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The Effects of Cooperative Learning Strategy on Academic Outcomes of Secondary School Students in Biology: Implications for Stem Subjects

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Abstract: *The main purpose of the study was to evaluate the effects of cooperative learning strategy on academic performances and outcomes of secondary school students in biology. Experimental design with randomized control trials (RCTs) was employed to carry out this study. The actual study addressed two secondary schools from North Shewa, Oromia: one experimental school (five biology teachers and 600 grade 9 students), and one control school (five biology teachers and 600 grade 9 students). The student team achievement division (STAD) model was used to evaluate the relationships between the cooperative learning strategy and students' academic outcomes in classrooms. Pre-test and post-tests were administered before and after intervention respectively. Data were analyzed using two-tailed test and one-way ANOVA to compare pre-test and post-test across the groups. Findings indicated that although teaching style can be conceptualized on a continuum ranging from teacher-centered to student-centered spectrum, cooperative learning strategy resulted in students' critical thinking and higher academic achievement scores in biology compared to the competitive and individualistic lecture method where the differences between the baseline and end-line remarkably showed significant increase after each intervention. There is a direct relationship between utilization of cooperative learning strategy and students' academic outcomes. Therefore, the intervention achieved its intended outcomes.*

Keywords: Cooperative learning strategy, biology, interventions and outcomes

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Introduction

Cooperative learning is one of the most remarkable and fertile areas of theory, research, and practice in education. On top of this, it is a generic term that refers to numerous methods for organizing and conducting classroom instruction. Accordingly, cooperative learning exists when students work together to accomplish shared learning goals (Johnson and Johnson, 1999). Each student can then achieve his or her learning goal if and only if the other group members achieve theirs (Deutsch, 1962). Evidently, different theoretical perspectives (social interdependence, cognitive-development, and behavioral learning) provide a clear rationale as to why cooperative efforts are essential for maximizing learning and ensuring healthy cognitive and social development as well as many other important instructional outcomes. Hundreds of research studies demonstrated that cooperative efforts result in higher individual achievement than do competitive or individualistic efforts in learning (Johnson, Johnson, and Stanne, 2000). Thus, there are relationships among individual and group members' actions and interactions to achieve the intended learning goals in cooperative learning strategies.

Although there is no single view of learning or teaching that might be called good teaching (Kember, 1997), a teaching method is generally understood as a means by which teachers attempt to impart the designed learning experiences so that the learners understand and bring about behavioral changes; it includes setting the objectives, selecting the contents and procedures to best achieve the objectives and evaluating the whole process (Firdissa, 2005). Accordingly, deep learning is associated with meaningful activities in a setting that includes collaborative peer learning and replacing most lectures by a small group learning that end in a mini-conference (TsaushuandTal, 2017). While there are various methods of teaching that teachers can use, the central focus and purpose are enhancing students' performances (Firdissa, 2005) although there are tensions and relationships between them. Even then, educators' teaching styles can be conceptualized on a continuum ranging from teacher-centered to student-centered teaching spectrum.

Meanwhile, the emergence of a global movement that calls for a new model of learning for the 21st century has been argued that formal education must be transformed to enable new forms of learning to tackle complex global challenges. Accordingly, the science curricula in Ethiopia aimed to empower young generations to develop their potential as individuals and make informed and responsible decisions for living and working in the 21st century. The world society today needs young people who are flexible, creative and proactive to solve problems, make decisions, think critically, communicate ideas and work efficiently within teams and groups (UNESCO, 2005; 2010). The epistemological assumption is no longer

enough to succeed in complex, fluid and rapidly evolving postmodern world in which we live.

To optimize life-long learning and potential success, it is now widely accepted that young people need to have opportunities to develop personal capabilities and effective thinking skills as part of their well-rounded education. Cooperative learning strategy as one of the learner-centered strategies is the deliberate instructional use of heterogeneous small groups of students who work together to maximize each other's learning (Igboanugo, 2013). Accordingly, students can be grouped based on their interests, ability and arbitrarily to form heterogeneous groups for effective practices of cooperative learning strategy. Therefore, there are four criteria for mixed group formation (MoE, 2014). These are; arbitrary grouping, ability grouping, mixed grouping and compatibility grouping. The groups are formed on the bases of these four criteria and are dynamic throughout the academic years.

Cooperative learning strategy is theoretically based on the work of psychologists like Levi Vygotsky who proposed that children actively construct knowledge in a social context (Conway, 1997). This indicates that it promotes learners' teamwork and creates something new rather than simply taking ready-made information. Students develop more positive attitudes to science when they work together cooperatively than when they work alone (Panitz, 2008). A lot has been done to improve science teaching in secondary schools in different countries. Despite such an effort, students continue to perform poorly in science subjects of which one is biology (Samba and Lortim, 2014). This situation has created the need for more effective teaching methods to enhance the academic performances of students in science in general and in biology in particular. Hence, the working out of conceptual frameworks used in this study was the systems theory in education which depicts that the teaching and learning process have inputs that interact to produce outputs (Shevelson, 1987). In the context of the teaching and learning process, the learner is the input and through the teaching-learning process, the learner undergoes desirable changes (Ayot and Patel, 1992). Therefore, the performance of the learners and their academic achievements are educational outputs and outcomes respectively.

For this particular study, therefore, five trained teachers were used as intervening groups and five teachers were used as control groups. The two methods of teaching were independent variables while students' academic performance and achievement scores were dependent variables. Teachers' and students' characteristics and school inputs were extraneous variables. Besides, the STAD model was adapted in this study assuming that it is the simplest and straight forward model of the cooperative learning approach (Arends, 1997; Slavin, 1995). Hence, the researcher used the STAD model in the evaluation of an application

of cooperative learning strategies in the experimental school.

Statement of the Problem

As perspectives are philosophical orientations to knowledge and learning, the responsibility of being a teacher is important to discourse that the transmission and developmental perspectives represent a legitimate view of teaching when enacted appropriately. Throughout the process, pre-conceived notions of "good teaching" are challenged as educators are asked to consider what teaching means to them. The researcher's long professional experiences as a secondary school biology teacher, biology subject area methodology and pedagogical instructor allowed him to witness the supremacy of positivist standpoints over constructivist standpoints in the science instructional system. This hegemony caused complications of implementing the hands-on and minds-on teaching strategies in science to enhance students' competencies. Academic achievement of students in biology at the secondary school level has nationally been low and a factor for low achievement is the teaching methods adopted by a teacher. It is acknowledged that learner-centered teaching approaches promote high order thinking and academic achievement as compared to teacher-centered approach (UNESCO, 2005). This promotes deep learning in comparison to surface cover approach of learning.

The cooperative learning method is an active education strategy with small groups in order that the students develop their learning potential (Knowles, 2007). Although some scholars consider it as a political language, the cooperative learning method actively involves learners in the teaching-learning process thereby promoting learning and higher academic achievement than a teacher-centered approach (Agashe, 2004). Thus, the rethinking pedagogy of the 21st century is fundamental to identifying the new competencies that today's learners need to develop and learn using their minds until they reach the Zone of Proximal Development. Besides, the cooperative learning method has positive effects on ranges of student outcomes including academic achievement and social skills development (Ferrer, 2004; Knowles, 2007). However, "implementation of cooperative learning does not occur within a vacuum but rather strongly influenced by school reforms and initiatives that occur within a shifting landscape of socio-political priorities and policies at multiple levels" (Han and Weiss, 2005). This shows that when critical factors are managed properly, there are direct relationships between effective utilization of cooperative learning strategy and students' learning out comes under optimum conditions.

Local studies conducted at macro and micro-levels indicated that active learning strategies were not practiced and thus did not bring about the expected outcomes due to lack of awareness, understanding

and inability to manage teaching perspectives and teaching methods, political ideologies, large class size, poor perceptions, lack of knowledge and skills, willingness and other inertia (Teshager, 2009; Arikew, 2015; Girma and Feyera, 2018). These studies revealed that the practices of active learning methods were downgraded because of perplexing impeding dynamics in secondary schools mainly poor perceptions and low professional competences of teachers. Besides, these are too general to thoroughly address the practices of cooperative learning strategy.

This study presented a promise that if cooperative learning method is implemented effectively, the likelihood of positive results is quite high. Consistent with this premise, the results of some meta-analysis provided evidences that show all cooperative learning methods have produced higher achievement than competitive and individualistic learning methods. The more conceptual approaches to cooperative learning methods may produce higher achievement than direct methods of instruction. From the highlighted and concealed gaps, the interventions of cooperative learning strategy helped the learners to minds-on and hands-on activities to headway their academic performance and achievement scores. However, in the Ethiopian context, the implementation of a cooperative learning strategy had never been practiced effectively beyond its theoretical understanding as a method of teaching. So, if educative measures are not taken on time to solve this dilemma, the quality of instructional system will negatively affect the education system and hamper the production of quality professionals. Therefore, the study was aimed at evaluating the relationship between treatment - on and academic outcomes of students, and the outcome of interventions of cooperative learning method on academic achievement of secondary school students in biology by using the STAD model.

Objectives

The main objective of this study was to evaluate the impacts of interventions of cooperative learning strategy on secondary school students' academic performances and outcomes in biology. More specifically, the study has the following objectives. These are:

1. To compare and contrast the differential effects of cooperative learning interventions and lecture methods on students' academic achievement scores in biology.
2. To evaluate the success of interventions of cooperative learning strategy in developing competencies of grade 9 students in biology. `
3. To examine the differential effects of interventions of cooperative learning methods between grade 9 male and female students on BAT.
4. To evaluate the degree of relationships between successive post- interventions of cooperative learning strategy and grade 9 students' academic outcomes.

Research Hypotheses

To test the impacts of interventions of cooperative learning strategy on secondary school students' academic outcomes in biology, the following alternative directional and null hypotheses were formulated on the base of independent and dependent variables. These are:

Ha1: Grade 9 students who are exposed to cooperative learning strategy interventions achieve higher biology mean achievement scores than those who are not exposed to cooperative learning method.

Ha2: Grade 9 students who are exposed to cooperative learning strategy interventions achieve higher biology mean achievement scores at different cognitive and psychomotor levels than those who are not exposed to cooperative learning method interventions.

Ho3: There is no statistically significant difference in biology mean achievement scores between grade 9 male and female students who are exposed to cooperative learning method interventions.

Ho4: There is no statistically significant difference in post-tests in biology mean achievement scores of grade 9 students who are exposed to and not exposed to successive post-interventions.

Significance of the Study

This study is instrumental to demonstrate the effects that interventions of cooperative learning strategy would have on secondary school students' academic performances and achievements in biology. Besides, itis capable to find out possible strategies to augment academic performances and achievements of secondary school students in biology by treating one variable and controlling the other variable. Likewise, it helps to provide strategies to department heads, instructors, technicians, and students themselves on how to improve academic performances and achievements. Besides, the findings of this investigation help the school management bodies to look at possible ways of shifting from lecture method to cooperative learning strategy to make learners construct their knowledge, skills and positive attitudes towards the application of this new paradigm in STEM subjects and help researchers as a source of information for further researches.

Methods

Research Design: Experimental research design with randomized control trials (RCTs) method was selected since a well-designed RCTs is seen as the gold standard for evidence-based educational practices and scientific research for measuring the impacts of an intervention (Styles, 2009; Torgersen and Chocks, 2014). Randomized control trials method helps the researcher to test the hypotheses to reach valid conclusions between independent and dependent variables (White, 2012). Hence, the schools in which cooperative learning strategy and lecture method were implemented were the intervening and control groups respectively. In comparison to the control group, the intervening one shows the

contact between implementers and recipients (Naylor *et al*., 2015) which was vital to ensure the effects of experiments on students learning outcomes. Accordingly, the sources of the data were the implementers (trained biology teachers) and grade 9 students to manage the treatment properly.

Sample Size and Sampling Techniques

The sample size of each target population was determined with the view that the ideal sample size of a target population is large enough to be selected economically in terms of both time and complexity and small enough to be manageable and specific for analysis (Best and Kahn, 1989). On the basis of this logic, appropriate sample was taken to measure the efficacy and effectiveness of outcomes of interventions by using the RCTs method.

Table1: Population and samples of the study

S/N	Categories	Samples of the study		
		Experimental School	Control School	Total Samples
1	No. of Schools	1	1	2
2	Biology teachers	5	5	10
3	Grade 9 Students	600	600	1200

Two secondary schools were taken from North Shewa Zone, Oromia Regional State, and randomly assigned as treatment-on school and comparison school in the 2018/2019 academic year. Accordingly, the total participants in the trials were 1200 grade 9 students (600 males and 600 females) and 10 biology teachers drawn from two secondary schools to teach experimental and control groups by using cooperative learning and lecture methods respectively. Hence, one school was randomly assigned for the treatment groups and the other for the control groups. Similarly, five biology teachers were linked to the experimental and five to the control groups to implement cooperative learning and lecture methods respectively. Besides, randomized control trial teachers were linked to the class before randomization (Torgersen and Cocks, 2013). This helps to prevent bias of estimation.

One secondary school (Abdisa Aga) was the experimental school while another (Gerbaguracha) was the control school. The intervening and control groups were those whose pre-test average mean scores were below and above the median scores respectively. Likewise, grade 9 students were selected assuming cooperative learning methods have been extended up to grade 12 and into all disciplines as Success for All (Slavinet al., 1996). This assures the welfares of cooperative learning method over competitive and individualistic lecture method in teaching science disciplines in secondary schools.

Data Collection Instruments

The instrument used for data collection was a biology achievement test (BAT) constructed by the researcher based on the biology topics taught by the traditional lecture method for pre-test and after teaching experimental and control groups by cooperative learning method and traditional lecture method respectively. The topics were cells, nutrition and digestion, breathing, cellular respiration and blood circulation in grade 9 biology. The validation of BAT was done by two experienced teachers of biological education, followed by a pilot test carried out on grade 9 students in a non-sample secondary school.

Data Collection Procedures

Ethics is a primary consideration in the research process, which tends to relate closely to the data collection, reporting, and distribution of reports (Creswell, 2012). Ethical approval or consent by concerned bodies was thus secured before entering a site. Following that, an experiment was carried out and data were collected on the bases of the permission and willingness of respondents. Finally, the respondents were thanked for their willingness to give genuine responses.

Besides, in this experimental research, the fidelity or adherence of implementers to the activities or intervention was evaluated based on the necessary literature (Odom *et al*., 2010). Five biology teachers were identified and trained on the application of cooperative learning (for the experimental groups) for one week while the other five biology teachers who taught the control groups used the lecture method. This indicates that teachers have direct contact with students in the teaching-learning process. A pre-test was carried out before randomization and any intervention. Then, the school with students who achieved a mean score below the median score was assigned as experimental school while the one with students who achieved a mean score above the median score was assigned as a control school. Then, a pilot test was carried on Biriti secondary school grade 9 students and the reliability coefficient between pre-test and post-test of BAT was calculated and found to be [$\alpha = 0.827$ (N=50)]; it was rated above 0.800 and the preparation of BAT and its external validity were accepted. This enabled the researcher and biology teachers to prepare BAT following a table of specification to address the cognitive, affective and psychomotor domains of learning. Finally, consecutive interventions were made for 12 weeks followed by post-tests until the experimental and control schools came to the end line (75).

Table 2: Mean of pre-test scores before randomization of schools

No. of Sample Schools	No. of Students			Mean	S.D	Median
	M	F	T			
2	600	600	1200	55.25	4.72	54.5

A pre-test was carried out on the topic "cells" which was taught using the traditional lecture method in the schools under investigation. The result in Table 2 indicates that the average mean score of students in both schools was 55.25 whereas the median was 54.5. Therefore, the school with students who scored below the median was assigned as an experimental school while the one with students who scored above the median was taken as a control school. From the above table, we understand that the baseline pre-equivalence test was 55.25, the midline was 65, and the end line was 75, at which the two schools reached the same level of mean score.

Data Management Method and Analysis

Mean, standard deviation, two-tailed t-test, and One-Way ANOVA were calculated using SPSS version 20 to analyze the data. Specifically, mean scores were used to categorize the experimental and control schools by using the median level. Two sample t-tests and One - Way - ANOVA were used to compare the two mean scores of the experimental and control schools, and male and female students' scores across the groups respectively.

Findings

In this section, the data were organized, analyzed and interpreted in line with the formulated hypotheses. Accordingly, the amount or dosage of intervention and how to carry out the intervention were determined by the researcher on the basis of suggestions provided in the literature (Moore *et al*., 2015). Based on this, five consecutive interventions were decided to be made for 12 weeks to record the effects of cooperative learning strategy on students' achievement through testing the formulated null hypotheses.

Ha1: Grade 9 students who are exposed to cooperative learning strategy interventions achieve higher biology mean scores than those who are not exposed to it.

Table 3: The mean difference between intervening and control groups

Groups	N	Post-test 1		Post-test 2		MD	T-value	T	DF	Sig (2-tailed)
		M	SD	M	SD					
Intervening Schools	600	55.25	1.99	65.41	2.88	10.16*	17	8.55	599	.000
Control Schools	600	55.25	1.68	55.89	2.56	0.64*			599	
Differences	0.00	0.00	0.31	9.52	0.33	10.52*				

Table 3 indicates that students in the experimental schools, who were taught using cooperative learning, achieved a mean of 65.41 with an achievement mean of 10.16 after three weeks' instruction on the topics, "nutrition and digestion" while

students in the control schools, who were taught using traditional lecture method, achieved a mean of 55.89 with mean achievement gains of 0.64 on the same topic. From the analysis, the t-value was [(599.599), t (17) = 8.55, p > 0.05]. The means of the two groups showed significant differences at 0.05 levels of significance. Thus, there is a statistically significant difference in BAT mean achievement between students who were taught using cooperative learning, on the one hand, and lecture method, on the other.

Table 4: The mean difference in achievement between intervening and control groups

Groups	N	Post-Test 2		Post-Test 3		MD	T-Value	T	DF	Sig (2-tailed)
		M	SD	M	SD					
Intervening Schools	600	65.41	1.57	71.59	1.89	6.18*	25	7.54	599	.002
Control Schools	600	55. 89	0.98	56.17	2.45	0.28*			599	
Differences	0.00	9.52	0.59	15.42	0.44	5.90*				

Table 4 indicates that students in the experimental schools, who were taught using cooperative learning, achieved an average mean of 71.59 with an achievement mean of 6.18 after two weeks of instruction on the topic, "breathing" while those in the control schools, who were taught using lecture method, achieved an average of 56.17 with mean achievement gains of 0.28 on the same topic. From the analysis, the test value was [(599,599), t (25) = 7.54, p > 0.05]. The means of the two groups show a statistically significant difference at 0.05 level. Therefore, Ho1was rejected and shifted to an alternative hypothesis. This remarks that there are significant differences in BAT mean achievement gains of students who were taught using cooperative learning and lecture methods. This the null hypothesis is shifted to an alternative hypothesis that remarks that there is statistically significant difference in BAT mean achievement gains of students who were taught using cooperative learning method over those who were taught using lecture method. This finding matches with the finding of Blase and Fixen (2013) which stated that understanding what makes a difference particularly in a complex intervention helps to ensure the achievement of intended learning outcomes.

Ha2: Grade 9 students who are exposed to cooperative learning strategy interventions achieve higher biology mean achievement scores at different cognitive and psychomotor levels than those who are not exposed to cooperative learning method.

Table 5: The differences on cognitive levels mean achievements between experimental and control groups

Groups	N	Post-Test 3		Post-Test 4		MD	T-Value	T	DF	Sig (2-tailed)
		M	SD	M	SD					
Intervening Schools	600	71.59	1.57	78.96	1.89	7. 37*	34	7.98	599	.000
Control Schools	600	56.17	1.38	57.19	1.63	1.02*			599	
Differences	0.00	15.42	0.21	21.77	0.26	6.35*				

Table 5 indicates that students in experimental schools who were taught using cooperative learning achieved a mean of 78.96 with an achievement mean of 7.37 after three weeks of instruction on the topic "cellular respiration" while those in control schools who were taught using lecture method achieved an average of 57.19with mean achievement gains of 1.02 on the same topic. From the analysis, the test value was [(599,599), t (34) = 7.98, p > 0.05]. The means the two groups showed a statistically significant differences at 0.05 level. This remarks that there are significant differences in BAT at cognitive levels with mean achievement gains of students who were taught using cooperative learning over those who were taught using lecture methods. In line with this finding, Tsaushu and Tal (2017) suggest that the instructional process is vital with the view of learning as a cognitive process takes place face-to-face among small heterogeneous groups and encourage their knowledge development activities through thinking and doing.

Table 6: The differences in mean achievements by levels of skills between experimental and control groups

Groups	N	Post-test 4		Post-test 5		MD	T - value	T	DF	Sig (2-tailed)
		M	SD	M	SD					
Intervening Schools	600	78.96	0.91	85.85	1.89	6.89*	28	9.81	599	.000
Control Schools	600	56.17	1.19	57. 01	0.95	0.84*			599	
Differences	0.00	19.92	0.72	28.84	0.94	5.81*				

Table 6 indicates that students in the experimental school who were taught using cooperative learning achieved an average mean of 85.85 with an achievement gain of 6.89 after three weeks instruction on the topics "blood circulation" while students in control school who were taught using the lecture method achieved an average of 57.01 with mean achievement gain of 0.84 on the same topic. From the analysis, the test value was [(599,599), t (288) = 9.71, p > 0.05]. The means of the two groups show a statistically significant difference at

0.05 level. Therefore, Ho2 was rejected and shifted to an alternative hypothesis. This remarks that there are significant differences in BAT at psychomotor level mean achievement gain by students who were taught using cooperative learning method compared to those who were taught using lecture method. This was in in imitation, manipulation and precision levels of skills. This is maintained by the finding of Tsaushu and Tal (2017) which states that deep learning is evidenced by the way students reflect on how they organize and apply knowledge through deep learning strategies such as cooperative learning, laboratory, etc.

Ho3: There is no statistically significant difference in biology mean achievement scores between grade 9 male and female students who are exposed to cooperative learning method interventions.

Table 7: Mean achievement scores between male and female students in experimental groups

Experimental Groups	N	Pre-test 1		Post-test		MD	T-value	T	DF	Sig (2-tailed)
		M	SD	M	SD					
Males	325	55.25	1.17	67.69	1.89	12.14*	29	11.23	324	.000
Females	275	55.25	1.09	65. 81	0.95	10. 26*			274	
Differences	50	0.00	0.08	1.88	0.94	5.81*				

Table-7 shows that male and female students in the experimental groups achieved a mean of 55.5 each in the pre-test but 67.69 and 65.81 in the post-test respectively after taking the lessons using cooperative learning method for three weeks. This respectively makes a mean difference of 12.14 and 10.26 respectively. The topic of the lesson was "breathing". From the table, we can see that the t-value was [(324, 274), t (29) = 11.23, $p > 0.05$]. The mean score of the two groups shows a significant difference at 0.05 levels. Therefore, Ho3 was rejected and shifted to an alternative hypothesis. This remarks that there was a significant difference in BAT mean achievement gains of female and male students who followed their instruction using cooperative learning.

Ho4: There is no statistically significant difference in post-tests in biology mean achievement scores of grade 9 students who are exposed to and not exposed to successive post-interventions.

Table 8: A Summary of One - way - ANOVA on BAT scores across the groups

Scores	Sum of Square	Df	Mean Square	F-Value	P-Value
Between groups	17972.500	3	5990.83	869.50	.000
Within groups	8247.84	1197	6.89		
Total	20220.33	1200			

Table 8 shows that [F (3, 1197) = 869.50, p < 0. 05] is significant. This is because 0.000 is less than 0.05 significant level set for the hypotheses. Hence, Ho4 is not accepted. There is a significant difference between the mean achievement scores of students taught using cooperative learning instructional strategy and those taught using lecture methods between groups and within groups. Therefore, the adaptation or incremental changes was observed on the practices of cooperative learning during the five consecutive interventions. In line with this, Naylor *et al*. (2015) suggest that adaptation is one dimension of intervention evaluation to measure changes in educational programs.

Discussion

The following major findings were identified from the study: These are:

1) The mean difference between the scores of the experimental group in the pre-test and post-test was due to the treatment effects. Experimental group students' mean score in the post-test was higher than their mean score in the pre-test most probably because of the cooperative learning interventions used to teach the group as opposed to the control group which was taught using the lecture method. This finding is consistent with five essential components systemically structured into the learning process to make cooperative learning successful (Johnson, Johnson and Holubec, 1993); positive interdependence, face-to-face promotive interaction, individual accountability, interpersonal and small group skills, and group processing.

2) Cooperative learning method interventions produced positive effects on students' academic achievement scores in the experimental schools. It enhanced higher academic achievement scores of students in biology at knowledge, comprehension and application levels compared to the lecture method. This finding is consistent with the findings by Dame (2006) who had found noted that in active learning procedures, students use their brains, studying ideas, solving problems and apply what they learn. Similarly, Girma and Feyera (2018) confirmed that student-centered pedagogy is instrumental to ensure excellence in the instructional system and an unquestionable method of teaching the young generation to develop the competencies required for the 21st century.

3) There are no significant differences in BAT mean achievement gains between female and male students taught using cooperative learning methods. A similar finding was reported by Johnson and Johnson (1989, 1999) who stated that cooperative group learning leads to improving students' performance and increases higher-order thinking skills of all students without differentiation.

4) The experimental groups performed better than the control groups due to peer-tutoring among the cooperating groups as opposed to the control group that did not cooperate to learn. These findings align with the findings of Bonwell and Elson (1991) who summarized that cooperative learning engages students in activities and creates a classroom environment that permits students ownership of the learning process. This, in turn, results in improved student performance as well as positive student attitudes towards the learning process.

5) There are direct relationships between the utilization of cooperative learning strategy interventions and students' academic outcomes. This indicates that the interventions achieved their efficacy and effectiveness of trials under optimal conditions. This is supported by Mohamed's (2008) finding which suggests that, in cooperative learning, students work together on problems in a small group working until all members of the group understand the problem and complete it.

Conclusions

The result of the study, similar to that of Pulac (2008), revealed that students taught using cooperative learning strategy performed better in BAT than those taught using the lecture method. The cooperative learning strategy interventions promoted high order thinking and academic achievement scores of secondary school students in biology as compared to the lecture method. The experimental group performed better than the control group due to peer tutoring among the co-operating groups that did not exist in the control group. Besides, the experimental group did better than the control group because members of the groups pooled their resources together to solve a common problem. The members who worked harder on the tasks, cooperated as much as possible to succeed and recognized the importance of cooperation improved their knowledge and skills while coaching or tutoring others. Therefore, cooperative learning strategy enhances conceptual understanding more than does the lecture method. However, there were no significant differences in academic achievement scores in biology due to gender and this approach is proper for both sexes. Hence, the directional alternative hypotheses No. 1 and 2, and the null hypothesis No. 3 were accepted, and the null hypothesis, No. 4 was rejected and rephrased. These are:

1) Ha1 (accepted): Grade 9 students who are exposed to cooperative learning strategy interventions achieve a higher mean score in biology than those who are not exposed to cooperative learning.
2) Ha2 (accepted): Grade 9 students exposed to cooperative learning strategy interventions achieve a higher mean score in biology at different cognitive and psychomotor levels than

those not exposed to the same learning strategy.

3) HO3 (accepted): There is no statistically significant difference in biology mean achievement scores between grade 9 male and female students who are exposed to cooperative learning strategy.
4) HO4 (rejected and rephrased)): There is no statistically significant difference in post-test biology mean scores between grade 9 students exposed to and not exposed to cooperative learning strategy.

Recommendations

- Based on the major findings of the study, the following recommendations are made. These are: cooperative learning educational interventions should be encouraged in schools in order to enhance the academic performance and achievement of students.
- Lack of taking responsibility and commitment are observed at different hierarchies to solve critical problems linked to the implementation of cooperative learning methods which would narrow down the gaps between theory and practices. Hence, biology curriculum designers should incorporate innovative pedagogical strategies into teacher education programs to enhance the applications of practical knowledge in classroom practices.
- Scholars in education should look for ways of encouraging students' participation by using models of cooperative learning strategy to address the principles of effective teaching and learning in biology. Hence, this study is an input that leads to critical pedagogical praxis.
- Biology teachers should be motivated to use cooperative learning strategies to improve their students' achievement in their subject. Besides, teacher education training programs should incorporate cooperative learning strategies in the form of workshops, conferences, and seminars. This ensures that sciences teachers are well-grounded on effective teaching-learning approaches to promote high order thinking and academic achievement of students in biology.
- Responsible bodies had better scale up this study to a larger-scale teaching strategy projects in STEM subjects such as biology, chemistry, physics, and mathematics.
- The practices of cooperative learning should be institutionalized through (3Rs); renewing, reforming and restructuring to help education leaders (supervisors and principals), teachers and students in the school system.

Policy Implications for Teaching Strategies in STEM Subjects

The evidence-based teaching strategies facilitate incremental changes and improvements in student performances and replicate best practices of applications of cooperative learning methods in curricular materials of natural sciences and mathematics. Therefore,

- Policy makers should emphasize learners hand-on and mind-on mathematical and sciences practical activities through cooperative learning strategy while designing sciences and mathematics curricular materials.
- Policy makers and school administrators should evaluate and redesign the use of time and school schedules to increase the opportunities to plan and learn practical sciences through collaboration, peer coaching and observations in classrooms and laboratories.

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