Achievement in Cooperative versus Individualistic Goal-Structured Junior Secondary School Mathematics Classrooms in Nigeria

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***Abstract*— This study investigated the comparative effect of cooperative variants of STAD/TGT and individualistic goal structure on the mathematics achievement of 80 junior secondary school Nigerian students. The study adopted a pre-test, post-test control group quasi-experimental design and data collected for the study were analysed using the t-test statistic. The results showed that significant difference existed in the mathematics achievement of cooperative and individualistic goal structure groups in favour of cooperative group. The cooperative strategy also enhanced students' mastery of mathematics content at both the comprehension and application levels than at the knowledge level of cognition. Based on the findings, the study recommended among others that STAD/TGT as variants of cooperative learning should be used by teachers to complement the teaching of mathematics at the secondary school level.**

***Keywords*—Cooperative learning, student teams and achievement division (STAD), teams-games-tournaments (TGT), individualistic goal structure, mathematics achievement, knowledge level of cognition, comprehension level of cognition, application level of cognition.**

I. INTRODUCTION

Reference [1] provided a theoretical framework for understanding the effect of different modes of instruction and further distinguished between three ways in which the motivations of different individuals can be interrelated: within (a) cooperative, (b) competitive, and (c) individualistic. These goal structures exist in the classrooms [7]. A goal structure is simply defined, as "how the teacher has students work together to achieve a learning goal" [12]. When students work against one another to achieve a learning goal, they are functioning within a competitive goal structure. When students are given individual goals and rewarded individually according to a 'criterion-referenced' evaluation system [18], the goal structure is individualistic, and when students work together to achieve a learning goal, the lesson structure is cooperative. The pedagogical goal for the teacher should be to achieve an understanding of the workability of the different goal structures in ways that advantage all students. Relying on the theory of motivation, [22] proposed another model which attributes the success of group learning to the goal structure of cooperative learning. There are five components to successful cooperative learning and which differentiate it form group work [12]. Using the mnemonic GIPSS, these components can be readily recalled as: group process (a structure exists for how students will work together); individual accountability (each student is still assessed on what he/she knows) positive interdependence (students need to be able to work together); social skills (particular social skills are emphasized during group work); and specific tasks (students work together to achieve a particular goal). These components are essential to the instructional effectiveness of cooperative learning. Eight instructional variations of cooperative learning which teachers can use to enable students to effectively work together toward some defined group goal have been identified [12]. These are: numbered heads together; groups of four; think-pair-share; groups of three; jigsaw II; teams-games-tournaments (TGT); student teams and achievement divisions (STAD); and team assisted individualization (TAI). Reference [24] found that small-group cooperative structures having the elements of group study with group reward for individual learning were the most consistently effective in improving achievement. Two pedagogical strategies that fit this model are STAD and TGT [18].

Both TGT and STAD are extremely useful when teachers are requiring students to focus on skills and content material that are clearly defined and on dealing with questions that have relatively discrete answers (for example, mathematics) [12]. The TGT and STAD models both use four-member groups in which each group reflects a cross section of the available academic ability within the classroom, that is, teams are all academically heterogeneous [18]. The inclusion of different racial/ethnic groups and both sexes is a way of maintaining heterogeneity in the teams. Teams function "to prepare members, through peer tutoring, for participation the next day in a learning-game-tournament by rehearsing subject matter presented earlier by the teacher" [17]. In both TGT and STAD, tournaments are held weekly and are made up of short-answer questions. Thus, in TGT, based on students' previous performance, three academically similar students are assigned to each tournament table. Once the games are completed, the three students are ranked and given points that they take back to their teams. While the highest scoring student gets 6 points, the middle scorer gets 4 points, and the lowest scorer gets 2 points. The sum of the team points, to which each team member has contributed, determines which team wins the tournament, thus maintaining "reward interdependence" within each practice team.

However, one distinguishing feature between the STAD and TGT is that the STAD does not use the TGT element of face-to-face competitive tournaments. Rather, in STAD, based on students' previous performance, teachers assign students to one of several equal-status achievement divisions and weekly test results are compared only to each student assigned academically similar division. This should enhance motivation through increasing the tendency that each student may get comparably high scores on their weekly tests. Thus, the test scores are converted into points that each student brings back to his/her team and the team with the highest points is considered the weekly winner of the inter-group competition. While group winners in either the TGT or STAD model are rewarded on the basis of a group contingency reward system, they are also reported in a classroom newsletter [18]. Summarily, in STAD, students are grouped according to mixed ability, sex and ethnicity. The teacher presents materials in the same way he/she always does, and then students work within their groups to make sure all of them mastered the content. All students take individual quizzes and students earn team points based on how well they scored on the quiz compared to past performance. Unlike STAD, in TGT quizzes are replaced by tournaments and students compete at tournaments table against students from other teams who are equal to them in terms of past performance. Students earn team points based on how well they do at their tournament tables. Empirical studies on cooperative learning methods are abound in the literature.

In a study regarding the effectiveness with regard to achievement gains of a cooperative as contrasted with an individualistic goal-structured unit of instruction in two secondary general mathematics classrooms, [18] found that although both groups obtained significant gains on their post-test scores as contrasted with their pre-test scores, the cooperatively goal-structured classroom demonstrated significantly higher achievement post-test scores than the individualistic group. Reference [29] found that cooperative learning methods improve students' achievement in mathematics and attitude towards mathematics. Reference [10] developed and tested a two-level small group model of cooperative learning with 50 in-service teachers. They concluded that the model was successful in raising the test scores of students and in reducing student reading time. Reference [2] found that the students of a community college had fewer misconceptions in chemistry following cooperative learning in comparison with those following traditional instructional methods. Many studies [8], [3], [6], [26], [5] show that cooperative learning can improve achievement, long-term memory and positive attitudes toward mathematics, self-concept and social skills.

Despite the frequently reported positive findings on the effectiveness of cooperative learning methods in enhancing students' learning outcomes in the literature some findings showed that cooperative learning might not be effective in promoting students' achievement. Reference [1] investigated the comparative effect of lecture and cooperative learning strategies on achievements in general chemistry at the undergraduate level in a teacher preparation course. They found that the overall achievement scores were similar in the two classes following different learning strategies. Reference [28] compared the effect of cooperative and individual learning on the achievement of 178 grade 10-12 students in problem-solving and found no statistically significant differences. The inconsistency in research findings points to the fact that more investigations into the effectiveness of cooperative learning are needed. More importantly, the research on the effectiveness of cooperative learning in mathematics classrooms in Nigeria is rather scanty. Reference [5] investigated the effectiveness of cooperative learning with respect to mathematics in Nigeria; the dependent variable being attitude towards mathematics. Reference [11] found cooperative learning strategy to be more effective than competitive learning strategy on academic performance of Nigerian students in mathematics. Reference [14] found the cooperative group to be superior on Nigerian students' achievement measure with no difference between the competitive and individualistic structures in biology. Based on the reviewed literature it can be said that cooperative learning is effective in enhancing students' learning outcomes particularly achievement in mathematics.

The dearth of literature on cooperative learning in Nigeria has uncovered the need for further study on the nature and effect of cooperative learning on students' achievement in mathematics. Thus, the present study was designed to investigate the comparative effectiveness of cooperative learning variants of STAD/TGT and individualistic goal structure strategy on students' achievement in junior secondary school mathematics in Nigeria.

II. RESEARCH QUESTION

This provided answers to the following questions:

1) Will there be any significant difference between the pre-test achievement scores of students exposed to the cooperative and individualistic goal structured strategies?

2) Will there be any significant difference between the post-test achievement scores of students exposed to the cooperative and individualistic goal structured strategies?
3) Will there be any significant difference between the students' knowledge, comprehension and application levels of cognition after being exposed to the cooperative and individualistic goal structured strategies?

III. METHODOLOGY

A. Research Design

The study adopted an untreated control group, pre-test, and post-test quasi-experimental design.

B. Target Population

The target population for this study consisted of all the second year students in public Junior Secondary Schools (JSS) in Calabar metropolis of Cross River State, Nigeria. There are 50 junior secondary schools in the metropolis. JSS year two students were chosen for the study because the researchers believed that:
1) The students have some level of maturity and confidence required to participate in the study having been previously taught mathematics at the JSS year one.
2) The students were not being prepared for any impending and immediate external examination that could distract them from full participation in the study.
3) The plane shape and Angle topics used as intervention in the study are contained in the JSS year two mathematics curriculum.

C. Sampling Procedure and Sample

Considering the underlisted criteria, the judgmental sampling technique was used to select the schools that took part in the study:
1) The school must be a public co-educational secondary school;
2) The JSS year two students in the school should not have received instruction on any of the topics under consideration;
3) The school has at least holders of the Nigeria Certificate in Education (NCE) mathematics teacher(s) teaching JSS year two students.
4) The school intends to register candidates for 2010 June/July Junior School Certificate Mathematics Examination.
5) The school must have JSS year two students offering mathematics and other science subjects.

From the eight secondary schools contacted and met the criteria stated above, two schools were purposively selected to participate in the study. The two schools chosen were those that have equal number of students (40 each) in their JSS year two classes. Thus, a sample of eighty (80) JSS year two students (48 boys and 32 girls) participated in the study. The two classes were then assigned randomly into an experimental class and a control class. In the case of school with more than one arm or class for JSS year two students, one arm or class was randomly selected. The median age of participants was 13 years.

D. Course Content Selection

The topics under the plane shape and angle aspect of JSS year two mathematics curriculum covered in this study were limited to parallelogram, rhombus, kite, angles between lines, angles in a triangle, angles in a quadrilateral and polygons. The choice of these topics was not only premised on the fact that students perceived them as difficult and thus perform poorly in them but that each topic can be taught at knowledge, comprehension and application levels of Bloom's cognitive taxonomy [15].

E. Instrumentation

One research instrument named Mathematics Achievement Test (MAT) was developed and used in this study. The MAT is a 20-item multiple-choice objective test items with one key and three distractors. The MAT was constructed by the researchers and face validated by a panel of secondary school mathematics teachers to measure students' achievement in mathematics covering the selected topics for the study. The MAT was based on lower level of cognitive domain (knowledge, comprehension and application). The first 7 items of the validated instrument covered knowledge skills, the next 7 items covered comprehension skills while the last 6 items covered application skills. To test the reliability of the instrument, the 20-item MAT was administered on a sample of 30 students (16 boys and 14 girls) in a school not chosen as part of the study schools but whose students' demographics such as age and class level are similar to the students involved in the study. From the students' responses, a reliability coefficient of 0.78, using the Kuder-Richardson method (formula 21) was obtained. The test items showed discrimination power of more than 0.40 and difficulty index of 0.40-0.60.

F. Procedure

The two mathematics teachers in the selected schools were the instructors for the students that took part in the study. They were trained for one week on how to execute the intervention and control treatments. Before instruction, the MAT was administered as pre-test to both experimental and control classes. Thereafter, each classroom was differentially taught a 20-day unit of instruction concerned with the plane shapes and angles. In the classroom taught by the cooperative structure ($n = 40$), students were divided into ten small, four-member groups that were heterogeneous with regard to academic ability as well as sex. Students' academic ability was ascertained using their performance in the promotional end of session results in junior secondary year one. The majority of instructional time was spent using the STAD structure four times and the TGT tournament structure once throughout the 20-day/three-week period of instruction. Teacher lecturing and drill exercises using peer tutoring in the small groups as required by STAD/TGT model were accomplished in class. In the individualistic goal structured classroom (n = 40), the teacher made use of individual drill and homework exercises as well as lectures and textbook assignments. Students in the cooperative structure formed the experimental group while those in the individualistic goal structured classroom were tagged the control group. Both experimental and control classes were not aware that they were being involved in a study. At the end of the 20-day unit of instruction, the rearranged items in the pre-test instrument were re-administered to the students to measure the learning that had taken place. The MAT items were rearranged in order to prevent hallo-effect that could result from familiarity of pre-test and post-test instruments. The three-week period between the two tests provided necessary time to reduce threats to validity due to repeated testing of participants on similar test items [16].

G. Data Analysis

The independent-samples t-test at the 0.05 confidence level was used to compare means of the two classes on the pre-test, post-test and on the knowledge, comprehension and application components of the test for possible test of significance difference.

IV. RESULTS

The results of this study are presented in accordance with the stated research questions:

Research Question 1: Will there be any significant difference between the pre-test achievement scores of students exposed to the experimental and control strategies?

Table 1 shows the means and standard deviations of the pre-test scores of the two classes. The result showed an insignificant difference (t = 0.28, p>0.05). This indicated that the mean pre-test score of the students in the experimental group is not significantly different from the mean pre-test score of the students in the control group at the 0.05 confidence level.

Research Question 2: Will there be any significant difference between the post-test achievement scores of students exposed to the experimental and control strategies?

Table 2 reveals the means and standard deviations of the post-test scores of the two groups under investigation. Comparison of the difference between the mean post-test scores of the two groups showed a significant difference (t = 5.94, p<0.05) in favour of the experimental group. Thus, students in the experimental group (exposed to cooperative structure) obtained significantly better post-test achievement scores than their counterparts in the control group (exposed to individualistic goal structure).

Research Question 3: Will there be any significant difference between the students' knowledge, comprehension and application levels of cognition after being exposed to the experimental and control strategies?

Table 3 shows the means and standard deviations of the students' post-test scores in the knowledge, comprehension and application levels of cognition of the two groups. The results revealed an insignificant difference in the students' scores at knowledge level (t = 0.77, p>0.05) but significant differences in their scores at comprehension level (t = 6.58, p<0.05) and application level (t = 7.23, p<0.05). These results showed that while there seem to be no significant difference between the mean scores of the two groups of students at their knowledge level of cognition, the students exposed to the experimental intervention significantly achieved better than their counterparts in the control group at their comprehension and application levels of cognition.

TABLE 1
COMPARISON OF THE STUDENTS' PRE-TEST ACHIEVEMENT SCORES

Group	**N**	$\bar{x}$	**SD**	**Df**	**t**	**Sig.**	**Remks**
Experimtal	40	10.13	1.84	78	0.28	1.41	ns (p>0.05)
Control	40	10.23	1.33				

TABLE 2
COMPARISON OF THE STUDENTS' POST-TEST ACHIEVEMENT SCORES

Group	**N**	$\bar{x}$	**SD**	**Df**	**t**	**Sig.**	**Remks**
Experimtal	40	17.43	2.69	78	5.94	0.00	Signi. (p<0.05)
Control	40	13.84	2.72				

TABLE 3
COMPARISON OF THE STUDENTS' POST-TEST KNOWLEDGE, COMPREHENSION AND APPLICATION SCORES

Cognitive Level	**Group**	**N**	$\bar{x}$	**SD**	**df**	**t**
Knowledge	Experim. Control	40 40	5.32 5.12	1.03 1.28	78	0.77
Comprehension	Experim. Control	40 40	5.48 3.42	1.38 1.42	78	6.58 *
Application	Experim. Control	40 40	4.82 2.63	1.32 1.39	78	7.23 *

* Significant at p<0.05.

V. DISCUSSIONS AND CONCLUSIONS

The results of the present study revealed that the mean pre-test score of the students in the experimental group was not statistically significantly different from that of the students in the control group. This outcome is an attestation that the two groups of students entered the instruction/experiment on equal strength since their pre-test scores showed no significant difference regardless of the higher mean score obtained by the control group. However, in as much as both groups were not significantly different on their pre-test scores, they at least started the unit of instruction equally, thus probably ruling out the influence of instrumentation. This finding is important in order to show that if any significant difference is seen in the mean pre-test scores then such disparity would not be attributed to chance but the influence of the intervention.

However, the mean pre-test score of the students in the experimental group was found to be statistically significantly different from that of their counterparts in the control group. Although, this finding runs contrary to the findings of [28], [1], it strongly support the efficacy of the use of cooperative strategy especially STAD/TGT in enhancing students' achievement in mathematics. This finding corroborates the position of [20], [22], [23], [18] regarding the effectiveness of the incentive and task structure associated with STAD/TGT, both requiring group study and group reward for individual learning. Other researchers such as [29], [27], [13] have equally demonstrated the efficacy of cooperative learning in increasing students' achievement in mathematics. To them cooperative learning gives more space and opportunities for students to discuss, solve problems, create solutions, provide ideas and help each other. Both STAD/TGT models require that participants are heterogeneously grouped and actively engaged in conversation in mathematics classroom. They also require cooperation within competing groups. This element of inter-group competition according to [18] provides the peer pressure as well as incentive structure hypothesized as the primary motivating force behind the efficacy of the STAD/TGT models in improving academic achievement.

An interesting but surprising finding in this study is the obtained significant differences between the experimental group and the control group at the comprehension and application levels of cognition but a non-significant difference between the two groups at the knowledge level of cognition. The interesting thing about this finding is that when STAD/TGT cooperative learning variants are used in mathematics instruction, there is that high possibility that the students would perform better at both the comprehension and application levels of cognition than at the knowledge level of cognition. The finding is surprising because it is a contrasting outcome against the strongly held position and general expectation that mastery of content is easier to achieve at the knowledge level than at the comprehension and application levels of cognition. One probable explanation regarding this outcome is that because the students in the experimental group were given the opportunity to compete and rehearse previously learnt subject matter through peer tutoring, the students' attention were actually directed to the most vital aspects of the lesson which involve what they were able to pick from the lesson in terms of understanding and applying the main concepts than the mere ability to regurgitate facts, definitions and formulae, which knowledge skill is more concerned with.

In conclusion, this study investigated the comparative effectiveness of cooperative and individualistic goal structured strategies on students' achievement in mathematics at the junior secondary school level. While neither group significantly differed from the other on a pre-test the cooperative group demonstrated significantly higher achievement on the post-test than the individualistic group. This shows the more facilitative effect of cooperative strategy in teaching and learning mathematics at the junior secondary school level. The strategy is also capable of improving learners' mastery of content at the comprehension and application levels than at the knowledge level of cognition.

Based on the findings of this study, it is hereby recommended that cooperative learning variants of STAD/TGT should be used by teachers of mathematics and other allied subjects in teaching their students at the secondary school level. It is equally recommended that teachers of mathematics need to be aware of the benefits and importance of cooperative learning and thus change the practice of teacher-centered teaching methods to student-centered inquiry-based teaching methods that emphasize meaningful learning. The conclusion in this study has been drawn based on scores on achievement test. Affective surveys (e.g. attitude, motivation self-efficacy etc.) to assess other learning outcomes than achievement on cognitive test, were not used. Moderator variables (e.g. gender, locus of control, cognitive style etc.) were also not considered. All these point to the limitations of this study which may be considered in future studies.

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