

# Cooperative learning as a strategy of improving mathematics performance and attitudes

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## ABSTRACT

There has been an increasing concerns that the traditional instructional methods militate against students' performance and positive attitudes towards school mathematics. This study employs cooperative learning strategy to provide an innovation as a way of ameliorating the canker. We utilised the quasi-experimental (prepost non-equivalent) design. In this design, two senior high schools selected. One school was the experimental (SHS A) and the other was the control (SHS B). A sample of 224 students were assigned to the experimental (110) and control (114) groups. After treatments, mathematics achievement tests were used to gather the data. The data was analysed with means, standard deviations, percentages, p-values and t-statistics. The outcomes revealed that students who had tutorials in the cooperative strategy performed better than those who had tuition through the traditional. Even within the experimental group, there was no statistically significance differences between boys and girls. It was concluded that students' performance and attitudes toward learning mathematics were positively enhanced by cooperative learning. It was therefore recommended that stakeholders make conscious efforts to inspire teachers to model more cooperative learning techniques in mathematics instruction.

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## INTRODUCTION

All over the world, new curricula seek to focus on task-based cooperative teaching and learning. Some of these are think-pair-share, team teaching, random selection and cooperative learning (Appiah, 2011; Carss, 2018; Lee, Li, & Shahrill, 2018; Ministry of Education, 2019; Moghaddam & Heidari, 2018). However, studies (Benning, & Agyei, 2016; Fletcher, 2018) suggest that these changes have not significantly improved upon the teaching and learning of mathematics. Two major reasons attributed to the abysmal learning outcomes are inadequate and/or little local content interactional-instructional models and low technological pedagogical content knowledge of teachers and students. This study seeks to fill these yawning gaps with cooperative learning method. In the cooperative learning, three interrelated theories have been proposed to beef their strengths and weaknesses. The quasi-experimental method has also been employed to test the method and infer its gender sensitivity. We also employed robust statistically analyses to link mathematics performance with students' attitudes and gender differences.

Bruner (1985) describes cooperative learning as a style of methodology where students with varying performance levels collaborate to accomplish a common objective. Collaborative learning is a teamwork that exhibits greater levels of reasoning and information retention than those who work independently (Ministry

of Education, 2020). In cooperative learning, students normally collaborate on a structured activity and are held personally accountable for both their own work and the group's overall performance. In recent times, this method has become a major pillar in teaching and learning of mathematics (Wyman, 2018).

A study of Edekor and Agbornu (2020) suggest that collaborative work arouses students' interest in learning, cultivates their ability to explore, think creatively, improves their collaborative spirit and develops their social communication skills. Assan-Donkoh et al. (2022) found that in an environment where competition is fierce and individualism is not encouraged, learners who ask their friends for assistance are frequently seen as weak or dumb. Assan-Donkoh et al. (2022) add that some students see themselves as being in the weaker bracket and are unwilling to collaborate with others. Edekor and Agbornu (2020) observe that the abysmal performance and low understanding in mathematical concepts can be attributed to the deployment of inappropriate instructional approaches.

### ***Intersubjective theoretical framework***

Intersubjectivity refers to shared understanding by various components of the theories (Sinclair et al, 2016). Subjectivity holds the notion that meaning is necessarily coloured by one's experiences and biases (Grant & Osanloo, 2014). This intersubjectivity recognizes that meaning is based on one's position of reference and is socially mediated through interactions (Bartolini Bussi & Mariotti, 2016). The main aim is to coordinate joint interactions of individual component's contributions towards a common goal (Ali, 2019). In this study, three interrelated theories have been intertwined to model the cooperative learning instructional methodology.

The first theory is the constructivist. The key proponents of constructivist theory are John Dewey, Jean Piaget, Lev Vygotsky and Jerome Bruner. The constructivist paradigm emphasized students' involvement in their own education. Students learn by building knowledge and sharing their experiences. In constructivism, learners actively develop their knowledge while working together with others to do so (AlMashjari, 2012). Cooperative learning is frequently used in constructivist teaching methods, assuming students would learn and understand concepts more easily if they talk to one another (Slavin, 2014).

The second theory is the cognitive learning theory. This theory suggests that learning is intrinsically driven and is dependent on the goals and objectives of the learner. In the view of Piaget, learners introduced to lectures lack the same brain stimulation as those involved in peer-mediated teaching. In the cognitive learning theory of Piaget, learners are placed at the center of their studies and can create new information based on previous experience. This theory suggests that learning is intrinsically driven and dependent on the goals and objectives of the learner. So learners who are introduced to lectures do not experience the same brain stimulation as compared to peer-mediated teaching. When students interact with their peers rather than adults, they can internalize and organize behavioral patterns more quickly (Piaget & Inhelder, 1969).

The third theory is the social interdependence or socio-cultural theory. The key proponents of this theory included Morton Deutsch, Kurt Lewin, Lev Vygotsky, David Johnson and Roger Johnson. Vygotsky (1978) proposed that there is a difference between what a learner can do without help and what he/she cannot do without help. Vygotsky holds the belief that, students' developments are linked to their social setting, particularly, learners could learn more on their own by collaborating with more capable adults (Assan-Donkoh et al., 2022). Students can advance by collaborating with peers in the Zone of Proximal Development model (Wyman, 2018).

### ***Empirical reviews of related studies***

Cooperative learning is a generally accepted pedagogy that fosters sociability and academic achievement across all grade levels and subjects (Gilles, 2016). Gilles (2014) opines that cooperative learning can be utilized to improve academic success in reading and writing, problem-solving in mathematics, and

higher-level thinking and reasoning. Assan-Donkoh et al. (2019) provide ample proof that cooperative learning is more effective than the traditional methods.

First and foremost, to determine the impact of cooperative learning practices on student engagement, Drakeford (2012) performed a study using several several-fold standards designs across two courses. It turned out that cooperative learning techniques increased the involvement of students in a classroom environment. Hossain and Termizi (2013), and Baloch and Brody (2017) compared the effect of cooperative learning on mathematics accomplishment and attitudes towards mathematics between boys and girls in the experimental group and it was established that there was equal performance between boys and girls after the implementation of cooperative learning. Hossain and Tarmizi (2013) showed the positive impact of cooperative learning on the attitudes of students toward mathematics. Thus, cooperative learning can be employed to increase students' performance in mathematics.

Secondly, Brandy (2013) also carried out a study in a high school. The study compared the performance of learners instructed using traditional methods with the performance of learners instructed using cooperative learning. Utilising descriptive statistical analysis and an experimental-control design, the finding of the research suggested that cooperative learning impacted more positively on the learners' accomplishments more than traditional instructional methods. Thus, cooperative learning increases the involvement and participation of learners yielding a good performance.

In addition, Mark-Mensah and Hanson (2018) investigated whether cooperative learning could improve test scores for upper primary pupils. The research used a quasi-experimental design and a mixed-method technique. The control and experimental groups both scored around the same on a pretest given to them at the outset which revealed that their entry-level was similar. However, the post-test results showed that the students performed well in the cooperative learning strategy (Mark-Mensah & Hanson, 2018).

Moreover, Wyman (2018) conducted to examine heterogeneous and homogeneous groups while employing a cooperative learning instruction structure. A quantitative, quasi-experimental study methodology was used. After analyzing the data using pair and independent sample t-tests, the result showed a substantial difference between the homogeneous and heterogeneous post-test scores. This simply means that grouping did not substantially impact the post-test scores for the two groups. Alcala, Garijo, Perez-Puoyo and Fernandez-Rio (2019) conducted a study on cooperative learning and students' motivation, social connections, and attitude from two different educational phases. The study adopted a mixed method. After subjecting the data from a post-test score on motivation, a p-value of 0.024 was obtained indicating a significant change in the student's motivation.

Furthermore, Edekor and Agbornu (2020) looked into how cooperative techniques affected junior high school pupils' mathematics performance. A quasi-experimental design was used in the investigation. The study found that regardless of ability level or gender, students performed better in cooperative learning classes than those instructed using traditional methods. After subjecting the data collected to analysis to provide answers to the research questions and to test the null hypothesis at a significant level of 0.05, statistical tools such as mean, standard deviation and analysis of covariance were used in the analysis. This implies that cooperative learning is an effective teaching technique and should be used to maximize learning.

More recently, Assan-Donkoh et al (2022) conducted an action research on how to apply a cooperative learning technique to increase the performance of high school students in mathematics. It was concluded that cooperative learning strategy had positively impacted on the academic accomplishment and interest of the learners. We therefore have sufficient evidence to show that cooperative learning is an asset to pedagogy.

### **Research objectives and questions**

The following research objectives guided the entire study:

1. To compare students' performance in mathematics using cooperative learning

2. To examine the effect of cooperative learning on students' attitudes towards mathematics.
3. To examine gender differences in cooperative learning in mathematics

Consequently, the following research questions served as the basis for this study's design:

1. What effect does cooperative learning have on students' performance in mathematics?
2. What effect does cooperative learning have on students' attitudes towards mathematics?
3. What difference does cooperative learning have on students' attitudes towards mathematics?

The following hypotheses address the Research Question 3.

1.  $H_{01}$ : There is no statistically significant difference between the mean performance scores of cooperative learning and traditional methods.
2.  $H_{02}$ : There is no statistically significant difference between the mean performance scores of boys and girls taught using the cooperative learning method.

## METHODS

### *Scope of research*

This study concerns pedagogical methods for mathematics learning in the senior high school. The right pedagogy is the Cooperative Learning. It was employed on crucial mathematics domains on students in senior high schools. The main scope are students' performance, attitudes and gender differences. The composition of the students were segregated into male and female students.

### *Research design*

The quasi-experimental approach was employed. The quasi-experimental design was preferred based on the fact that it was more appropriate and as it falls within positivism (Waghmare, 2021). This arose from students' prior knowledge in simultaneous linear equations, plane geometry and probability. The reason was that high school students are normally put into specific classes based on their programmes. This called for the use of intact groups in order not to disorganize the classes. To demonstrate cause and effect, the experimental design with pre-test and post-test approaches was much more ideal (Mark-Mensah, San & Honson, 2018).

In the quasi-experimental approach, the key aim was to establish cause and effect. Since the quasi-experimental design permitted comparisons between the experimental and control groups, measurement of the dependent variable, and the use of inferential statistics, it was found very suitable for the study. In this design, the classes that received training using traditional methods made up the control group, whereas those using the cooperative method assume the role of the experimental group (Creswell & Creswell, 2018).

### *Data collection and data analysis*

All year two students from two senior high schools made up the targeted population. These students were targeted because year one students were on break at the time and year two students were writing their final external examinations conducted by the West African Senior School Certificate Examination (WASSCE). Four mathematics teachers were recruited to assist in the treatment phases. The sample constituted two classes drawn using convenient sampling from each school. A sample size of 224 students was drawn using the Krejcie and Morgan table (Bukhari, 2020).

**Table 1.** Distribution of Participants in the Experimental and Control Groups

Sample	Experimental group (SHS A)	Control group (SHS B)
Boys	63	60
Girls	47	54
Total	110	114

The distribution of sampled participants in the experimental and control groups is also shown in Table 1. The two selected schools were both category C schools implying that the students exhibited similar characteristics and abilities. For anonymity reasons, the researchers preferred to refer to the schools as SHS A and SHS B. Purposive sampling was used to assign intact classes to the two groups; one serving as an experimental group and the other as a control group (Bukhari, 2020).

The treatment lasted for eight weeks. The first six weeks were for the treatments, which were specifically based on the scope of the selected topics in the senior high school mathematics syllabus. The final two weeks were for the group presentation on topics taught, and revision. Each period lasted for 1 hour and each week had four periods for each class. After each lesson, the students were made to complete an assignment.

### **Research instruments**

A mathematics achievement test with 40 multiple-choice questions was employed as a pre-test. A second mathematics achievement test with the same weight on the same topics was administered after the treatment and labelled as a post-test. Both the pre-test and post-test were conducted with the same procedures for the control and experimental groups. The goal of the mathematics achievement test was to evaluate students' knowledge, comprehension, and application of mathematics cognitive domains. These domains were simultaneous linear equations in two variables, statistics and plane geometry.

The questions were in line with international examinations standards and serialized to ensure independent work by students. Objective test question serialization is the process of testing students with the same set of questions. However, the students have their questions numbered differently. For instance, student A may have question number 1 numbered 20 for student B, and question 40 for student C. The purpose of the serialization was to reduce copying. This method also helped in ensuring validity and reliability as well.

In addition, the items were partitioned into demographic information, effects of cooperative learning on the performance of students on selected topics in mathematics and effects of cooperative learning on students' attitudes towards learning mathematics. A five-point Likert scale items were restructured for the effects of cooperative learning, personally to help improve the response rate, a day after the post-test. The five points on the likert scale were *strongly agree* (SA), *agree* (A), *neutral* (N), *disagree* (D) and *strongly disagree* (DA). The weights of these points were 5, 4, 3, 2 and 1 respectively, for positive statements. For negative statements, the weights of these points were 1, 2, 3, 4 and 5 respectively (i.e. the responses received the value points in the opposite order). The items were made simple, clear, unambiguous and reader-friendly.

### **Pilot test of instruments**

The research instruments were piloted in a third school that was not part of the research but belonged to the same category as the two schools selected. Fifty-two students participated in pilot test. A group of 30 students with mixed abilities was drawn from the 52 students and the treatment was administered to them for two weeks. A mixture of think-pair-share, group investigation, and learning-together strategies was used during the pilot test stage. The instruments were guaranteed their functionality. We eliminated any threat to their validity and reliability.

### **Reliability and validity of research instruments**

The appropriateness of an instrument provided information on the instrument's level of accuracy in measuring the things for which it was made. Experts in test construction were consulted during the construction of the mathematics achievement test and questionnaire on the selected topics to ensure both

content and face validity. With the aid of professionals, threats to both internal and external validity were eliminated.

Reliability shows how consistent an instrument is when evaluated over time. The research instruments were pilot-tested in a third school that was not part of the study. The respondents were made to answer and re-answer as test and re-test procedures. During the test and re-test processes, Pearson Product Moment Correlation was employed to compare the two sets of responses. A reliability coefficient of 0.8974 was obtained. This indicated that a good positive agreement between the two sets of test scores. The mathematics achievement test was scored out of 40 marks.

### **Research procedure**

As part of research procedures, the researchers delivered an introductory letters to the participating schools. The heads gave us formal authorization to conduct the study in their schools. The researchers were then introduced to the participating students of the various classes on the first day and followed by a brief explanation of the whole program. Two instructors from the two schools assisted in the treatment and data collection procedures. Students were allowed a one week period to revise the topics to put them in readiness for the test. The pre-test findings demonstrated that the two schools were comparable and that any changes in the students' performance following the treatment should be attributed to the treatment itself and not to any pre-existing differences.

**Table 2.** Determination of differences between mean scores of groups

Groups	Test	Mean	Standard Deviation	t-value	p-value
Experimental group	Pre-test	17.22	5.54	1.2666	0.2067
Control group	Pre-test	16.37	4.42		

On Table 2, the means of the experimental and the control groups were 17.22 (SD = 5.54) and 16.37 (SD = 4.42) respectively, and with a p-value of 0.2067. It was evident that the mean scores for the two groups did not statistically differ significantly. This means students from the two schools entered into the treatment with equal ability. So, any differences in mean performance scores after treatment should be attributed to the treatment itself.

### **Treatment stage**

The control group received traditional approaches. The traditional method relied heavily on the lecture, demonstration, and questions-and-answers methods for most of the introductory part of the lessons. It employed the demonstration and the questions and answers methods during the main lesson deliveries. Class assignments and exercises were completed individualised. Lesson plans or manuals were prepared and followed accordingly.

The experimental group received cooperative learning strategies. The cooperative learning class adapted multiple strategies including a think-pair-share, group investigation, jigsaw, and learning together. The experimental group's students were seen collaborating in teams of four to six members. A distinct function was given to each group member, and they were all urged to make constructive contributions to their work. Each lesson had a plan or a manual to ensure the flow of the lesson was orderly in scope. Although most often, students were seen completing assignments in groups, they were also ranked independently depending on their contributions to the group work and completed some class exercises and test independently. This ensured individual accountability.

### **Analysis of data**

Various statistical tools were used to analyze the data collected. On one instance, descriptive statistics such as percentages, mean, and standard deviation were employed. On another instance, inferential statistics

such as paired sample t- test and independent sample t-test were used. The outcomes of the research were reported based on the already developed research questions (Bukhari, 2020).

## RESULTS AND DISCUSSION

**Research question 1:** What effect does cooperative learning have on students' performance in mathematics?

The test results acquired before and after the intervention— were utilised to answer research question 1. The outcomes of the paired sample t-test are displayed on the following tables.

**Table 3.** Mean score difference within control group

Group compared	Test	Mean	Standard Deviation	t-statistics	p-value
Control group	Pre-test	16.37	4.42	-5.0403	0.0000
Control group	Post-test	19.35	4.52		

Table 3 shows the analysis of the null hypothesis  $H_{01}$ . It was evident that cooperative learning significantly impacted on students' performance in mathematics. However, indicated on Table 2 that students in both groups performed creditably well in the post-test than they did in their respective pre-test when pair t-Test analyses were conducted.

**Table 4.** Mean score difference within experimental group

Groups compared	test	mean	standard deviation	t-statistics	p-value
Experimental group	Pre-test	17.22	5.54	-21.5133	0.0000
Experimental group	Post-test	25.14	5.56		

On Table 4, a sample paired t-Test analysis of pre-test ( $M = 17.22$  and  $SD = 5.54$ ) and post-test ( $M = 25.14$  and  $SD = 5.56$ ) scores of students in the experimental group showed  $t$ -statistics = -21.5133 and  $p = 0.0000$ . The  $p$ -value of 0.0000 indicated that there was a significant difference in mean performance scores of students' pre-test and post-test favoring the latter. To determine the extent of significant difference existing between the pre-test scores and the post-test scores, there was the need to calculate for their effect sizes.

The effect size was used to determine how large the difference existing between the experimental group and the control group, an effect size based on the mean comparison, and unequal variances revealed Hedges'  $g = 0.8568815$ , indicating a large difference. Hedges'  $g$  was the appropriate measure for two groups of different sample sizes and also of different standard deviations. This signifies that the students taught using cooperative learning approaches had a better understanding of the topics selected for the study than their counterparts exposed to the traditional instructional approaches (Bukhari, 2020).

**Research question 2.** What effect does cooperative learning have on students' attitudes towards mathematics?

The following statements were used to analysed this research question using frequency and percentages.

**Table 5.** Effects of cooperative learning on students' attitudes

Statement	SA (%)	A (%)	N (%)	D (%)	SD (%)
Cooperative learning can improve my attitude.	43(39.1)	56(50.9)	4(3.6)	7(6.4)	0(0.0)
I prefer to work on my own rather than in a group.	9(8.2)	9(8.2)	12(10.9)	60(54.5)	20(18.2)
I would be more comfortable in more group activities	52(47.3)	38(34.5)	11(10.0)	3(2.7)	6(5.5)
CL enhances good working relationships.	54(49.1)	48(43.7)	0(0.0)	4(3.6)	4(3.6)
I would prefer if teachers use more group activities/assignments.	53(48.2)	45(40.9)	6(5.5)	4(3.6)	2(1.8)

Table 5 shows that the effect of cooperative learning on students' attitudes toward the learning of mathematics. The results indicated that 99 students representing 90%, 80 representing 72.7%, 90 representing 81.8%, 102 representing 92.7% and 98 representing 89% responded positively to the statements, "Cooperative learning can improve my attitude towards work", "I prefer to work on my own rather than in a group", "I would be more comfortable if more group activities were incorporated into mathematics class", "Cooperative learning enhances good working relationships among students" and "I would prefer if teachers use more group activities/assignments" respectively.

On the other hand, Table 5 shows that 7 students representing 6.4%, 18 representing 16.4%, 9 representing 8.2%, 8 students representing 7.3%, and 6 students representing 5.5% responded negatively to the statement "Cooperative learning can improve my attitude towards work", "I prefer to work on my own rather than in a group", "I would be more comfortable if more group activities were incorporated into mathematics class", "Cooperative learning enhances good working relationships among students" and "I would prefer if teachers use more group activities/assignments" respectively.

A combined percentage shows that 85.3% of the students responded positively, and only 8.7% of the students responded negatively. However, 6% of the students remained undecided. This implied that cooperative learning had significant favorable effects on the attitudes of students towards the learning of mathematics which agreed largely with Edekor and Agbornu (2020).

**Research question 3:** What difference does cooperative learning have on students' attitudes towards mathematics?

The following hypotheses address the Research Question 3.

**Testing of hypothesis  $H_{01}$ :** What There is no statistically significant difference between the mean performance scores of cooperative learning and traditional methods.

We sought to determine whether there was a statistically significant difference between the experimental group and the control groups after the treatment.

**Table 6.** Mean score difference between experimental and control groups

Groups compared	Test	Mean	Standard Deviation	t-statistics	p-value
Experimental group	Post-test	25.14	5.56	8.5272	0.0000
Control group	Post-test	19.35	4.52		

On Table 6, an independent t-Test analysis of post-test scores of students in the experimental group ( $M = 25.14$  and  $SD = 5.56$ ) and the control group ( $M = 19.35$  and  $SD = 4.52$ ) showed  $t$ -statistics = 8.5272 and  $p = 0.0000$ . The null hypothesis ( $H_{01}$ ) was rejected. Accordingly, there was a significant difference between the performance of the experimental group and the control group. The findings imply that the significant impacts of cooperative learning were responsible for the improvement in the experimental group's post-test mean mathematics scores over their counterparts in the control group.

**Table 7.** Magnitude of effect for the treatments

Group	Pre-Test( $M_1$ )	Post-Test( $M_2$ )	$M_2 - M_1$	Cohen's d
Experimental Group	17.22(5.54)	25.14(5.56)	7.92	1.42
Control Group	16.37(4.42)	19.35(4.52)	2.98	0.67

On Table 7, the independent t-test analysis revealed the experimental group ( $M = 17.22$  and  $SD = 5.54$ ) and the control group ( $M = 16.37$  and  $SD = 4.42$ ). The  $t$ -statistics = 1.2666 and  $p = 0.2067$  indicated that



there was no statistically significant difference in performance between experimental and control groups in the pre-test. This implies that the two groups had the same entry ability.

Cohen's  $d$ , which is suited for measuring effect sizes when two groups with the same sample size or one group's before and after-treatment behaviors are involved, was the preferred method among those used to determine effect sizes. The results of Cohen's  $d$  showed that the effect size for the experimental group was larger than the effect size of the control group. An effect size based on the mean comparison, Cohen's  $d=1.42$  was obtained for the experimental group and 0.67 for the control group. This indicated that the difference was large. This means using cooperative learning strategies has greater effect on students' achievement as compared to using the traditional strategies. The implication is that, cooperative learning strategies have a significantly positive impact on the performance of students in mathematics.

**Testing of hypothesis  $H_{02}$ :** There is no statistically significant difference between the mean performance scores of boys and girls taught using the cooperative learning method.

**Table 8.** Mean score difference for boys and girls in the experimental group

Group compared	Test	Mean	Standard Deviation	$t$ -statistics	$p$ -values
Experimental Boys	Post-test	25.68	6.03	1.1942	0.2350
Experimental Girls	Post-test	24.40	4.84		

On Table 8, the performance of boys and girls who were taught mathematics utilizing the cooperative learning method was compared using an independent-sample  $t$ -test. Table 8 below shows that the mean performance scores from the post-test of the experimental group for boys ( $M= 25.68$ ,  $SD= 6.03$ ) and girls ( $M= 24.40$ ,  $SD= 4.84$ ) were compared. The  $t$ -statistics = 1.1942 with  $p= 0.2350$  showed that there was no statistically significant difference in the post-test mathematics performance scores of boys and girls in the experimental group. The outcomes showed that after implementing cooperative learning strategies, the mathematics performance of boys and girls in the experimental group was equal. The findings also agree with Assan-Donkoh et al. (2019) that cooperative learning is more effective than the traditional methods.

## Discussion

### *Effect of cooperative learning on students' performance in mathematics*

The results have shown that cooperative learning is one of the temporary strategies of improving performance and changing students' attitudes towards mathematics. The results were in consonance with Hossain and Tarmizi (2013) who investigated the impact of cooperative learning on students' mathematics achievement and attitudes towards mathematics. Hossain and Tarmizi (2013) equally utilized an independent sample test to examine data while employing a quasi-experimental design. The results revealed that students' mathematics achievement were significantly impacted by cooperative learning. In deed, students do benefit from the implementation of cooperative learning to raise their mathematics performance.

In addition, the results supported the findings of Mark-Mensah and Hanson (2018) investigated the use of cooperative learning to improve upper primary students' performance. The study used a mixed-method strategy and a quasi-experimental methodology. The post-test findings showed that students who had been using cooperative learning strategy had high academic achievement at the end of the programme. This is an excellent demonstration that the effectiveness of cooperative learning strategies relies on paired or group modeling work.

Moreover, the results of Tables 2, 3 and 4 went in line with Wyman (2018) findings of heterogeneous and homogeneous groups in employing a cooperative learning instruction. In the quasi-experimental groups, statistics on the pair and independent sample  $t$ -tests showed statistically significant differences between the groups. Even though Alcala, Garijo, Perez-Puoyo and Fernandez-Rio (2019) study on cooperative learning

adjudged students' motivation as the most important, the social connections, peer tutoring and collective outputs yielded a better learning outcomes.

#### *Effect of cooperative learning on students' attitudes towards mathematics*

Appiah-Twumasi et al. (2020) demonstrated that the cooperative learning technique was the most successful technique for improving students' attitudes toward physics. Once more, the implication is that cooperative learning procedures foster more favorable feelings and views about the educational experience than competitive or individualistic ones. The findings showed that just 28% of students believed that class was fascinating when conventional teaching methods were used. However, the number increased to 86% when cooperative learning strategies were employed. Hossain and Tarmizi (2013) offered ample proofs that cooperative learning was beneficial for studying mathematics than any other subject.

The findings also comply the studies of of Edekor and Agbornu (2020), and Assan-Donkoh et al. (2022) who discovered that collaborative work arouses students' interest to learn mathematics, evokes their curiosity to explore, creates freidnldy environment and deppens their social netwroks. Assan-Donkoh et al. (2022) alluded to the fact that competitive environment, challenging group tasks and naturally assertive class encourage learners to learn mathematics. In doing so, the students develop positive attitudes and willing to collaborate with peers, teachers and other stakeholders in the larning mileua.

Again, the findings aligns with many studies (Appiah, 2011; Carss, 2018; Karali & Aydemir, 2018; Lee, Li, & Shahrill, 2018; Ministry of Education, 2019; Moghaddam & Heidari, 2018)) on the impact of cooperative learning on students' attitudes and mathematics proficiency. The results on Tables 5, 6 and 7 evidently epitomizes students who have wholeheartedly followed and understood the tenets of cooperative learning. All statistics favoured the experimental group. The results of the control suggested that students who do not utilise cooperative learning strategy perform low.

#### *Gender differences in ooperative learning*

Findings from the analysis of the first hypothesis indicated that cooperative learning significantly affects students' performance in mathematics. After the treatments were implemented, students in both the experimental group and the control group showed improvements in their mathematics performance. But the findings showed that the experimental group's students had more pronounced improvement than their colleagues in the control group. The findings imply that the experimental group's post-test mean mathematics performance scores improved as a result of the significant effects of cooperative learning.

Also, the findings from the analysis of the second hypothesis indicated that there was no significant difference in the performance of boys and girls in the post-test. This findings was supported by Hossain and Termizi (2013) who similarly compared the effects of cooperative learning on mathematics achievement and attitudes between boys and girls in the experimental group. They equally discovered that once cooperative learning was implemented, boys and girls performed on par with each other.

In both hypotheses, there were ample evidence that gender does not differ in cooperative learning (Table 8). Thus, both boys and girls really engaged in the exercises, tasks and problems posed to them in both experimental and control groups. These findings are in tandem with Gambari and Yusuf (2014) who discovered no discernible differences in the experimental group's performance between boys and girls. This means gender did not influence performance in cooperative learning settings. Edekor and Agbornu (2020) equally revealed that discovered that gender has no bearing on a student's performance when a cooperative learning technique is used.

Gilles (2016) discovered that cooperative learning is generally accepted because the method builds sociability and academic achievement across all grade levels, subjects and genders. The method comes with reading, writing and problem-solving in mathematics. As a result, the student does not only work concentrate on numerate domains but also literacy areas (Assan-Donkoh et al., 2019). The students get

involved and actively participate in the learning and teaching process. Thus, cooperative learning should be employed to propel and support students' performance in mathematics.

## CONCLUSION

First, the outcome of the research suggested that cooperative learning strategies had positive effects on the achievements of students performance in mathematics. The improved performance of the students was attributed to the utilisation of the cooperative learning method.

Second, the findings have also showed that cooperative learning has impacted positively on the attitudes of students towards mathematics. The positive attitudes of the students towards mathematics was effective and efficient support of the cooperative learning method.

Also, the first hypothesis showed that students who were taught using cooperative learning methods outperformed their counterparts in the traditional methods groups. The second hypothesis revealed that boys and girls performed similarly after the experimental group treatment, with no obvious differences. This means cooperative learning method does not discriminate based on gender or any other observed differences in students. This makes it a universally acceptable method for all students irrespective of any differences.

It was therefore recommended that stakeholders make conscious and pragmatic efforts to inspire students and teachers to model cooperative learning techniques in mathematics instruction.

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