Effects of Jigsaw, Team-Pair-Solo and Reciprocal Teaching Strategies on Secondary School Students' Achievement in Mathematics in Onitsha Education Zone

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***Abstract:** The study investigated the effect of jigsaw, team-pair-solo and reciprocal teaching strategies on secondary school students' achievement in mathematics. Four research questions and five hypotheses guided the study. The quasi-experimental design was adopted for the study. The population of the study was 4,852 senior secondary school year two (SS2) mathematics students in Onitsha Education Zone, of Anambra state. A sample of 211 SS 2 mathematics students was involved in the study. The instrument for data collection was Mathematics Achievement Test (MAT) validated by two experts from Nnamdi Azikiwe University, Awka and one experienced secondary school mathematics teacher. The reliability of the instrument was established using Kuder-Richardson Formula 20 for MAT which yielded coefficient of internal consistency of 0.71. The three experimental groups were taught mathematics using jigsaw, team-pair-solo and reciprocal teaching strategies respectively while the control group was taught using conventional method. Data were collected by administering the instruments as pretest and posttest before and after treatment respectively. The data obtained were analyzed using mean and standard deviation to answer the research questions and analysis of covariance was used to test the hypotheses at 0.05 level of significance. The findings of the study revealed that there was significant difference in the mean achievement scores of the students with jigsaw improving achievement the most. The study recommended that workshops should be organized by government and Ministry of Education for mathematics teachers to familiarize them with different strategies of collaborative learning such as jigsaw and team-pair-solo.*

***Keywords:** jigsaw, team-pair-solo, reciprocal teaching, achievement, mathematics*

I. Introduction

The process of learning enables one to develop good reasoning ability, think creatively and analytically. One subject that is known to facilitate analytical thinking and improves rational reasoning in an individual is mathematics (Pi-Day, 2019). At every level of education in Nigeria therefore, mathematics is taught as an indispensable subject which the students must learn and pass. Despite the important of mathematics, students' academic achievements in the subject have continued to remain poor. The evidence from the analysis of the WAEC reports showed that since 1991 to 2016, the percentage of students who obtained less than a credit pass in mathematics (D7-F9) have remained above 50%, except in 2004 where 53.8% credit pass and above was recorded. Thus, fewer percentages of the students who enroll for mathematics pass the subject at the required minimal grade of C6. In recent examinations (2017-2018), the West African Examination Council's (WAEC) Chief Examiner's Report on Senior School Certificate Examination (SSCE) in mathematics noted significant weakness in the following areas: algebra, translation of word problems into mathematical expressions and diagrams, commercial arithmetic, probability, geometry (circle theorems and plane geometry), adherence to rubrics of questions, reading and answering questions from graphs and approximations.

In view of these weaknesses, the WAEC Chief Examiners suggested in their various reports the following as remedies: teachers should endeavour to use interactive methods of teaching; and should give more worked problems during class lessons. The weaknesses noted by the Chief Examiner in the WAEC May/June mathematics examination of 2018, prompted the repetition of the previous suggested remedy, that is, that teachers should give more worked problems during class lessons and assignments. The suggested remedy by the Chief Examiner reinforces the research findings of (Bessong & Felix, 2018; Ogundele, Olanipekun & Aina, 2018) which reported that the teaching method adopted by mathematics teachers is one of the major contributing factors to the students' poor academic achievement.

Academic achievement is the outcome of instruction indicating the extent to which learning has occurred. Awan, Noureen and Naz (2011) view academic achievement as examination marks, teachers' given

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grades and percentiles in academic subjects. In this study, academic achievement is the students' scores in the test of achievement in the content taught. Academic achievement in various subject areas including mathematics is known to be affected by various factors wherewith, the teaching methods have proven to be the most common. This is because mathematics teachers often adopt the teacher-centred method of teaching otherwise known as conventional teaching method.

The conventional teaching method is a teacher centred method of instruction where the teacher is seen as the custodian of knowledge. The preference for conventional teacher-centred teaching methods by most teachers is because the method makes it easy to reach large population of students at the same time as well as cover large content areas within a short time. Yet such teaching strategies as reported by researchers (Gull & Shehzad, 2015; Van-Leeuwen, Janssen, Erkens & Brekelmans, 2016) have continually reported may not improve mathematics achievement much like other teaching strategies such as jigsaw, team-pair-solo and reciprocal teaching that allows for greater interaction as suggested by the Chief Examiners. It is pertinent therefore, that studies be conducted to investigate whether the use of aforementioned cooperative teaching/learning strategies could improve achievement in mathematics. This could help to solve the problem of mathematics education in Nigeria.

Jigsaw teaching strategy (JTS) is a cooperative teaching strategy where by students learn or study a section/topic on a learning material in an expert group and return to their original team group to teach others (Tukur, Nurulwahida & Madya, 2018). In the present study, the teacher in the jigsaw classroom assigned students to teams containing only five students. The teacher gave the students before each lesson period, sections of the learning materials to be studied by every five members of the team. All the team members assigned to study a particular section outside studying the entire materials gathered in another expert group to discuss the particular section. After all other experts have mastered their section within the specified time, all experts returned to their original teams to teach team members the aspect of the materials they have mastered. Each team solved questions relating to all sections of the materials as a group and later as individuals.

Team-Pair-Solo teaching strategy (TPSTS) like jigsaw is another cooperative learning strategy that facilitates greater interaction among students, with the learning materials as well improves mathematics achievement. TPSTS according to Catherine (2018) is a cooperative learning strategy in which students solve problems first as a team, then with a partner, and finally on their own. In the present study, before the lesson, the teacher assigned students to group categories containing only four students according to their scores in the pretest. The groups were arranged such that, those with varying scores meet in the same group. Within the groups, students with varied scores were paired. The teacher gave the students group, paired and individual exercises during the lesson and have the students scored individually for every class exercise or assignment. The individual learning and practice is similar but differs significantly from reciprocal teaching strategy (RTS).

Reciprocal teaching strategy (RTS) is a dialogue between teacher and students (Agoro & Akinsola, 2013). According to Leila (2018), RTS is reciprocal in that students and teacher take turns in leading the class learning, teaching, dialogue, discussion, demonstration of any learning mode as the case may be. In the present study, in the reciprocal teaching class the teacher led the class first by introducing the lesson, solving an example and then hand over to the groups. There were in groups of 5 students. In the groups one student was assigned the position of a leader for one exercise and another students, a leader for another exercise, until the five members take their turns. When male and female student takes the position of leading others to learn a mathematical concept or operation, they boost their mathematics achievement (Chaika, 2012).

Gender effects on academic achievement has remained inconclusive. The problem of Studies revealed that effect due to gender differ significantly in various subject areas (Jacob & Linus, 2017; Judith, Nicholaus & John, 2018) while other reported that the effect due to gender did not differ significantly (Busari, Ernest & Ugwuanyi, 2016; Monica & Ofem, 2015). The inconclusiveness of the information about effect due to gender on achievement instigates the need for further investigation into the effect due to gender on achievement.

II. Purpose Of The Study

The purpose of the study was to investigate the effects of jigsaw, team-pair-solo and reciprocal teaching strategies on secondary school students' achievement in mathematics. Specifically, the study investigated the:
1.   Differences in the mean achievement scores of students taught mathematics using jigsaw teaching strategy (JTS), team-pair-solo teaching strategy (TPSTS), reciprocal teaching strategies (RTS) and those taught using conventional method.
2.   Difference between the mean achievement scores of male and female students taught mathematics using JTS.
3.   Difference between the mean achievement scores of male and female students taught mathematics using TPSTS   4. Difference between the mean achievement score of male and female students taught mathematics using RTS

III. Research Questions

The following research questions guided the study.

1. What are the differences in the mean achievement scores of students taught mathematics using jigsaw teaching strategy (JTS), team-pair-solo teaching strategy (TPSTS), reciprocal teaching strategies (RTS) and those taught using conventional method?
2. What is the difference between the mean achievement scores of male and female students taught mathematics using JTS?
3. What is the difference between the mean achievement scores of male and female students taught mathematics using TPSTS?
4. What is the difference between the mean achievement scores of male and female students taught mathematics using RTS?

IV. Hypotheses

The following hypotheses were tested at 0.05 level of significance:

1. There is no significant difference in the mean achievement scores of students taught mathematics using jigsaw teaching strategy (JTS) team-pair-solo teaching strategy (TPSTS), reciprocal teaching strategies (RTS) and those taught using conventional method.
2. There is no significant difference in the mean achievement scores of male and female students taught mathematics using JTS.
3. There is no significant difference in the mean achievement scores of male and female students taught mathematics using TPSTS.
4. There is no significant difference in the mean achievement scores of male and female students taught mathematics using RTS.
5. There is no significant interaction effect of teaching strategies and gender on students' achievement in mathematics.

V. Method

The design adopted for the study was quasi-experimental. The population of the study was made up of 5,898 (2,733 males, 3,165 females) senior secondary school year two (SS2) mathematics students in Onitsha Education Zone of Anambra State. The sample of the study was 211 SS2 mathematics students obtained through a multi-stage sampling procedure. The instrument for data collection was Mathematics Achievement Test (MAT) developed by the researcher. The researcher also developed lesson plans using jigsaw, team-pair-solo and reciprocal teaching. MAT was validated by two experts from Nnamdi Azikiwe University, Awka and one experienced secondary school mathematics teacher. The reliability of MAT was established using Kudder-Richardson 20 to be 0.7. The treatment commenced with brief orientation of the various groups (Jigsaw, TPS and RTS) from the various experimental group schools. The mathematics teachers oriented the students on their group function, expert group function, pair function, individual function and leader function as the case may be. The treatment procedure for each group is described as follows:

Jigsaw: Generally, before the lesson, the teacher assigned students to team containing only five students. The teacher gave the students before each lesson period, sections of the learning materials to be studied by every five members of the team. All the team members assigned to study a particular section outside studying the entire materials gathered in another expert group to discuss the particular section given to them. After all other experts have mastered their section within the specified time, all experts returned to their original teams and to teach team members their own aspect of the materials which they must have mastered. Each team solved questions relating to all sections of the materials as a group and later as individuals.

Team-Pair-Solo teaching Strategy (TPSIS): Before the lesson, the teacher assigned students to group categories containing only four students according to their scores in the pretest. The groups were arranged such that, those with varying scores meet in the same group. In the groups, students with varied scores were paired. The teacher gave the students group, paired and individual exercises during the lesson. The students were scored individually for every exercise. Before each lesson, the teacher directed the students to seat according to their groups. In the lesson, after the teacher has given the solution to a problem as an example, the teacher gave the students similar problems to solve as a group activity. The students in their groups, using group effort tried to solve the problems. After the group has found the solution to the problem, the group made sure that all the members of the groups learns the procedure to getting the solution.

Reciprocal Teaching Strategy (RTS): Generally, in the reciprocal teaching class the teacher led the class first by introducing the lesson, solving an example and then hand over to the groups. There were groups of 5 students. In the groups one student was assigned the position of leader for one exercise and another students, a leader for another exercise, until the five members take their turns. The function of the leader was to ask the group members to silently read a problem. Later, when the entire group has read the problem, the leader asked

for vocabulary or phrases that need to be clarified (questioning). Any group member can provide the meaning of a word or phrase or their understanding of the problem. After all words and phrases have been clarified, the leader used questions to recognize the key parts of the problem (questioning). The group leader then summarized the purpose of the problem (clarifying) from the interaction among the group. The leader guides the group in devising a plan to answer the problem. The steps and operations necessary to solve the problem were listed (summarizing and predicting). Once the plan has been checked to make sure that it makes sense, the mathematical problem is solved. Solving the problem may be done independently or jointly. Following the solution of the problem, a new leader was chosen to assist in solving of the next problem. However, after the solution to each problem has been found, the leader made all the group members learn as much as other members know. The control group was taught using conventional method. The same content was taught using presentation of fact with little questioning. The last stage of the exercise which was the fourth stage involved the administrated of the posttest. Data relating to the research questions were analyzed using mean and standard deviation while Analysis of covariance (ANCOVA) was used to test the null hypotheses at 0.05 level of significance. Scheffe PostHoc analysis was used to determine the direction of significance whenever a significant main effect of the treatment was observed. The Decision rule was to reject the null hypothesis where the Pvalue is less than or equals 0.05, otherwise do not reject the null hypothesis.

VI. Result

Research Question 1: What are the differences in the mean achievement scores of students taught mathematics using JTS, TPSTS, RTS and those taught using Conventional Method?

Table 1: Mean Pre-test and Posttest Achievement Scores of Students taught Mathematics using JTS, TPSTS, RTS and those taught using Conventional Method

Method	N	Pretest Mean	Posttest Mean	Mean Gain	Pretest SD	Posttest SD
JTS	57	13.77	86.23	72.46	3.31	5.69
TPSTS	54	20.00	80.46	60.46	3.76	3.54
RTS	49	30.20	71.94	41.74	3.67	5.38
CONVENTIONAL	51	38.92	54.90	15.98	4.28	6.12

Table 1 shows that the group taught mathematics using JTS has mean gain achievement score of 72.46, those taught using TPSTS has mean gain achievement score of 60.46, those in RTS group has mean gain achievement score of 41.47 while those taught using conventional method has mean gain achievement score of 15.98. The spread of score was greatest in the posttest mean of those taught using conventional method, followed by those taught using JTS, RTS while those taught using TPSTS having the least scores spread.

Research Question 2: What is the difference in the mean achievement scores of male and female students taught mathematics using JTS?

Table 2: Mean Pre-test and Posttest Achievement Scores of Male and Female Students taught Mathematics using JTS

Gender	N	Pretest Mean	Posttest Mean	Mean Gain	Pretest SD	Posttest SD
Male	29	16.21	83.45	67.24	2.18	3.30
Female	28	11.25	89.11	77.86	2.21	6.24

Table 2 shows that the male students taught mathematics using JTS has mean gain achievement score of 67.24 while the females has mean gain achievement score of 77.86. The spread of scores was greatest among the females.

Research Question 3: What is the difference in the mean achievement scores of male and female students taught mathematics using TPSTS?

Table 3: Mean Pre-test and Posttest Achievement Scores of Male and Female Students taught Mathematics using TPSTS

Gender	N	Pretest Mean	Posttest Mean	Mean Gain	Pretest SD	Posttest SD
Male	30	22.50	82.67	60.17	2.54	2.54
Female	24	16.88	77.71	60.83	2.47	2.54

Table 3 shows that the male students taught mathematics using TPSTS has mean gain achievement score of 60.17 while the females has mean gain achievement score of 60.83. The spread of scores was the same for both the males and females.

Research Question 4: What is the difference in the mean achievement scores of male and female students taught mathematics using RTS?

Table 4: Mean Pre-test and Posttest Achievement Scores of Male and Female Students taught Mathematics using RTS

Gender	N	Pretest Mean	Posttest Mean	Mean Gain	Pretest SD	Posttest SD
Male	21	27.14	71.43	44.29	2.54	3.59
Female	28	32.50	72.32	39.82	2.55	6.45

Table 4 shows that the male students taught mathematics using RTS has mean gain achievement score of 44.29 while the females has mean gain achievement score of 39.82. The spread of scores was greatest among the females.

Hypothesis 1: There is no significant difference in the mean achievement scores of students taught mathematics using JTS, TPSTS, RTS and those taught using conventional method.

Table 5: ANCOVA on Difference between the Mean Achievement Scores of Students taught using JTS, TPSTS, RTS and those taught using CONVENTIONAL METHOD

Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	29599.461[a]	4	7399.865	266.147	.000	
Intercept	22168.496	1	22168.496	797.323	.000	
Pretest	15.234	1	15.234	.548	.460	
Method	5358.616	3	1786.205	64.244	.000	S
Error	5727.554	206	27.804			
Total	1186475.000	211				
Corrected Total	35327.014	210				

Table 5 shows that at 0.05 level of significance, 1df numerator and 210 df denominator, the calculated F is 64.244 with Pvalue of .000 which is less than 0.05. Thus, the null hypothesis was rejected. Therefore, there is significant difference in the mean achievement scores of students taught mathematics using JTS, TPSTS, RTS and those taught using conventional method.

Table 6: Scheffe PostHoc

(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
JTS	TPSTS	7.328[*]	1.184	.000	4.994	9.661
	RTS	17.744[*]	2.200	.000	13.406	22.083
	CONVENTIONAL METHOD	36.709[*]	3.258	.000	30.286	43.133
TPSTS	JTS	-7.328[*]	1.184	.000	-9.661	-4.994
	RTS	10.417[*]	1.581	.000	7.300	13.533
	CONVENTIONAL METHOD	29.382[*]	2.569	.000	24.316	34.448
RTS	JTS	-17.744[*]	2.200	.000	-22.083	-13.406
	TPSTS	-10.417[*]	1.581	.000	-13.533	-7.300
	CONVENTIONAL METHOD	18.965[*]	1.501	.000	16.004	21.926
CONVENTIONAL METHOD	JTS	-36.709[*]	3.258	.000	-43.133	-30.286
	TPSTS	-29.382[*]	2.569	.000	-34.448	-24.316
	RTS	-18.965[*]	1.501	.000	-21.926	-16.004

Table 6 reveals that significant difference exists between the mean achievement scores of students taught using JTS and TPSTS in favour of JTS. Table 6 also reveals that a significant difference exists between the mean achievement scores of students taught using JTS and RTS in favour of JTS. Table 6 further shows that there is significant difference between the mean achievement scores of students taught using RTS and TPSTS in favour of TPSTS. This shows that the direction of significance moves from JTS, TPSTS and RTS.

Hypothesis 2: There is no significant difference in the mean achievement scores of male and female students taught mathematics using JTS.

Table 7: ANCOVA on Difference between the Mean Achievement Scores of Male and Female Students taught using JTS

Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	456.974[a]	2	228.487	9.092	.000	
Intercept	10355.040	1	10355.040	412.046	.000	
Pretest	.790	1	.790	.031	.860	
Gender	177.796	1	177.796	7.075	.010	S
Error	1357.061	54	25.131			
Total	425625.000	57				
Corrected Total	1814.035	56				

Table 7 shows that at 0.05 level of significance, 1df numerator and 56df denominator, the calculated F is 7.075 with Pvalue of .010 which is less than 0.05. Thus, the null hypothesis was rejected. Therefore, there is significant difference in the mean achievement scores of male and female students taught mathematics using JTS.

Hypothesis 3: There is no significant difference in the mean achievement scores of male and female students taught mathematics using TPSTS.

Table 8: ANCOVA on Difference between the Mean Achievement Scores of Male and Female Students taught using TPSTS

Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	330.212[a]	2	165.106	25.270	.000	
Intercept	5135.208	1	5135.208	785.968	.000	
Pretest	2.411	1	2.411	.369	.546	
Gender	116.878	1	116.878	17.889	.000	S
Error	333.214	51	6.534			
Total	350275.000	54				
Corrected Total	663.426	53				

Table 8 shows that at 0.05 level of significance, 1df numerator and 53df denominator, the calculated F is 17.889 with Pvalue of .000 which is less than 0.05. Thus, the null hypothesis was rejected. Therefore, there is significant difference in the mean achievement scores of male and female students taught mathematics using TPSTS.

Hypothesis 4: There is no significant difference in the mean achievement scores of male and female students taught mathematics using RTS.

Table 9: ANCOVA on Difference between the Mean Achievement Scores of Male and Female Students taught using RTS

| Source of variation	SS	Df	MS	F	P-value	Decision
Corrected Model	255.459[a]	2	127.730	5.175	.009	
Intercept	687.449	1	687.449	27.853	.000	
Pretest	245.893	1	245.893	9.963	.003	
Gender	86.769	1	86.769	3.516	.067	NS
Error	1135.357	46	24.682			
Total	254975.000	49				
Corrected Total	1390.816	48				

Table 9 shows that at 0.05 level of significance, 1df numerator and 48df denominator, the calculated F is 3.516 with Pvalue of .067 which is greater than 0.05. Thus, the null hypothesis was not rejected. Therefore, there is no significant difference in the mean achievement scores of male and female students taught mathematics using RTS.

Hypothesis 5: There will be no significant interaction effect of teaching strategies and gender on students' achievement in mathematics.

Table 10: ANCOVA for Testing Significance of Interaction Effect of Teaching Strategies and Gender on Students' Mathematics Achievement

Source	SS	df	Mean Square	F	Sig.	Decision
Corrected Model	30529.168[a]	8	3816.146	160.668	.000	
Intercept	10938.891	1	10938.891	460.552	.000	
Pretest	67.505	1	67.505	2.842	.093	
Gender	3868.061	3	1289.354	54.285	.000	
Method	2.103	1	2.103	.089	.766	
Method * Gender	929.106	3	309.702	13.039	.000	S
Error	4797.846	202	23.752			
Total	1186475.000	211				
Corrected Total	35327.014	210				

Table 10 shows that at 0.05 level of significance, 1df numerator and 210 df denominator, the calculated F is 13.039 with Pvalue of .000 which is less than 0.05. Thus, the null hypothesis was rejected. Therefore, there is significant interaction effect of teaching strategies and gender on students' mathematics achievement.
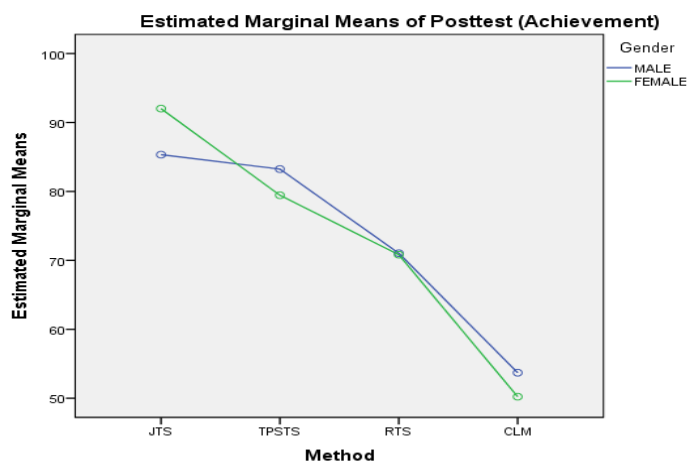
Figure 1: Plot of significant Interaction between Teaching Strategies and Gender on Students' Mathematics achievement

The plot of the interaction effect between teaching strategies and gender on achievement is significant and disordinal.

VII.   Discussion

The findings of the study showed that there is significant difference in the mean achievement scores of students taught mathematics using jigsaw teaching strategy (JTS) team-pair-solo teaching strategy (TPSTS), reciprocal teaching strategies (RTS) and those taught using conventional Method in favour of JTS, followed by TPSTS and RTS. Jigsaw strategy specifically improved achievement in mathematics more than other strategies because the students took part at different times as experts who mastered different aspects of the learning materials while learning the remaining parts from other experts. As experts, the students learnt the concepts to the extent that they could not only teach others to master the concepts but answered any questions related to that concept. To be able to do this, students evaluated themselves by solving similar questions helping them to understand the steps to the solution of similar questions. Since this happened with all the students in each group, wherein, each students was a master of one concept or the other, achievement is improved.

The finding of the study is in line with that of Bukunola and Idowu (2012) that jigsaw was significantly more effective than conventional lecture method. The finding of the study also supported that of Isiaka and Mudasiru (2016) that students taught physics using computer-assisted Jigsaw II performed better and retained the physics concepts longer than those taught using individualized computer instruction. The findings of Iweka (2017) that there were significant differences between students taught using Jigsaw II and students taught using teacher-centered method on mathematics achievement is also in line with the finding of the study. The finding of the study however contrasted that of Sengul and Katranci (2014) that jigsaw did not significantly improve the mathematics achievement of students more than the conventional method.

VIII.   Conclusion

The study established that jigsaw, team-pair-solo and reciprocal teaching strategies all significantly improved academic achievement more than conventional method. Jigsaw teaching strategy is however most effective when the teacher has achievement in focus.

IX. Recommendations

The following recommendations were made based on the findings:
1. Workshops should be organized for mathematics teachers by school principals to familiarize them with different strategies of collaborative learning such as jigsaw and team-pair-solo.
2. Greater emphases should be given to the place of student to student interaction in the process of learning so as to enable students learn from others those things they could not learn from the teacher or their textbooks from each other.

Acknowledgement

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