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Looking for a More Facilitative Cooperative Learning Strategy for Biology: Students' Team Achievement Division or Jigsaw?

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: The study determined the effects of Jigsaw and Students' Team Achievement Division (STAD) cooperative learning strategies on the achievements of secondary school biology students.
Study Design: The research adopted the non randomized, pretest – posttest control group quasi experimental design.
Place and Duration of the Study: The study took place in Wamba LGA of Nasarawa state of Nigeria. The study lasted for 6 weeks in 2012.
Methodology: Data were collected from a sample of 188 students comprising of 95 boys and 93 girls from 6 randomly selected schools. A 30 item instrument called Biology Students Achievement Test (BSAT) developed by the researchers with a reliability coefficient of 0.84 using Kuder-Richardson formula 21 was used for data collection. The schools were grouped into 3 with 2 schools per group and assigned randomly into 1 control and 2 experimental groups. The control was taught using the Lecture method while cooperative learning strategies were used in experimental groups.
Results and Discussion: Data collected were analyzed using mean, standard deviation to answer the research question and ANCOVA and Pairewise analyses at 0.05 levels of significance to test the hypothesis. The result shows that there is a significant difference

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between the mean achievement of students taught using lecture and cooperative learning strategies; STAD was found to be superior to Jigsaw strategy.
Conclusion and Recommendations: Both STAD and Jigsaw learning strategies facilitated learning of biology in secondary school in the study area. However, STAD was found to facilitate learning more than Jigsaw. It was recommended that teachers should use the STAD strategy in teaching and that seminar, workshops and conferences should be organized to train teachers. The curriculum should be reviewed to reflect the method while book writers should be encouraged to incorporate the method in their books.

Keywords: Cooperative learning; jigsaw; students team achievement division; biology achievement.

1. INTRODUCTION

Some of the aims of teaching biology include the preparation of students to acquire the relevant knowledge, skills and attitudes so as to apply same to solve their everyday life problems as well as contribute meaningfully to national development [1]. It is in view of this that the subject is made compulsory for all students at the secondary school level except where health science is offered and a credit pass in the subject is required for admission into science and related courses in the tertiary institutions in Nigeria.

However, there are evidence on the students and the school leavers as well, that these aims are seen not to be achieved. For instance, the youths are found engaging in prostitution, rape and other practices which subject them to STDs, HIV and other infections. More so, curiosity, honesty, tolerance etc, which are some of the qualities of a scientifically literate person are lacking in the youths. This could be the reason why they show poor reading culture and engage in examination malpractice to pass any form of test; youths are found spearheading communal unrests, thuggery, drug abuse and trafficking etc. One may not be far from the truth to say that students do not assimilate the biological concepts taught in schools. This may be attributed to the way the subject is taught because Oloruntegbe and Omoifo [2] assert that the success of teaching depends on methods of teaching adopted by the teachers. Olutade [3] also affirms that appropriate teaching methods accelerate students' knowledge acquisition. Hence the biology curriculum recommends guided discovery and laboratory approach for teaching in the secondary schools in Nigeria.

The appropriate use of these methods however, seems not possible because of the over loaded biology syllabus, the large class size and the examination oriented nature of the education system. Teachers therefore make use of lecture methods which they feel is the easy way to pass the large amount of information to the students in order to prepare them for the examinations. The problem with lecture method is that it does not allow for students' participation in the learning process and because they are not mature at this level they become passive members. Moreso, students commit learning materials to short term memory (or rote learning) rather than understanding and mastering them. Gbamanja [4] agrees that rote learning occurs because teachers use inappropriate teaching methods. To buttress this, Marton and Saljo as cited by Merburger [5] add that because of the rote learning, students are less able to apply theoretical concepts to new contexts**.** Another problem with the lecture method is that it takes little or no consideration of individual difference that exists in the class. This widens the gap between the brilliant and the weak students, those from the rich and the poor homes, and so on [6].

Students' achievement has been the major focus of the educational processes. In view of this therefore, researches have been carried out to identify factors that affect it in an effort to improve it. For example, Ayodele [7] identified school facilities, teachers' qualification, teachers' experience, leadership qualities of principals, school size, and school location. The role of the teacher as an important variable cannot be overemphasized. The teacher is expected in all situations to develop the three learning domains of the learner. These are the cognitive, affective and the psychomotor domains. Because studies in biology have a lot to do with living things and, it is one of the science subjects that is related to everyday life, its learning seems to be unique and challenging. For example, the development of psychomotor skills through practical activities sometimes is hindered by factors such as cultural and superstitious beliefs, emotions to mention but a few. Some Students for special reasons do not participate in some activities. In this case, more skill and effort of the teacher is required. This means that the teacher must adopt the teaching strategies that will motivate the learners as well as encourage all of them to achieve irrespective of beliefs and other differences. Therefore, the search for the method that is capable of helping both the teacher and the learner has become an issue of necessity.

Many teaching methods are available for the science teachers to use. Some of which include: Lecture, discussion, demonstration, inquiry, field trip, Laboratory, others include scaffolding, concept mapping, Think - list –pair- share, cooperative learning.

The cooperative learning, though special in its use, seems to lend itself to this contemporary situation because Scholars such as Slavin [8], Okebukola [9], Esiogbu [10] recommended its use in teaching science. This is probably because as the students learn in small groups, they all participate fully in class activities; interact among themselves and the lessons become interesting to them. The social interaction in the group gives the method an added value beyond the classroom.

Slavin [8] emphasized the applicability of cooperative learning to planning instruction on school subjects and formation of heterogeneous groups. His definition on cooperative learning is that cooperative learning methods are structured, systematic, and instructional strategies which are used at any grade level and in most school subjects. All of the methods consist of having the teacher assign the students two-to six member learning composed of high, average, and low achievers; boys and girls; black, Anglo, and Hispanic students, and mainstreamed academically handicapped students as well as non handicapped classmates [11]. Slavin shed that that cooperative learning has three important features. First, cooperative learning is a kind of group work. Learners have to work together in small groups between two and six members. Second, learning is structured to ensure that everyone in the group is able to fulfill the learning task. Third, students have to be dependent on each other to achieve their learning goals.

Eight types of cooperative learning strategies according Johnson, Johnson, and Stanne, [12] have been researched and found to be effective in teaching different subjects in different parts of the world. These include: Students Team Achievement Division (STAD), Group investigation, Jigsaw approach, Constructive Controversy, Learning Together, Team Accelerated Instruction, Team Group Tournament, Cooperative Integrated Reading and Composition.

This study examined two cooperative strategies: STAD and Jigsaw. This is because the Problem in Nigeria today calls for the education that will impart knowledge as well as bring the youths together to see themselves as one united and responsible for the nation's

building thereby doing away with the ethnic and religious differences. In these strategies, students work in small groups and depend on one another for success. This creates in them, the spirit of love, tolerance and collective responsibilities which they may grow up with.

According to Slavin [13], three elements are central to all Student Team Learning methods – team rewards, individual accountability, and equal opportunities. Team rewards on cooperative learning research indicates that if students are rewarded for doing better than they have in the past, they will be more motivated to reach than if they are rewarded for doing better than others. Because students will work together towards a common goal and their learning efforts will help their teams succeed. Individual accountability means that the success of a team relies on the learning of every individual in all team members. Accountability focuses the team member's activity on helping others learn and making sure that team members are ready for a quiz without teammate's help. Equal opportunities for success mean that students can contribute to their teams by improving over their past performance. This ensures that all the students, including high, average, and low students are equally to do their best to value individual contributions. This, in essence justifies the need for use of these strategies in this study for empirical back up.

1.1 The Students Team Achievement Division (STAD) and Jigsaw Strategies

Slavin and Associate developed STAD at Johns Hopkins University in 1978 as part of a student learning approach program along with other cooperative methods such as Teams-Games-Tournaments, Jigsaw II. In this strategy, students are divided into a four members mixed ability group (i.e. 1 high, 2 average or medium and 1 low ability). It consists of regular cycle of activities. First the teacher presents the lesson to the class using the traditional method. Then students in their groups work together and help one another to master the material by studying the materials and complete the worksheet together. According to CoeDubey, Dubey and Ndagi [6], the students with high ability are expected to assist those with low ability or learning difficulties. This is a way of reducing the gap in achievements of students due to individual differences in the class.

The jigsaw strategy was developed by Elliot Aronson and associate. In particular, the jigsaw technique was first developed in the early 1970s by Elliot Aronson and his students at the University of Texas and the University of California. In this strategy, the students are divided into small groups of five or six each (called the Jigsaw groups) and the concept to learn is broken into segments or subtopics. Each student in the jigsaw group is assigned a segment to specialize on as all students with same topics form expert groups. After the session, they reconvene in their jigsaw groups where each expert explain his /her topics to other members after which they take up quiz individually without help from group members. The scores of individual members are summed up to form the group scores which are used to reward the best group. In this method, each piece- each student's part is essential for completion and full understanding of the material. Because each student's part is essential, each student is equally essential.

The success story of cooperative learning is predicated on the Maslow's theory of needs hierarchy, that the students' love and acceptance by peers in their various groups motivate them to learn. Also by observing brilliant group mates, weak students observe, imitate and eventually learn their study styles. This agrees with Bandura's social learning theory. Empirical reports also confirm the success of the method. For example, the study by Adesoji and Ibraheem [14], Abdullahi and Duyilemi [15], Kolawole [16], Wachanga and Mwangi [17], Pandey and Kishore [18] all agree that cooperative learning is superior to other methods.

However, one may be wrong to assume that the methods will yield the same result in the area of this study without empirical support. Moreover, no study on cooperative learning has been conducted in this area specifically to compare the effects of different strategies of cooperative learning. Therefore, this study was conducted to find out the effect of STAD and Jigsaw cooperative Learning on the achievement of SS1 biology students in Wamba LGA of Nasarawa state of Nigeria.

1.2 Research Questions and Hypothesis

The following question serves as guide:

> What is the effect of STAD, Jigsaw and Lecture teaching methods on the achievements of students in biology?

The following null hypothesis guided the study:

> There is no significant difference between the mean achievements of students taught biology using STAD, Jigsaw and Lecture teaching methods.

2. MATERIALS AND METHODS

The research adopted the non randomized, pretest – posttest control group quasi experimental design. Data were collected from a sample of 188 Senior Secondary 1(SS1) students comprising of 95 boys and 93 girls from 6 randomly selected schools. Therefore 62, 60 and 66 students based on class arrangement were randomly assigned to STAD, Jigsaw and Control groups respectively. The SS1 students who were just being introduced to biology needed to have understanding of the new concepts such as cells, plants and animal characteristics reproduction. A 30 item instrument called Biology Students Achievement Test (BSAT) was developed by the researchers. The instrument first went through preliminary development and validation. In the process, the instrument was given to two experts in test and measurement and one experienced biology teacher for face, construct and content validity. The instrument was pilot tested in one of the schools not included in the study and data collected were used to establish reliability coefficient of 0.84 using Kuder-Richardson formula 21. Each item was scored 2 marks with a total of 60 marks. The items in the instrument were reshuffled thoroughly to give two instruments with same characteristics: number of items, options the same though rearranged, topics covered the same and language or sentences the same except that item 1 could become item 8 and so on. Both required same time for the students to answer them. The schools were grouped into 3 with 2 schools per group and assigned randomly into 1 control and 2 experimental groups. Three graduate biology teachers with at least five years of teaching experience were trained using the training package developed by the researchers. The training took care of how to use each of the cooperative strategies, how to group and monitor the learners to ensure a heterogeneous but socially cohesive group that will take advantage of the individual differences in ability to ensure learning. The three groups learned under the same conditions except for the treatment.

2.1 Experimental Procedure

Students' ability was determined using average of 3 internal examination results which were on ground before the commencement of the study. By the nature of the design, the use of

intact group could only permit dividing the students in each class into three groups (having arranged them serially based on score from lowest to highest): the first 1/3 as high ability, second 1/3 as medium ability and last 1/3 as low ability. Cut off scores was not possible as the groups were not equivalent in ability. By so doing it was possible to group them into high, medium and low ability groups for ease of assignment into groups. In STAD the group was made up of 3 to 4 students while Jigsaw was made of 5 to 6 students. The little difference in number in groups was considered non influential in performance since the difference was 1 within groups and 1 or 2 across groups. Besides, the heterogeneous nature of the group was far more important than the little difference in group size.

Each assistant was assigned a group to teach using the assigned method. The control was taught using the Lecture method while the two (STAD and Jigsaw) cooperative learning strategies were used in the 2 experimental groups. Intact classes were used in all the schools in order not to disorganize the schools' set up which the principals would not allow. Prior to the study, the students were pre tested using the BSAT and this was followed by treatment for 6 weeks after which they were post tested using the reshuffled BSAT.

With STAD (experimental group 1 or EG 1), students were divided into a four members mixed ability group (i.e. 1 high, 2 average or medium and 1 low ability) by the assistant. First the teacher presented the lesson to the class using the traditional method. Then students in their groups worked together and helped one another to master the material by studying the materials and complete the worksheet together. The worksheet is made up of activities where students have reason, debate on and finally provide accepted answer which is written down as the group answer. Though all write down the correct answer, a member (group leader) read out the group answer when the entire class came together.

STAD cooperative learning consists of five main components, namely the presentation of class, study groups, quizzes, score development, and awards groups. STAD also consists of a regular cycle of teaching activities. The main purpose of this teaching was for the teacher to present the subject matter in accordance with the plan. The presentation covered the opening, development and guided practice of the lessons with an emphasis in preparing the course material. The opening conveyed to students what they learned about and why it's important. Curiosity caused students with a demonstration what puzzling, real-life problems, or other means. The teacher informed students to work in groups to find a concept or stimulate their wishes on these lessons. The teacher repeated briefly skills or information that was absolutely necessary. Learning materials were developed in accordance with what students learnt in groups. Cooperative learning was emphasized so as to understand the lesson. The understanding of students was controlled as often as possible by providing the questions. Explanations were given as to why the answers to the questions were true or false. The teacher then switched to another concept if the student understood the point. Guided practices were ensured such as telling all students to do the problems on a given question, calling the students at random to answer or solve problems, that all students were always prepared as best as possible and the tasks were not time-consuming (students did one or two problems and provided direct feedback).

In the study groups, task group members were master teachers and materials provided to help a friend of one group to master the material. Students are given a sheet of activities that can be used to train the skills that are taught to evaluate themselves and one group of friends. The first time a teacher used cooperative learning in each class, they provided assistance by way of explaining the order, review the concept or answer questions. Quiz students worked independently. It was to show what students had acquired while studying in

groups. Quiz results used as the value of individual development and denoted the value of group development. The first step that was done on this activity was to calculate the value of the group and the value of individual development and provided certificates or awards from other groups. Group awards were based on the average value of individual development within the group.

In Jigsaw (experimental group 2 or EG 2), the students were divided into 5 person per group except the last group in a class that were 6. The groups were diverse in terms of gender, ethnicity and ability which were the main focus of the strategy as opposed to STAD that is ability focused. One student from each group was the leader supposedly the most mature student in the group. The day's lesson was divided into 5-6 segments and each student was assigned to learn one segment, the teacher ensured that students have direct access only to their own segment. The students were given time to read over their segment at least twice to become familiar with it (there is no need for them to memorize it). Form the temporary "expert groups" by having one student from each jigsaw group join other students assigned to the same segment, students in these expert groups were given time to discuss the main points of their segment and to rehearse the presentations they were to make to their jigsaw group and finally, the students were brought back into their jigsaw groups.

Students were each asked to present their segment to the group. Others in the group were encouraged to ask questions for clarification. Floating from group to group, the teacher observed the process. He made appropriate intervention where any group was having trouble (e.g., a member dominating or disruptive). Eventually, the group leader handled this task. Leaders were trained by whispering an instruction on how to intervene, until the leader got the hang of it. At the end of the session, a quiz was given on the material so that students quickly came to realize that these sessions were not just fun and games but really count.

The control group (CG) was a normal class activity with teacher talk; students listen, ask questions and watch demonstration. The use of instructional materials was ensured to avoid the students being purposefully placed at disadvantage. The entire class was taken as a group, that is, there were no subgroups as we had in STAD and Jigsaw.

Before the commencement of the teaching, each class was given a pretest (first version of BSAT). This was scored over 60% and kept. The teachers in the three groups (EG 1, EG 2 and CG) were then allowed to teach for six weeks following the training guide and processes described in this section with regular visit by the researchers. During this period, the teachers meticulously used the lesson plans prepared along with the researchers and based on the principles of each teaching strategy to cover the biology contents selected (that is, the scope). The post test (that is, the second version of BSAT) was administered in the 7^{th} week when all groups covered the expected contents. They were given the same day and about the same time to avoid interference since some of the schools were not too far apart.

2.2 Data Analysis

Data collected were analyzed using Mean and Standard deviation to address the research question while ANCOVA and Pairwise test at 0.05 level of significance addressed the hypothesis. The pairwise analysis helps to indicate direction of significance since we have more than two methods to compare. ANCOVA however is a relevant statistical tool since there was no randomization of subjects so as to take care of initial difference among subjects and groups.

ANCOVA was used in this study to increase statistical power, that is, the ability to find a significant difference between groups when one exists by reducing the within-group error variance. Unexplained variances which include error variance (e.g., individual differences), as well as the influence of other factors were addressed by the statistics. ANCOVA was used to adjust for preexisting differences in nonequivalent (intact) groups permitted by the design. This application was intended to correct for initial group differences (prior to group assignment) that exists on dependent variable among intact groups. Also, it was because participants could not be made equal through random assignment, so covariates were used to adjust scores and make participants more similar than without the covariates. There are five assumptions that underlie the use of ANCOVA and affect interpretation of the results in this study:

Assumption 1: Normality of Residuals. It was ensured that the residuals (error terms) was normally distributed.
Assumption 2: Homogeneity of Variances. It was ensured that the error variances were equal for different treatment classes.
Assumption 3: Homogeneity of Regression Slopes. The slopes of the different regression lines were confirmed to be equivalent, i.e., regression lines were parallel among groups.
Assumption 4: Linearity of Regression. The regression relationship between the dependent variable and concomitant variables was linear.
Assumption 5: Independence of Error terms. It was ensured that the error terms were uncorrelated.

Some external sources of error were taken care of in the study. For instance, the non randomization of the subjects was taken care of by use of ANCOVA thereby using the pretest to co-vary with the post test. This to some extent eliminated the initial differences among the groups. Also, by use of subject teachers was expected to eliminate Hawthorn effect so that students do not become unnecessarily sensitive to the study. Reshuffling of the items in the instrument after each use was part of the measures to forestall familiarity with the contents and boredom.

3. RESULTS

Information for answering research question are contained in (Table 1).

(Table 1) shows that the mean gains of the cooperative learning (STAD and Jigsaw) methods (31.36 and 25.67) are higher than that of the lecture method (17.79). This indicates that the students in the two cooperative learning classes (experimental groups) achieved more than those in the lecture method (control group). The STAD (31.36) has higher mean gain than the Jigsaw (25.67). The posttest standard deviation (SD) of STAD group (6.49) is lower than that of the Jigsaw group (8.36) and lecture group (7.77).

From (Table 2), the F value for the methods is 44.66 at 2 and 187 degrees of freedom and it is significant at 0.0001 [$F_{2,187} = 44.66$; $p < 0.05$]. Since $p < 0.05$, it means that there is a significant difference in the achievements of students among the three groups. Therefore, the Null hypothesis is not retained. Details of the level of significance among the students taught with different methods are contained in (Table 3).

Table 1. Means and standard deviations of students' score in pretest and posttest for lecture, jigsaw and STAD methods

Method		Pre test	Post test	Mean gain
Lecture	Mean	14.39	32.18	17.79
	Number	66	66	
	SD	2.85	7.77	
Jigsaw	Mean	12.57	38.23	25.67
	Number	60	60	
	SD	4.44	8.36	
STAD	Mean	13.58	44.94	31.36
	Number	62	62	
	SD	4.16	6.49	

3.1 Hypothesis

Data addressing the hypothesis are contained in (Tables 2 and 3).

Table 2. ANCOVA test of between–subjects effect for the lecture, jigsaw and STAD methods

Source	Sum of squares	Df	Mean square	F	Sig
Corrected model	5405.83	6	900.97	15.67	.00
Intercept	19307.46	1	19307.45	335.79	.00
Pretest	6.48	1	6.48	.113	.74
Method	5135.78	2	2567.89	44.66	.00
Error	10407.03	181	57.50		
Total	291864.00	188			
Corrected total	15812.85	187			

a.R squared = .342 (Adjusted R Squared =.320)

Table 3. Pairwise comparisons of posttest for the three methods

Method pair	Mean	Mean diff	Sig.	Remarks
Lecture	32.182			
Jigsaw	38.233	-6.021	.000	S
Lecture	32.182			
STAD	44.936	-12.736	.000	S
Jigsaw	38.233			
STAD	44.936	-6.715	.000	S

(Table 3) shows that the difference in the mean achievements of students between any pair of the three groups is significant at 0.05 significance level ($p<0.05$). This means that there are significant differences between each EG and the CG as well as between the two EGs with STAD being more facilitative.

4. DISCUSSION AND IMPLICATIONS OF FINDINGS

The result in (Table 1) shows that the two cooperative learning methods have higher mean gain than the lecture method (Jigsaw = 25.67, STAD = 31.36, Lecture = 17.79) and (Tables

2 and 3) show significant differences in the mean achievements of students in the three groups and between each pair of the three groups. This indicates the superiority of cooperative methods over the lecture method which is in line with the previous findings of Abdullahi and Duyilemi [15], Adesoji and Ibrahim [14], Adeyemi [19], Kolawole [16], Peklaj [20], Wachanga and Mwangi [17], Kilic [21], Iqbal [22], Achor, Wude and duguryil [23].

Although the Pairwise test for the three methods (Table 3) shows a significant difference, the mean difference between Lecture and STAD is higher than between lecture and Jigsaw methods. This shows that students achieved more in the STAD than in the Jigsaw method.

The superiority of the STAD is expected because the students worked together in mixed ability groups to complete their worksheets. Since the teachers were instructed in each experimental group to have minimal contacts with the learners, one therefore attributes this gain to the strategy used. Here the high ability students pulled the average and the weak ones so that at the end all of them improved in achievement thereby resulting to high gain in the group. Moreover, by presenting the materials in brief, the teacher provided the background as well as the focus for the students so that completing the worksheet was easy.

The superiority of Jigsaw over the lecture methods agrees with the findings of Al-badawi [24] and Kilic [21]. Its inferiority to STAD however, is probably because in the Jigsaw group, students worked in groups irrespective of their abilities. It might be possible that some Jigsaw groups have all members being of low ability. Such groups could not understand what they discussed in their expert groups thereby misinforming themselves in their Jigsaw groups when they reconvened. Another probable cause of the weakness of Jigsaw method is that since students were left on their own to search and study materials, they might have wasted much time searching for the materials and have little left to study and master the topics. One other reason according to Al-badawi [24] is that for Jigsaw to succeed, students must interact and treat each other as resources. It is possible that students were not used to working together cooperatively and were not able to treat each others as resources.

5. CONCLUSION AND RECOMMENDATIONS

Both STAD and Jigsaw learning strategies facilitated learning of biology in secondary school in the study area. However, STAD was found to facilitate learning more than Jigsaw. This means that though there are many cooperative learning strategies, among the two considered in this study, STAD was identified to favour study of biology more than Jigsaw and conventional strategies.

By implications success in the two experimental groups was not independent of how the teachers adhered to instructions given, good mix of the groups especially STAD and emphasis of reward on improvement noticed rather than doing better than other groups which tended towards competition. This implies that cooperative learning strategy not carefully applied could still promote competition which may defeat the essence.

It is therefore recommended that where choice is required especially in biology at the secondary school level, STAD should be adopted for use. Secondly, school supervisors, ministry officials and authors are encouraged to emphasize on use of STAD to teach biology at the secondary school level. It is also recommended that seminar, workshops and conferences should be organized to train teachers. The secondary school biology curriculum should be reviewed to reflect STAD as one of the recommended teaching strategies.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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