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Effect of Cooperative Learning (STAD, Jigsaw II and TAI) Strategies on Students' Achievement and Retention in Basic Science and Technology

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Abstract: This study investigated the effect of cooperative learning strategies (Student Team Achievement Division, Jigsaw II and Team Assisted Individualization) on achievement and retention of Basic Science and Technology students in Akwanga Local Government Area, Nasarawa State, Nigeria. A simple random sampling procedure was employed to select 167 Junior Secondary School (JSS) students from four public coeducation schools in the area of study. Quasi experimental design was employed for the study. Two research questions and two research hypotheses guided the study. Basic Science and Technology Achievement Test (BSATAT) was used as instrument for data collection. The reliability of BSATAT was determined using K-R20 formula and the reliability coefficient obtained was 0.82. Mean and Standard Deviation were used to answer the research questions while the hypotheses were tested at 0.05 level of significance using Analysis of Covariance (ANCOVA). Scheffe's post-test was used to determine the magnitude of any differences observed. The findings of the study revealed that significant differences were found in the achievement and retention of students taught using STAD, Jigsaw II, TAI cooperative learning strategies over the conventional lecture method.

Keywords: Basic Science and Technology, Achievement, Retention, Cooperative Learning Strategies

1. Introduction

The role of science and technology in the development of a nation can never be disputed. It is evident that the current development in science and technology has greatly affected the life of every human being so much that to be ignorant of the basic knowledge of this development is to live an empty, meaningless and probably unrealistic life. It would also be difficult for a nation with a scientifically and technologically illiterate citizenry to make any reasonable technologically based political decision on issues of everyday life such as the environment, agriculture, health, transport and communication or population growth. This is so because such a nation lacks the rudimentary tools to grasp the various arguments that are necessary to taking such decisions. Science and Technology therefore, have a privileged function of exerting a domineering if not a decisive influence on the development of a nation.

The vital role played by science in contemporary society is indispensable. In recognition of the important role of science for national development; the Federal Government of Nigeria in the National Policy on Education [6] gave a special place to science, technology and mathematics education and the promotion of scientific and technological literacy to her citizenry. In addition, the government put in place some reforms and measures aimed at harnessing the human and material resources in the country. Prominent among these is the National Policy on Science and Technology that has spelt out objectives and direction of science and technology education in Nigeria. Some of the objectives include:

a. Producing world class scientists, engineers and technologists who are well grounded in theory, practice of basic science and the needs of entrepreneurship.
b. Providing adequate support for continuous training of academic staff in tertiary and research institutions.
c. Strengthening the curricular in technological

entrepreneurship and management of technology for science and engineering students.

d. Mainstreaming students in arts and social sciences to appreciate the relevance of Science Technology and Invention (STI) in order to profitability equip them for business as well as personal development.
e. Encouraging and providing opportunities for the products of informal training schemes in STI for further formal training.
f. Strengthen capacity building institutions within the military, public and private sectors of the economy.
g. Facilitate on-the-job standardized training for professionals in STI organizations.
h. Promoting academic industry exchange programmes to enhance knowledge sharing [7].

Despite all the aforementioned that are aimed at improving the production of scientists and the subsequent development and use of scientific products among the citizenry, students' achievement has remained largely not encouraging [16]. The persistent underachievement in science and technology if not checked, may jeopardize the placement chances of students in post-secondary institutions. This has serious implications for national development, security, economy, and manpower for a country with a vision of becoming one of the leading nations in science and technology [9].

Researchers such as [5, 18, 2, 17, 13, 19] observed that poor instructional strategies employed in the teaching of the subjects by teachers contribute to students' under-achievement. Students find it difficult to understand the basic concepts taught, hence a child that is not well grounded in science and technology at the basic level, will not show interest in offering core science and technology subjects. In order to achieve the objectives of Basic Science and Technology Education, the student-activity-based mode of teaching strategies have been recommended by the Federal Republic of Nigeria [8].

Cooperative learning can be defined as a teaching method that involves students in learning process in order to understand and learn content of the subject [21]. Traditional class activities create a win-win situation, where one can only succeed if others loose, while cooperative learning is direct opposite of it. In the latter case, conquest of all is success of all. Cooperative learning has been identified as having an edge over other teaching methods in terms of its effectiveness for improved cognition, social skills and motivation [1, 3, 5, 13, 10, 9].

There are dozens of strategies that can be used by the teachers under the umbrella of cooperative learning process. While they have exerted varied influence on students' learning capacity, some of them have gained more popularity than others. This includes: Students Team Achievement Division (STAD), Jigsaw II and Team Assisted Individualization (TAI).

In STAD strategy, students are assigned to a heterogeneous group that consists of three members that are mixed in achievement level and genders. Students take a group quiz during which they reach consensus in decision making. They also take individual quizzes on the material without helping one another. Students' scores are then summed up to form team scores. Teams that meet certain criteria earn certificates or other rewards [21].

In Jigsaw II, students are assigned to three member teams to work on academic materials. Initially, all students are assigned to study and understand the basic concept of the materials. Later, each student is given a section/topic on which to become an expert. Students with the same section/topic meet in expert groups to discuss their topic, after which they return to their original teams to teach what they have learnt to their team mates. The students take group and individual quizzes that result in a team score based on the improvement score system [21]. The difference between Jigsaw I and II is that, the expert takes quizzes before returning to his/her home group.

Team-Assisted Instruction (TAI) strategy combines cooperative learning with individualized instruction. In TAI, students are assigned to three-member heterogeneous group. Each team member is placed on a stand-alone and learns the materials individually and proceeds at their own pace. Team mates check each other's work against answer sheets and help each other with any problems. Finally, individual and group unit tests are taken and scored by the teachers. Each week, teachers total the number of units completed by all team members and give certificates or other rewards to the best team [20, 22].

Retention is the ability to reproduce a learnt concept or skills when the need arises. For so long, researchers have been keen on knowing what can be done by teachers to enhance maximum retention of knowledge or skills long after they have been acquired whether in the classroom or outside the classroom [4]. Generally, it is believed that the more the human senses are brought into interaction during the learning process, the greater the retention capacity of the learner. This explains why the use of varied teaching strategies is increasingly advocated in the education industry.

The persistent under-achievement of students in Basic Science and Technology in Nigeria is alarming. The present study therefore, sought to determine the extent to which classroom exposures of students to STAD, Jigsaw II and TAI would enhance Basic Science and Technology students' achievement and retention. Specifically, the study sought to find out:

1. The effect of STAD, Jigsaw II and TAI cooperative learning strategies on Basic Science and Technology students' achievement.
2. The effect of STAD, Jigsaw II and TAI cooperative learning strategies on Basic Science and Technology students' retention.

Research Questions

1. What is the effect of STAD, Jigsaw II and TAI cooperative learning strategies on Basic Science and Technology students' achievement?
2. What is the Effect of STAD, Jigsaw II and TAI cooperative learning strategies on Basic Science and Technology students' retention?

Research Hypotheses

$H0_1$: There is no significant difference in the mean achievement scores of students taught Basic Science and Technology using STAD, Jigsaw II and TAI cooperative learning strategies.

$H0_2$: There is no significant difference in the mean retention scores of students taught Basic Science and Technology using STAD, Jigsaw II and TAI cooperative learning strategies.

2. Methodology

Quasi-experiment of the non-equivalent pretest, post-test, Post-post-test, control group design was employed for the study. The sample for the study comprised one hundred and sixty-seven JSS II Basic Science and Technology students from four intact classes randomly selected from public coeducation schools in Akwanga Local Government Area of Nasarawa State, Nigeria. The experimental groups I, II and III were taught using STAD, Jigsaw II and TAI cooperative learning strategies respectively while the control group was taught using the conventional lecture method.

Basic Science and Technology Achievement Test (BSATAT) was developed as instrument for data collection. BSATAT was a 50 items instrument with options A – D that tested the students' knowledge, comprehension, application of selected topics in Basic Science and Technology. The items were allotted 2 marks each, culminating to the total score of 100 marks. The test was validated by 3 experts, 2 in Science and Technology Education and 1 in Measurement and Evaluation. The reliability of the instrument was determined using Kuder-Richardson formula 20 (K-R 20) after a trial test among a representative sample of the students which gave a reliability coefficient of 0.82. The instrument was therefore, considered reliable enough for the investigation. Mean and Standard Deviation were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the research hypotheses at 0.05 alpha level of significance. Scheffe's post-hoc test was used to determine the magnitude of the differences among the strategies of instruction used.

3. Results

Research Question One

What is the effect of STAD, Jigsaw II and TAI cooperative learning strategies on Basic Science and Technology students' achievement?

The mean and standard deviation of students taught Basic Science and Technology using STAD, Jigsaw II and TAI cooperative learning strategies and conventional lecture method are presented in Table 1.

Table 1. *Mean and Standard Deviation of Achievement Test Scores of Students Taught Basic Science and Technology Using STAD, Jigsaw II and TAI Cooperative Learning Strategies and Conventional Lecture Method.*

Teaching method	Type of test	No of students	$\bar{X}$	SD
STAD	Pre-test	46	20.55	8.99
	Post-test	46	65.43	10.87
Jigsaw II	Pre-test	42	25.56	9.57
	Post-test	42	68.38	12.63
TAI	Pre-test	41	20.13	8.75
	Post-test	41	62.73	10.56
Conventional (Lecture) Method	Pre-test	38	50.03	7.73
	Post-test	38	55.39	9.21

Table 1 shows that, the mean scores of students taught Basic Science and Technology using STAD, Jigsaw II and TAI cooperative learning strategies were 65.43, 68.38 and 62.73 respectively and standard deviation of 10.87, 12.63 and 10.56 respectively. While those taught using the conventional lecture method had a mean score of 55.39 and standard deviation of 9.21.

Research Question Two

What is the effect of STAD, Jigsaw II and TAI cooperative learning strategies on Basic Science and Technology students' retention?

The post-post-test mean and standard deviation of the scores of BSATAT are presented in Table 2.

Table 2. *Mean and Standard Deviation of the Post-post-test Achievement Test Scores of Students Taught Basic Science and Technology using STAD, Jigsaw II and TAI Cooperative Learning Strategies and the Conventional Lecture Method.*

Teaching Method	Type of Test	No of Students	$\bar{X}$	SD
STAD	Post-post-test	46	71.46	12.13
Jigsaw II	Post-post-test	42	74.17	14.21
TAI	Post-post-test	41	69.98	11.78
Conventional Lecture Method	Post-post-test	38	56.63	9.98

Table 2 shows that the mean achievement scores of students taught using STAD, Jigsaw II and TAI cooperative learning strategies after the post-post-test were 71.46, 74.17 and 69.98 respectively with standard deviations of 12.13, 14.21 and 11.78 respectively. For the students who were taught with conventional lecture method, the mean achievement score was 56.63 and standard deviation was 9.98.

Hypothesis One

$H0_1$: There is no significant difference in the mean achievement scores of students taught Basic Science and Technology using STAD, Jigsaw II and TAI cooperative learning strategies and those taught using conventional lecture method. The data that is used for testing this Hypothesis is shown on table 3.

Table 3. *Result of Analysis of Covariance on Students' Achievement Scores in BSATAT.*

Source	Sum of Squares	Df	Mean Square	F	Sig.	Result
Corrected model	11289.931	2	5644.9635	98.962	0.000	S
Intercept	694.372	1	694.372	14.766	0.001	S

Source	Sum of Squares	Df	Mean Square	F	Sig.	Result
Posttest	2896.539	1	2896.539	51.356	0.000	S
Group	8954.306	1	8954.306	157.032	0.000	S
Error	5325.510	162	32.8735			
Total	29160.658	167				

Significant at P<0.05

Table 3 shows a significant difference among the learning strategies on post-test achievement, F (3,164) – 157.032, P<0.05. The null hypothesis of no significant difference was therefore rejected meaning that there is significant difference. Based on the established significant difference in the post-test achievement scores of the groups, scheffe's test was used for post-hoc analysis to determine the magnitude of the difference. The results of the post-hoc analysis are as shown in Table 4.

Table 4. *Scheffe's Post-hoc Analysis of the Groups' Mean Post-test Achievement Scores.*

Group	Mean	STAD	Jigsaw II	TAI	Conventional Lecture Method
STAD	65.43		0.411	0.521	0.245
Jigsaw II	68.38	0.411		0.010	0.005
TAI	62.73	0.521	0.010		0.958
Conventional Lecture Method	55.39	0.245	0.005	0.958	

The mean difference significant at 0.05 level

The results in Table 4 indicate that there was no significant difference in the post-test mean scores of students exposed to STAD (X=65.43) and those exposed to Jigsaw II (X=68.38). A significant difference was not established in the post test mean scores of students exposed to TAI (X=62.73) and those exposed to the conventional lecture method (X=55.39) in favor of Jigsaw II. Student achievement was also compared based on the mean gain-scores between the pre-test for each group. The results of this comparison are shown in Table 5.

Table 5. *Mean Gain Scores of Students' Achievement in STAD, Jigsaw II, TAI and Conventional Lecture Method.*

Group	Pre-test	Post-test	Mean Gain Score
STAD	20.55	65.43	44.88
Jigsaw II	25.56	68.38	42.82
TAI	20.13	62.73	42.60
Conventional Lecture Method	20.03	55.39	35.36

Table 5 shows that STAD had the highest mean gain score of 44.88, followed by Jigsaw II with a mean gain score of 42.82, TAI with a mean gain score of 42.60, and the conventional lecture method with a mean gain score of 35.36. This implies that all the groups benefitted from the treatment, with STAD having the highest achievement.

Hypothesis Two

$H0_2$: There is no significant difference in the mean retention scores of students taught Basic Science and Technology using STAD, Jigsaw II and TAI cooperative learning and those taught using conventional lecture method.

To determine whether there were significant differences in the Post-post-test mean scores of STAD, Jigsaw II, TAI groups and the conventional lecture method group, data were analyzed using Analysis of Covariance (ANCOVA) in Table 6.

Table 6. *Results of Analysis of Covariance on Post-post-test Achievement Scores in BSATAT.*

Source	Sum of Square	Df	Mean Square	F	Sig.	Result
Corrected model	852.701	2	426.3505	9.513	0.002	S
Intercept	3261.208	1	3261.208	38.738	0.000	S
Posttest	528.946	1	528.946	11.476	0.000	S
Group	98.438	1	98.438	5.695	0.001	S
Error	2410.439	162	14.879			
Total	7141.732	167				

Table 6 indicate that there was a significant difference in the mean scores of students taught using different learning strategies on Post-post-test achievement, F=5.695, P<0.05. This implies that the instructional strategies produced significant effects on the Post-post-test scores of students when the covariate effect (pre-test) was controlled. Based on the established significant difference in the post-post-test scores of the groups, scheffe's test was used for post-hoc analysis. The results of this post-hoc analysis are shown in Table 7.

Table 7. *Scheffe's Post-hoc Results of Students' Mean Post-post-test Scores of STAD, Jigsaw II, TAI and Conventional Lecture Method.*

Groups	Mean Scores	STAD	Jigsaw II	TAI	Conventional Lecture Method
STAD	59.34		0.652	0.542	0.243
Jigsaw II	62.02	0.652		0.024	0.004
TAI	58.78	0.542	0.024		0.982
Conventional lecture method	54.32	0.243	0.004	0.982	

The mean difference is significant at 0.05 level

The results shown in Table 7 indicate that there was no significant difference in the Post-post-test mean scores of students exposed to STAD (X=59.34) and those exposed to Jigsaw II (X=62.02). There was a significant difference in the Post-post-test mean scores of students exposed to Jigsaw II (X=62.02) and those exposed to TAI (X=58.76) in favour of Jigsaw II group. A significant difference was not established in the Post-post-test mean scores of students exposed to TAI (X=58.76) and those exposed to conventional lecture method (X=54.32). A significant difference was established between Jigsaw II (X=62.02) and conventional lecture method (X=54.32) in favor of Jigsaw II.

In order to examine retention, the achievement of students in the four groups was further compared based on the mean loss scores between the post-test and post post-test for each group. The results are shown in Table 8.

Table 8. *Mean Loss Scores between Post-test and Post-post-test for STAD, Jigsaw II, TAI and Conventional Lecture Method Groups.*

Group	Post-test	Retention Test	Mean Loss Score
STAD	65.43	59.34	6.09
Jigsaw II	68.38	62.02	6.36
TAI	662.73	58.76	3.97
Conventional Lecture Method			

Table 8 shows a decrease in delayed post-test scores of the four groups as compared to post-test scores. Jigsaw II had the highest decrease in the form of a mean loss score of 6.36, followed by STAD with a mean loss score of 6.09, TAI with a mean loss score of 3.97, and conventional lecture method with a mean loss score of 1.07. This indicates that the cooperative groups retained more what had been learnt when compared to the conventional lecture method group.

4. Discussion

The results of this study revealed that there is significant difference between the achievement of Basic Science and Technology students in STAD, Jigsaw II, TAI cooperative learning strategies and conventional lecture method in favor of the cooperative learning strategies. This result indicates that the cooperative learning strategies are more effective in enhancing students' academic achievement than the conventional lecture method.

These findings are consistent with that of [12, 1, 3, 5, 10, 14, 15, 9] who reported that, students taught using cooperative learning strategies achieve better academically than those taught using the conventional lecture method. In relation to retention, the researchers also found that cooperative learning strategies had greater retention of what they had learnt compared to the conventional lecture method.

These findings have strong implications for the teaching and learning of Basic Science and Technology in Nigeria secondary schools. Clearly it shows that emphasis should be placed on the use of cooperative learning strategies for effective teaching of Basic Science and Technology.

5. Conclusion

The findings of the study, amongst others have shown that: STAD, Jigsaw II and TAI cooperative learning strategies is a way of overcoming under-achievement in Basic Science and Technology at the junior secondary school level in Nigeria. The present conventional lecture method employed by teachers should drastically be minimized and only used when necessary.

Recommendations

1. Cooperative learning strategies should be used to enhance the teaching and learning of Basic science and Technology. This is because it is innovative and has the potential to motivate learners towards learning science and technology.
2. Students should always be encouraged to work together in groups so as to enable them imbibe the culture of working together cooperatively in order to promote their understanding of science and technology.
3. Seminars and workshops should be organized to equip teachers to enable them acquire more knowledge and skills of how to use cooperative learning strategies in the teaching and learning of Basic Science and Technology.

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