that the mode of teaching presentation influences effective learning of mathematics. Furthermore, Jameel and Ali (2016) pointed out that teachers' methods of teaching mathematics in Nigeria is among the contributory factors responsible for students' poor performance in mathematics. This is one of the major reasons why Sagaas, cited in Saribas (2015), asserted that if the existing strategy of teaching is not yielding results, then other teaching strategies should be adopted. Consequently, there is a need for teachers to be exposed to effective teaching and learning methods that are learner-centered, such as cooperative learning strategies, which provide students with the opportunity to participate actively in the teaching and learning activities during mathematics lessons.

Cooperative learning is an instructional strategy that facilitates the process of learning, which is why it is described as a student-centered mode of learning. The strategy can be achieved by dividing the students into small groups to work together on learning tasks (Machado & Coimbra, 2015). There are several types of co-operative learning. The Jigsaw strategy is one of them. Jigsaw is a cooperative learning technique that was developed by Elliot Aronson and his colleagues in 1978. The jigsaw technique was created with the goals of reducing conflict, enhancing positive educational outcomes and encouraging cooperation in a learning environment. Furthermore, jigsaw is a cooperative learning strategy in which everyone becomes an expert and shares learning so that eventually all group members know the content given by their instructors. There are currently six types of Jigsaw cooperative learning strategies available for teachers to use in the classroom (Bolaji, Kajuru, & Timayi, 2015). They are: Jigsaw I, Jigsaw II, Jigsaw III, Reversed Jigsaw, Subject Jigsaw, and Jigsaw IV. Jigsaw IV was adopted in the study; the Jigsaw IV cooperative Instructional Strategy (J4CIS) was developed by Holliday (2002). It involves assigning students to a heterogeneous group (using some coding system) called the Home Group (HG) based on the number of items in the content to be learned. All the members in the HGs with the same code are grouped again into different Expert Groups (EG), where they

learn only a part of the entire material content called the Expert Sheet (ES). They return to their home group, teach all their group members, and take quizzes, all based on the original material. Finally, the teacher re-teaches any material that was misunderstood after the individual assessment process.

According to Abdel-Mordy, Sabry, and Mahmoud (2022), the jigsaw technique reduces racial conflict among students, promotes better learning, improves student achievements, and enhances their self-esteem and self-confidence. It is better than the lecture method. This research is interested in comparing the Jigsaw IV cooperative instructional strategy with the lecture method. The conventional method remains one of the more popular teaching methods used to transmit information and ideas by teachers, trainers, and speakers. Yusuf (2012) stated that the conventional method can be referred to as the technique that involves the teacher's incomplete verbal instruction or exposition. In this method, the instructors are the ones who play an important role in educating students. The lecture method usually involves one-way communication and allows for little or no student participation. It also contributes to low potential and performance in learning among students (Salleh-Abu & Abidin, 2013). In view of this, the conventional method has been criticized as a poor method of teaching hands-on skills in sciences, including mathematics (Ali, Hukumdad & Khan, 2010). This, by implication, can lead to poor students' academic performance in mathematics in external examinations.

Academic performance refers to mastering a set of skills and knowledge that a student can possess after being exposed to educational experiences in a particular study subject or group of subjects (Al-Salakhi, 2013). Furthermore, Jimoh, Idris, and Olatunji (2016) opined that academic performance is the level of success attained by students in school subjects. Therefore, to assist students in attaining high academic success in mathematics, teachers need to adopt certain instructional methods and strategies that emphasize students' active involvement and give them opportunities to interact, reason, and develop self-confidence. In a study carried out by Fasasi (2015), the author discovered that low academic performance in mathematics was caused by teachers' non-utilization of the appropriate teaching method. Fasasi further stated that the most commonly used method of teaching in Adamawa State is teacher-centered, and it is inadequate to equip the students to learn mathematics effectively.

Furthermore the dwindling general academic performance of students in science subjects, especially mathematics in particular, in external examinations such as the West Africa Senior Secondary Certificate Examination (WASSCE) at the post-basic school level over the years is of great concern to all students, parents, teachers, government, and the general public because the statistics revealed that the percentage of students who failed to obtain a credit pass in mathematics at the senior school certificate examination has been very high (Chief Examiner's Report WAEC, 2011-2020). Likewise, students' performance in mathematics at the WASSCE examinations in Adamawa State did not exceed 40% for the past nine years, based on statistics (WAEC Statistics, 2011–2020). This is definitely a disturbing issue for the government as well as

parents. One of the indicators of the incessant poor academic performance of students in mathematics is that they find some mathematics concepts difficult to understand, like geometry. Generally, studies such as Tele and Gyang, (2015), Abugu, (2017), have consistently reported low performance of students in mathematics, and geometry was found to be a core difficult area in mathematics, which contributes to this malady. It has also been observed that students are generally weak in geometry, and only very few candidates attempt questions on geometry over the years during WASSCE and NECO examinations, as pointed out by Adolphus (2011) and Ali, Bhagawati and Samah (2014). These difficulties in learning mathematics concepts have been associated with or attributed to the constant use of the teacher-centered method (talk and talk method) in the teaching and learning of mathematics. Mathematics teachers rely most on teaching approaches that are easy but most often inadequate and inappropriate (Moore, 2012). As a result, students approach mathematics problems by simply applying the steps they have memorized without a good understanding of the mathematical concepts, whereas mathematics is a practically oriented subject. There is a need for an alternative method of instruction to enhance the teaching and learning of mathematics because several studies (such as Jameel & Ali, 2016; Gambari & Yusuf, 2017) have shown that students' academic performance is more likely to improve when they are given the opportunity to monitor and regulate their learning strategies.

Another interesting variable that may affect students' performance in mathematics is gender issue. Many researchers such as (Agwagah (2013) pointed out that gender disparity in mathematics education still exists in favour of the male students. Studies such as Adaramola and Obomanu (2013), Imoko and Anyagh(2012) reported that males achieved higher than females in mathematics whereas others like Timayi, Ibrahim and Surajo (2016) found no significant difference in the interest and academic achievement (in geometry) and mathematical proficiency of boys and girls taught mathematics using Jigsaw IV cooperative learning. This implies that various results regarding gender on different field of studies are contradictory. Therefore, it was necessary to include the gender variable in this study to ascertain whether academic performance of students could be based on gender. Based on the forgoing, the question arises as to what are the effects of using Jigsaw IV Cooperative Instructional Strategy (J4CIS) on academic performance in mathematics among post-basic school students' in Adamawa State, Nigeria

Purpose of the Study

The purpose of the study was to determine the effect of Jigsaw IV Cooperative Instructional Strategy (J4CIS) on academic performance in mathematics among post-basic school students in Adamawa State, Nigeria. Specifically, the objectives of the study were to:

1. determine the effect of Jigsaw IV cooperative instructional strategy and lecture method on post-basic school students 'academic performance in mathematics.
2. determine the effect of the Jigsaw IV cooperative instructional strategy on the academic performance of male and female students in mathematics.

Research Questions

The following research questions were raised to guide the study

1. What is the difference between the mean performance scores of students taught mathematics using Jigsaw IV cooperative instructional strategy and those taught using conventional method?
2. What is the difference between the mean performance scores of male and female students taught mathematics using the Jigsaw IV cooperative instructional strategy?

Hypotheses

The following hypotheses were formulated and tested at 0.05 level of significance and guided the direction of the study:

H_{O1}: There is no significant difference between the mean performance scores of students taught mathematics using Jigsaw IV cooperative instructional strategy and those taught using conventional method.

H_{O2}: There is no significant difference between the mean performance scores of male and female students taught mathematics using the Jigsaw IV cooperative instructional strategy.

Methodology

The study adopted a pretest-posttest, non-randomized quasi-experimental research design that involved two groups, one experimental and the other control. The population of the study comprised all 40,976 senior secondary school year two (SSII) students in the public schools in Adamawa State. A multi-stage sampling technique was used to obtain 240 students as the sample size for the study from four public co-educational schools. In the four schools selected for the study, two SSII intact classes in two of the schools were selected and taught mathematics using the Jigsaw IV cooperative instructional strategy, which was referred to as the experimental group. The Jigsaw IV cooperative instructional strategy was strictly followed during lesson presentations, in which the students were guided on the use of cooperative learning procedures and how to form home and expert groups. The other two intact SSII classes were taught using the conventional method and were referred to as the control group. The instrument used for data collection was the Student Mathematics Performance Test (SMPT), which was validated by three experts, two from the Faculty of Education and another staff member from the Faculty of Science, Mathematics Department, Modibbo Adama University, Yola. The SMPT consisted of a 50-choice multiple-choice objective test with four alternative responses, A to D, adapted from the past West African Examination Council (WAEC, May/June, 2011–2020). The internal consistency of the Student Mathematics Performance Test (SMPT) was determined to be 0.74 using Kuder-Richardson's formula (KR-21). Furthermore, the researcher prepared two different sets of lesson plan covering topics in geometry such as length of arc and chord, perimeter and area of a sector, surface area of a cube and volume of a cube, cuboid, and cylinder that were used for the study. One set of lesson plans was based on the Jigsaw IV cooperative instructional strategy, which was used for the experimental group, and the other set was based on the conventional method which was used for the control group. The sets of lesson plans prepared were used by the four research assistants who participated in the four schools selected for the study. They were initially trained for one week, and micro-

teaching was organized to ascertain the impact of the training and mastery of the content to be taught using the Jigsaw IV cooperative instructional strategy. Data collected were analyzed using mean and standard deviation to answer research questions, and Analysis of Covariance (ANCOVA) was used to test the null hypotheses at the 0.05 level of significance.

Results

Research Question One

What is the difference between the mean performance scores of students taught mathematics using Jigsaw IV cooperative instructional strategy and those taught using conventional method?

Table1: Mean Performance Scores of Students taught Mathematics using Jigsaw IV (J4CIS) and those taught using Conventional Method

Method of instruction	n	Pre-Test Mean	Std.dev.	Post-Test Mean	Std.dev.	Mean gain
J4CIS	125	20.05	6.95	66.51	11.15	46.46
LM	115	18.35	6.41	54.50	8.8	36.15
Mean difference		1.70		12.01		10.31

Table 1 reveals the mean pretest and posttest performance scores in mathematics for students taught mathematics using Jigsaw IV cooperative instructional strategy (J4CIS) and those taught with lecture method. For students taught with Jigsaw IV cooperative instructional strategy, the results show mean scores of 20.05 and 66.51 for pre-test and post-test, respectively, which yielded a mean gain of 46.46. Also, for students taught mathematics using the lecture method, the table shows 18.35 and 54.50 for the pre-test and post-test mean values, respectively. This yielded 36.15 as the mean gain. This implies that those taught using J4CIS had a greater mean gain than those taught with the lecture method.

Research Question Two

What are the pre-test and post-test mean performance scores of male and female students taught mathematics using the Jigsaw IV cooperative instructional strategy?

Table 2: Mean Performance Score of Male and Female Students taught Mathematics using Jigsaw IV Co-operative Instruction Strategy

Gender	n	Pre-Test Mean	Std.dev.	Post-Test Mean	Std.dev.	Mean gain
Male	63	20.19	6.64	65.14	10.61	44.95
Female	62	19.90	7.31	67.90	11.59	48.00
Mean difference		0.29		-2.76		3.05

Table 2 reveals the pretest and posttest mean performance scores for male and female students taught mathematics using Jigsaw IV co-operative instruction strategy. In the category of male students taught using Jigsaw IV co-operative instruction strategy, the table shows mean scores of 20.19 and 65.14 for pre-test and post-test, respectively, which yielded a mean gain of 44.95. Also, for female students, the table shows mean pre-test and post-test scores of 19.90 and 67.90, respectively, which yielded a mean gain of 48.00. This means female students benefited a bit more than their male counterparts.

Hypothesis One

There is no significant difference between the mean performance scores of students taught mathematics using the Jigsaw IV cooperative instructional strategy and those taught using the lecture method.

Table 3: ANCOVA Summary of Performance Scores of Students Taught using Jigsaw IV Cooperative Instructional Strategy and Lecture Method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	9701.119[a]	2	4850.560	49.729	0.00	.443
Intercept	71498.393	1	71498.393	733.020	0.00	.751
Pre-test	165.116	1	165.116	1.693	0.401	.024
Treatment	**8276.685**	**1**	**8276.685**	**84.86**	**0.00***	**.271**
Error	23116.864	237	97.540			
Total	918796.000	240				
Corrected Total	32817.983	239				

a. R Squared=.443(Adjusted RSquared=.438)

Table 3 presents one-way ANCOVA results on effect of Jigsaw IV cooperative instructional strategy and lecture method on students' academic performance in mathematics. The table reveals that F (1,239) = 84.86 at p = 0.00. Thus, F = 88.855 is significant since P computed (0.00)< (0.05). The null hypothesis is therefore rejected. This implies that there is a significant effect of treatment on the post-test mean scores of students taught mathematics using the Jigsaw IV cooperative instructional strategy and those taught using the lecture method in favor of those taught using J4CIS. More so, the eta-squared (0.271) indicated that about 27.1% of the academic performance noticed at the post-test between the two groups of students was due to the use of instructional strategies.

Hypothesis Two

There is no significant difference between the mean performance scores of male and female students taught mathematics using the Jigsaw IV cooperative instructional strategy.

Table 4: ANCOVA Summaryof Male and Female Students Performance Scores Taught Mathematics using Jigsaw IV Cooperative Instructional Strategy

Source	TypeIII Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2953.001[a]	2	1476.501	14.454	.000	.192
Intercept	37468.052	1	37468.052	366.796	.000	.750
Pre-Test(Performance Score)	214.903	1	214.903	2.104	.117	.017
Gender	**272.502**	**1**	**272.502**	**2.668**	**.105**	**.021**
Error	12462.231	122	102.149			
Total	568396.000	125				
Corrected Total	15415.232	124				

a. R Squared=.192(Adjusted R Squared=.178)

Table 4 presents one-way ANCOVA results on the effect of Jigsaw IV cooperative instructional strategy on performance scores of male and female students in mathematics Post Basic Schools in Adamawa State. The table reveals F(1,124)=2.67 at p=0.105. Thus, F = 2.67 is not significant since P computed (0.105) > P hypothetical (0.05). Therefore, the null hypothesis was retained. This implies that there is no significant difference between the mean performance scores of male and female students taught mathematics using the Jigsaw IV cooperative instructional strategy. More so, the eta-squared (0.021) was reported. This indicates that just about 2.1% of academic achievement was noticed at the post-test between the male and female teachers of mathematics using the JigsawIV cooperative instructional strategy.

Discussion of Findings

The findings from this study revealed that those students taught using the Jigsaw IV cooperative instructional strategy had a higher mean performance score than those taught using the conventional method. Specifically, the results from the tested hypothesis established that the difference observed between the academic performances of those taught mathematics using the Jigsaw IV cooperative instructional strategy and those taught using the lecture method was statistically significant. This may be a result of the learning opportunities offered by the Jigsaw IV cooperative instructional strategy, where students could modify their learning pace as well as their ability to share knowledge gained horizontally within them. This concurs with the earlier finding made by Abdulmumini, Garba, Babangida, and Kamisu (2019) that Jigsaw teaching strategies significantly improve expertness among learners because they stimulate skill development within the group. Also, the fact that each member within the group contributed toward learning through active participation made them develop an experience that was required for group learning activities. This finding buttressed the earlier finding of Agu and Samuel (2018), which established a significant improvement in the performance of students while partaking in a jigsaw teaching strategy. The improvement in performance can also be attributed to features of the jigsaw teaching strategy, such as keen listening, speaking, cooperation, reflection, and problem-solving skills among students.

Also, Alshatri *et al.* (2019) found that Jigsaw IV teaching strategy has a significant effect on the academic performance of students, and this was attributed to students' ability to develop in-depth knowledge, which was not possible if students tried to learn all the material on their own. Thus, as students are encouraged to present their findings to the home group, their understanding expands, corrections to mistakes are made, and their expertise on the particular concept is enhanced. Anderson, Teisl, Tisher, Smith and Hunter, (2017) also found that using the jigsaw learning strategy made students detect and correct misunderstandings of concepts in mathematics within the group. However, Boer (2018) found that the jigsaw strategy was less effective among students when there was a time constraint. This shows that a lot of time is needed by students to rehearse mathematics several times for every member of their group to comprehend it to the expected level. Zan and Di Martino (2017) also found that Jigsaw VI was effective on students' performance based on the fact that it allowed re-teaching after group presentations. Furthermore, the current study showed that female students performed better than male students. However, further analysis established that the difference in their performances was not significant. This could be an indication that both genders benefited from the use of the Jigsaw IV teaching strategy for teaching mathematics. This finding is in line with the earlier discovery of Geiger and Bennison (2018) that both males and females gained significantly when taught using the Jigsaw IV instructional strategy. A gender-friendly Jigsaw IV instructional strategy was also ascertained by the findings of Odumodu and Unachukwu (2021) that the issues with female students' performance in schools' subjects could not be directly attributed to gender but to the dissimilarities that educators put in place in curriculum implementation, which tends to favor male students more than female students. This shows that the Jigsaw IV cooperative instructional strategy is capable of enhancing students' performance, irrespective of gender. The use of Jigsaw IV cooperative instructional strategy has been found to bridge gender gap as findings have shown that the instructional strategy is not gender sensitive. This implies that teachers should actively involve male and female students in learning activities to avoid gender stereotyping and help create equal educational opportunities for both male and female mathematics learners.

Conclusion

Teaching method is one of the indicators of teaching competency, which has an effect on students' academic performance, especially in mathematics at the secondary education level. This study, through its findings, has established that using the Jigsaw IV cooperative instructional strategy significantly enhanced the academic performance of students in mathematics. Likewise, the adoption of the Jigsaw IV cooperative instructional strategy by teachers has similar and enhanced effects on the performance of both male and female students in mathematics. It is hopeful that when the ministry of education in Adamawa State makes provision of facilities that will support mathematics teachers and teachers in other subjects to use Jigsaw IV cooperative instructional strategy as their instructional method, the students' academic achievement will improve.

Recommendations

Based on the findings of this study, the following recommendations were made

1. Adamawa State Post-Primary Management Board should embark on training of mathematics teachers on how to use Jigsaw IV cooperative instructional strategy as mode of teaching to ensure high performance of students irrespective of gender.
2. Principals in secondary schools should encourage mathematics teachers to use the Jigsaw IV cooperative instructional strategy since both male and female students benefited equally and their academic performance improved considerably.

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