The Effect of Cooperative Learning on Students' Performance in Trigonometry: A Case Study of Mukuba Boys Secondary School, Kitwe, Zambia

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***Abstract:*-Trigonometry is a very important topic in mathematics education. Trigonometric functions have many applications in fields such as adverse physics, mechanical and electrical engineering, music, astronomy and biology. This study investigates the effect of Cooperative Learning specifically the Jigsaw on students' performance in trigonometry at Mukuba Boys Secondary School and explores the following Research Questions: (a) What effect does Cooperative Learning (Jigsaw) have on students' performance in Trigonometry? (b) What are the students' perceptions toward learning of trigonometry using the Cooperative Learning Approach? (c) What are the challenges that students face in trigonometry using Cooperative learning (Jigsaw) vis-à-vis conventional method? The design of the study was pre-test post-test control quasi-experimental design which involves two grade 11 classes. One was assigned experimental group and the other control. The sample for the study consisted of 60 students of which 30 students were in each group. The experimental group was taught using cooperative learning approach while the control group was taught using conventional learning. A pre-test was used to establish the equivalence and homogeneity of the two groups in academic ability whereas a post-test was used to assess the effect of cooperative learning on student's performance in trigonometry. The study compares the means of scores between experimental and control groups and an independent sample t-test was used to analyse the data at an alpha level of 0.05. In the pretest, comparison results did not show any statistical significance between the two groups. The post-test comparison results showed that there was a statistical significance of p-value$= 0.000 < 0.05, t(58) = 4.138$in favour of the experimental group. Furthermore, results of the study indicated that the cooperative learning approach had a positive effect on enhancing students' performance and perception toward trigonometry. The main challenges encountered by students when learning trigonometry were lack of understanding of the concepts. It was also noticed that cooperative learning group were more engaged, more responsible in completing group assignments while working in their respective groups. Therefore, cooperative learning approach was found to have had a positive effect on students' performance in trigonometry. The study recommended that cooperative learning techniques are well integrated with heuristic approaches in order to enhance involvement of students in classroom interaction and participation in the teaching and learning of trigonometry and the use and implementation of cooperative learning strategies should be embrace by teachers in order to develop variety of instructional method that best befits the learning needs of their students.**

Key words: **Jigsaw, Cooperative Learning Approach, Performance, Trigonometry.**

I. BACKGROUND OF THE STUDY

In Zambia and the rest of the world, greater emphasis has been placed on science and technology. Mathematics is one subject that cut deep across all the sciences and technology. Mathematics would equip the students to live in the modern age of science and technology and enable the learners to contribute to the social and economic development of the country and the world at large. As the country matches toward scientific and technological advancement, there is a need to focus the attention on a good performance in mathematics at all levels of schooling. The only setback is that Zambia has continued to rank as one of the lowest in the mathematics and science assessment performance in Southern Africa (https://www.lusakatime.com). The study conducted by the Southern and Eastern African Consortium for Monitoring Education Quality (SACMEQ) which aimed at testing learners' mathematical and reading skills in fifteen Southern and Eastern African countries, ranked Zambian students as the worst in mathematics and reading skills (SACMEQ, 2018). A number of examination analysis reports have also revealed that the performance of students in mathematics at the end of secondary education has not improved in the past years substantially (ECZ, 2013, 2014, 2017).

There are several factors affecting the performance of mathematics of students and one among these factors is the ineffectiveness of instructional strategies that some mathematics teachers are using in their classrooms. According to the Ministry of General Education, the poor performance of Zambia in mathematics can be attributed to a lack of interest by teachers to apply strategic and conceptual teaching methodologies in their lesson plans (Ministry of Education, 2018).

Over the years, in Zambia, different teaching strategies have been used in an attempt to redeem the poor performance of mathematics in secondary school but mathematics still poses a challenge to many students despite the revised curriculum.

According to ECZ (2017), topic like trigonometry in ordinary level mathematics has been reported to be challenging to most of the students even in the past years. The challenge of this topic has been reflecting in a poor performance in mathematics along the years among students at grade 12 examination results. The fact that students have continued to face challenges in this topic but much has not been done to improve performance on this topic, Hence, calls for serious interventions in order to improve the performance of the results at in mathematics grade 12 examinations. It is against this background that this study was carried out with the aim of assessing the effect of Cooperative Learning Approach on student's performance in trigonometry at Mukuba Boys Secondary School.

II. DATA PRESENTATION AND ANALYSIS

2.0 Introduction

This chapter presents the findings, analysis and interprets of the data collected from the respondents that are the experimental and the control group. It highlights how the collected data from the respondents by means of a questionnaire, pre-test, and post-test were presented analysed and manipulated to answer the research questions.The purpose of this study was to ascertain the effect of Cooperative learning (Jigsaw) on students' performance in trigonometry. The study also determined whether the teaching method influences the perception of students' towards a topic or subject.

Descriptive statistics relates to student's performance in trigonometry before and after the treatment were measured using trigonometry performance tests that are the pre-test and post-test. Students' perception of learning trigonometry using cooperative learning approach after treatment was obtained by a Likert-type questionnaire. Descriptive statistics results of trigonometry performance tests and the inferential statistics results for testing the one null hypothesis are presented in this chapter. The results are based on trigonometry test data from 60 students and a Likert-type attitude questionnaire data from 30 students in an experimental group from grade eleven students at Mukuba Boys Secondary School. The sequence of the presentation of the results or research findings is in accordance with the research questions and research hypothesis.

2.1 Pre-tests for the experimental and control group

The study was the quasi-experimental pre-post-test control group research design. The quasi- experimental design compared a control group using conventional teaching method with an experimental group using Cooperative Learning. The independent variable was the teaching strategy of Cooperative learning namely Jigsaw and the dependent variable was students' performance. Participants in the research study consisted of sixty (60) grade eleven (11) students who were purposively selected. Two-grade eleven classes (11P and 11S) were selected and assigned to be the experimental and control group respectively. Each class comprised of 30 students.

At the beginning of the research study, both the experimental and control group were pre-tested with the prerequisite topics of trigonometry. The pre-test allows the researcher to assess whether the groups are equivalent before the treatment is given to the experimental group. The coverage of the pre-test was the prerequisites of trigonometry that is Pythagoras Theorem, angles of the triangle, and area of a triangle. The results or performance scores for pre-test was used to determine if there was any difference in terms of academic ability at the beginning of the study between the two groups.

2.1.1 Test for normality

The score obtained from the performance pre-test from both groups were first tested for normality. This was done to check if the scores were normally distributed and help the researcher on which statistical test to be used. There are several methods of assessing whether data is normally distributed or not. But they all fall into two broad categories; graphical and statistical. According to Pallant (2007), one of the methods used to test if the scores are normally distributed is the Shapiro-Wilk test. Shapiro-Wilk is one of the statistical tests for normality that calculate the probability that the sample was drawn from a normal population. This test for normality is based on the correlation between the data and the corresponding normal scores. Table 2.1.1 and figure 2.1.1. shows the results of the test of normality for the pre-test for both groups.

Hypothesis

$\boldsymbol{H_0}$**:** The sample data is normally distributed.

$\boldsymbol{H_1}$**:** The sample data is not normally distributed.

Table 2.1.1: Tests of normality for pre-tests for both groups (N=60)

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
PERFORMANCE	.141	60	.005	.971	60	.155

a. Lilliefors Significance Correction

Similarly, figure 2.1.1 shows the graphical results of the test of normality for the pre-test for both groups namely the experimental and control group.

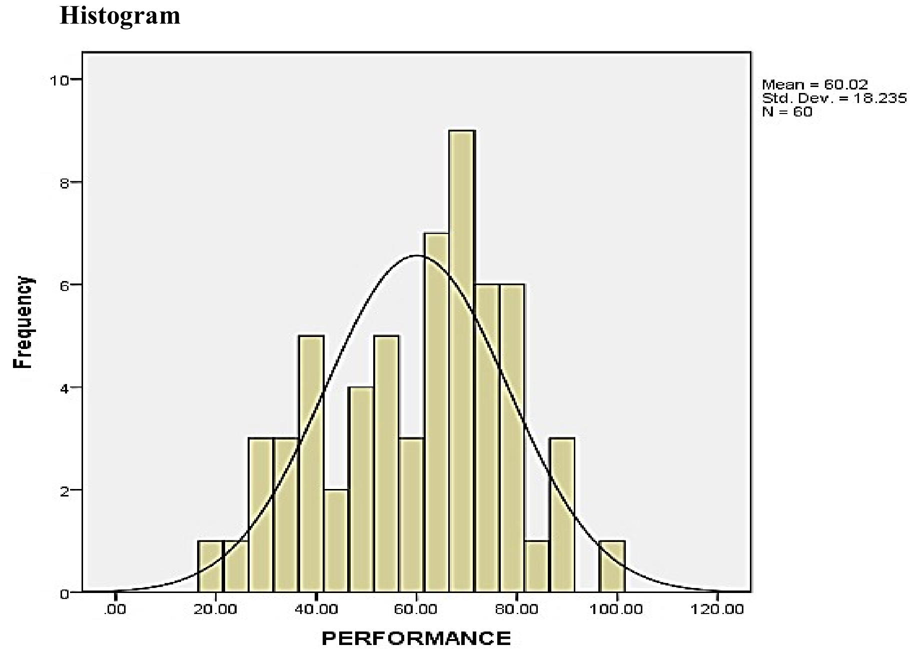

Figure 2.1.1: Pre-test test of normality (n=60)

Table 2.1.1 and figure 2.1.1 show the statistical and graphical results of the test of normality for the pre-test for both groups respectively. The number of the participants on the pre-test was 60; the mean score is 60.02 and standard deviation 18.235, the histogram in figure 2.1.1 graphically confirms that results are normally distributed. On the other hand, table 2.1.1 shows the result after running the Shapiro-Wilk test. From the table 2.1.1 of the test of normality, the p-value of the pre-test is 0.155 which is greater than the set alpha of 0.05, we fail to reject H_0since the p-value$= 0.155 > 0.05$ and conclude that the sample data is normally distributed. Since the data for the two groups were normally distributed, an independent samples t-test was used to analyse the data.

2.1.2 Independent sample t-test for the pre-test scores

According to Sherri (2009), an independent samples t-test is a parametric statistical test that is used to compare the means of two different groups. In other words, an independent sample t-test compares the means between two unrelated groups on the same continuous dependent variable. The independent sample t-test is a powerful test used on data that is parametric and normally distributed. The results of this statistical test entail whether the means of two groups are statistically different from one other. An independent samples t-test was therefore conducted on pre-test scores before the intervention to determine whether the average performance of students' in the two groups is statistically significantly different or not. Table 2.1.2 shows the results of the independent sample t-test of the pre-test done on the experimental and control group before the intervention.

Table 2.1.2: Descriptive Statistic for the Pre-Test Performance of the Experimental and Control group (N=60)

	Group	N	Mean	Std. Deviation	Std. Error Mean
Performance	Experimental	30	59.8333	19.48489	3.55744
	Control	30	60.2000	17.22748	3.14529

In the Descriptive Statistics in Table 2.1.2, the mean score for the experimental group was 59.8333. The mean score for the control group was 60.2000. The standard deviation for the experimental group was 19.48489 and 17.22748 for the control group. The number of participants in the control group was 30 whereas in the experimental group was 30 as well. Table 2.1.2 further showed that from the mean score the control group (60.2000) performed significantly better than the experimental group (56.8333). This indicates the non-equality of the two groups in terms of performance. However, an explanation based on average scores for the two groups were not enough to suggest that both the experimental and control group were not equal in terms of academic ability at the beginning of the study.

However, to substantiate the statistically significant difference in terms of performance, conducting independent sample t-test, the explanations on the non- equality of the two groups was based on the Levene's test, the p-value approach, and the t-test for equality of means was done.

2.1.3 The Levene's test for Equality of Variance the Pre-test Scores

Levene's test is an inferential statistic used to assess the equality of variances in different samples. It provides a test of one of the assumptions of the t-test that is the condition of homogeneity of variance. It also helps to decide on what p-value is to be used. The p-value is the probability level at which the test statistic would be statistically significant. From the Levene's test if the probability of the p- value is greater than 0.05 which is the set alpha, then the equal variance is assumed. If the probability of the p- value is less than or equal to 0.05, then the variances in the groups being compared are different, thus, the condition of homogeneity of variance has not been satisfied. If this assumption is violated in the data, then a statistical adjustment needs to be made. In this case, the output in the equal variances not assumed row will be used for the evaluation of the t-test statistic which will be based on an adjusted degree of freedom. Table 2.1.3 shows the results of a Levene's test for homogeneity of error variances done on the pre-test score for the experimental and control group.

Table 2.1.3: Analysis Independent Sample T-test for the Pre-Test Performance (N=60)

	Levene's Test		t-test for Equality of Means						
								95% Confidence	
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	.710	.403	-.077	58	.977	-.36667	4.74850	-9.87182	9.13849
Equal variances not assumed			-.077	57.143	.977	-.36667	4.74850	-9.87486	9.143152

From Table 2.1.3 above the p-value of the pre-test for the equality of variances was 0.403. This p-value is greater than the alpha value set at 0.05. Since the p-value $= 0.403 > 0.05$ and we can conclude that the variances for the experimental group and control group were equal, and therefore the output in the equal variances assumed row was used.

To determine if the difference in mean performance in table 2.1.3 between the experimental group and control group is statistically significant, the columns labeled t-test for equality of means from the independent sample t-test in table 2.1.3 was used. Using t-test for equality of means, since the p-value$=$ $0.939 > 0.05$, this result clearly indicates that there was no statistically significant difference in mean performance between the experimental group and control group. Therefore we can conclude that the mean for the experimental group and the mean for the control group were the same. Thus the two groups were equal in terms of academic ability at the beginning of the study. This made the researcher proceed with the intervention of integration cooperative learning approach namely jigsaw in the teaching and learning trigonometry.

2.2 Post-test for the Experimental and Control group

2.2.1 Research Question One: What effect Cooperative Learning has on students' Performance in Trigonometry?

The post-test was administered to the experimental and control groups after the intervention. Both groups were taught trigonometry, but the experimental group was taught using cooperative learning which is the treatment, while the control group was taught using conventional learning method. During this process, the two groups covered the same concepts in the period of four weeks respectively. The content coverage for both groups included introduction to trigonometry, trigonometric ratios, sine and cosine rules, area of a triangle (CDC, 2013).

After the topic was entirely covered, post-test was administered to both groups at the same time and under the same conditions. The post-test of trigonometry was developed to assess the student's conceptual knowledge and meaningful understanding of trigonometry. The questionnaire was used for the experimental in the post-test. The scores obtained by the students in the tests were used as a measure of their performance in trigonometry. The scores obtained are here presented and analysed in stages. The scores achieved by students in the trigonometry test at the end of the study and were summarised in table 2.2.1 and table 2.2.2 using the frequency stem and leaf plots.

Table 2.2.1: Post-Test performance scores Stem and Leaf plot for the Experimental group (N=30)

Frequency	Stem	& Leaf
2	Extremes	(=<20)
4	4	0469
5	5	03577
8	6	00056689
6	7	012258
3	8	038
2	9	28
Stem width:	10.00	
Each leaf:	1 case(s)	

On the otherhand table 2.2.2 shows the post-test performance scores for the control group.

Table 2.2.2: Post-Test performance scores Stem and Leaf plot for the Control group (N=30)

Frequency	Stem &	Leaf
1	0	7
3	1	569
3	2	278
5	3	13578
7	4	1447799
5	5	03367
4	6	0257
2	7	04
Stem width:	10.00	
Each leaf:	1 case(s)	

From Table 2.2.1 and 2.2.2 results showed that students who were exposed to jigsaw method of cooperative learning performed better in the post-test than learners in the control group who were taught using conventional learning strategy. For instance, only 6 students got scores below average that is less than 50% in the experimental group compared to 16 students in the control group. However, the data in Table 4.2.1 and Table 2.2.2 can easily be understood using statistical analysis. In order to compare the performance scores from the post-test using a statistical analysis, the scores were first tested for normality to check if the post-test scores were normally distributed. Results of test for normality are stated in Table 2.2.3 and figure 2.2.3.

Hypothesis

$\boldsymbol{H_0}$**:** The sample data is normally distributed.

$\boldsymbol{H_1}$**:** The sample data is not normally distributed.

Table 2.2.3: Tests of Normality for Post-Test for both groups

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
PERFORMANCE	.065	60	.200*	.986	60	.710

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Similarly, figure 2.2.3 shows the graphical results of the test of normality for the post-test for both groups namely the experimental and control group.

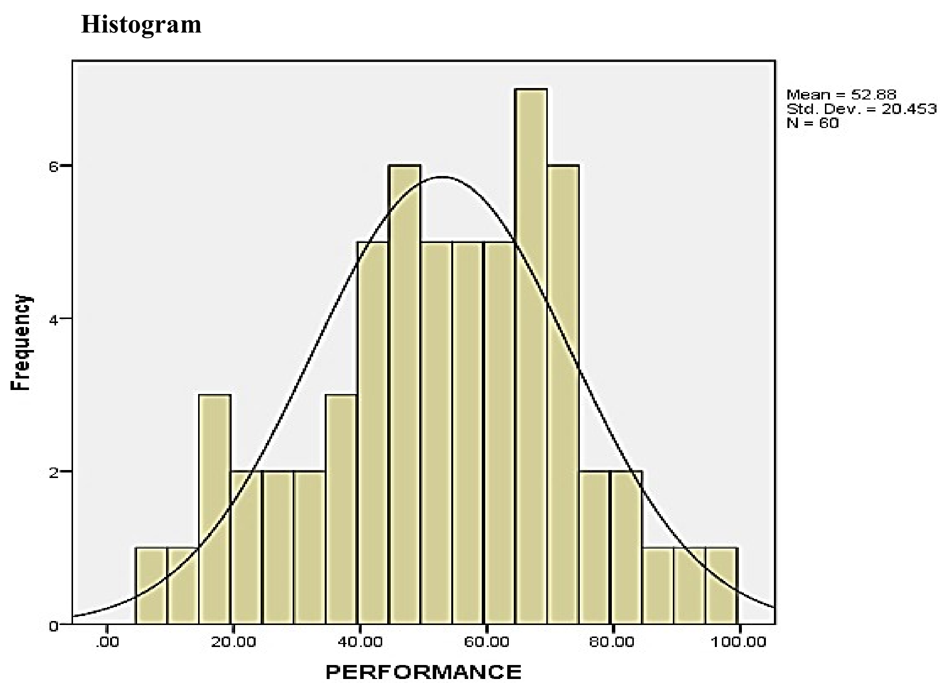

Figure 2.2.3: Post-Test test for normality for both groups (N=60)

Table 2.2.3 and figure 2.2.3 shows the statistical and graphical results of the test of normality for the pre-test for both groups respectively. The number of the participants on the pre-test was 60; the mean score is 52.88 and standard deviation 20.453, the histogram in figure 2.2.3 graphically confirms that results are normally distributed. On the other hand, table 2.2.3 shows the result after running the Shapiro-Wilk test. From the table 2.2.3 of the test of normality, the p-value of the post-test is 0.710 which is greater than the set alpha of 0.05, hence we fail to reject $\mathrm{H_0}$since the p-value$= 0.710 > 0.05$ and conclude that the sample data the post-test results was normally distributed with p-value = $0.710 > 0.05$.

Since the post-test data for the two groups were normally distributed, an independent samples t-test was used to analyse the data.

2.3 Comparing the Post-Test Performance of the Experimental and Control Group

This section attempts to answer the research question, "*What effect does Cooperative Learning have on Students' Performance in Trigonometry."* In order to determine the effect of cooperative learning (Jigsaw) on students' performance in trigonometry, an independent sample t-test was carried out. The results of the descriptive statistics analysis are stated in Table 2.3.1.

Table 2.3.1: Descriptive Statistics for the Post-Test Performance of the Experimental and Control group (N=60).

	Group	N	Mean	Std. Deviation	Std. Error Mean
Performance	Experimental	30	62.5667	18.80697	3.43367
	Control	30	43.2000	17.41858	3.18018

According to descriptive statistic Table 2.3.1, the mean score for the experimental group was 62.5667. The mean score for the control group was 43.2000. The standard deviation for the experimental group was 18.80697 and 17.41858 for the control group. The number of participants in the control group was 30 whereas in the experimental group was 30 as well. Table 2.3.1 further showed that from the mean score the experimental group (62.5667) performed significantly better than the control group (43.2000). This indicates the non-equality of the two groups in terms of performance. However, an explanation based on average scores for the two groups were not enough to suggest that both the experimental and control group were not equal in terms of performance at the end of the study.

However, to substantiate the statistically significant difference in terms of performance, conducting independent sample t-test, the explanations on the non- equality of the two groups was based on the Levene's test, the p-value approach, and the t-test for equality of means was done.

2.4 Independent Sample t-test for the Post-Test Scores

This section attempts to answer the research hypothesis "**$\mathbf{H_0}$:** *There is no statistically significant difference in performance in trigonometry between students who were taught using Cooperative Learning Approach and Conventional methods."* The result of the research hypothesis is presented in Table 2.4.1.

Table 2.4.1: Analysis Independent Sample T-test for the Post-Test Performance (N=60)

	Levene's Test		t-test for Equality of Means						
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence	
								Lower	Upper
Equal variances assumed	.000	.988	4.138	58	.000	19.36667	4.68013	9.99836	28.73497
Equal variances not assumed			4.138	57.662	.000	19.36667	4.680123	9.99720	28.73614

Table 2.4.1 presents the results of the analysis conducted on the effect of cooperative learning (Jigsaw) on students' performance in trigonometry. From Table 2.4.1 the p-value for the equality of variances was 0.000. This p-value is less than the alpha value set at 0.05. Since the p-value$= 0.988 > 0.05$, hence, we can conclude that the variances for the experimental group and control group were equal.

In order to determine whether there is a statistically significant difference between the experimental and control group in mean performance, the columns labeled t-test for equality of means from the independent sample t-test in table 2.4.1 was used. Using t-test for equality of means, since the p-value$= 0.000 < 0.05$, this result clearly reveals that there is statistically significant difference in mean performance between the experimental and control group (p-value$= 0.000 < 0.05, t(58) = 4.138$). The revelation means that we reject$\mathrm{H_0}$and conclude that there was a statistically significant difference in performance in trigonometry between students who were taught using Cooperative Learning approach and conventional learning approach**.** This result means that statistically significant difference exists in the mean scores of the experimental and control group. The experimental group performed significantly better in the post-test (mean of 62.5667) than the control group (mean of 42.2000). These results suggested that cooperative learning has the capacity to improve students' academic performance. In addition, cooperative learning improves students' performance through jigsaw strategies, and consequently the experimental group received better scores. Also, it can be seen through the result that cooperative learning helped the students better understand the content of trigonometry.

2.5 Experimental Group on Students' Perception toward Learning Trigonometry through Cooperative Learning.

2.5.1 Research Question Two: What are the Students' Perceptions toward learning of Trigonometry using the Cooperative Learning Approach?

The study sought to establish the perception of students toward the learning of trigonometry using Cooperative learning namely Jigsaw. Perception of students toward learning trigonometry using Cooperative learning was collected from the experimental group after the intervention. Perceptions were measured through a questionnaire which consisted of eight items that was answered on a 5-point Likert Scale and three open-ended questions. The respondents were asked to rate the statement on the scale of 1 to 5; (1: Strongly Disagree, 2: Disagree; 3: Uncertain, 4: Agree, 5: Strongly Agree) to determine the extent to which they agree or disagree with the statements. Means for the factors were established in order to provide a generalized feeling of all the respondents. Means less than 1.5 implied that the respondents strongly disagreed with the statements on perception; means greater than 1.5 and less than 2.5 implied that the respondents disagreed with the statements. Means greater than 2.5 and less than 3.5 implied that the respondents were uncertain with the statements. Means greater than 3.5 and less than 4.5 implied that the respondents agreed with the statements; while means greater than 4.5 implied that the respondents strongly agreed with the statements. A standard deviation of 1 indicates that the responses are further spread out, greater than 0.5 and less than 1, indicates that the responses are moderately distributed, while less than 0.5 indicates that they are concentrated around the mean. A standard deviation of more than 1 indicates that there is no consensus on the responses obtained. The results are indicated in the Table 2.5.1 below.

Table 2.5.1 Item by item frequency distribution for the questionnaire responses (N=30).

	SA[5]	A[4]	U [3]	D[2]	SD[1]	M	Std
Trigonometry is difficult, involving and too abstract.	70%	23.3%		6.7%		4.7	0.9
Cooperative learning helped me understand and develop interest in trigonometry.	89.7%	13.3%				4.9	0.8
Through Cooperative learning members of the group were all active at every point of interaction and could report the findings.	56.75%	30%	3.3%	10%		3.4	1.2
Cooperative learning makes me express options, argue, debate and ask questions.	63.3%	36.7%				4.6	0.8
Through cooperative learning I feel a strong sense of belonging to my class.	30%	50%	6.7%	13.3%		3.8	1.1
The teacher valued students thinking than incorrect answers.	16.7%	63.3%	6.7%	13.3%		3.2	1.0
Trigonometric language was easier to understand through cooperative learning.	50%	40%		10%		3.1	1.1
Cooperative learning helped me to improve my result in trigonometry.	60%	23.3%		16.7%		4.1	0.9

- Blank spaces means a frequency of zero (0%)

Key: SA= Strongly Agree, A= Agree, U= Uncertain, D= Disagree, SD= Strongly Disagree, M= Mean, Std= Standard Deviation

Table 4.5.1 shows the mean and standard deviation for each of the subsidiary variable regarding students' perceptions towards learning of trigonometry using cooperative learning approach. The results showed that the mean ranged from 3.1 to 4.9 and the standard deviation ranged from 0.8 to 1.2.

The deviation of the responses from the mean rating was fairly small as evident by some of the standard deviations in each case. To some extent, this warrants a higher confidence level that the responses obtained are a true reflection of reality.

On averagethe research findings in table 2.5.1 revealed that the respondents agreed that trigonometry was a difficult and abstract topic of mathematics, and that Cooperative learning helped them to understand and develop interest in trigonometry. Cooperative learning made them express opinions, argue, debate and asked questions. It was through cooperative learning where they felt a strong sense of belonging to their class; Cooperative learning helped them to improve their results in trigonometry as evidently seen at 4.7, 4.9, 4.6, 3.8 and 4.1 respectively.The table further showed that when teachers used appropriate teaching aids,students understood the concepts better which must be encouraged. Hence, this indicates that students' perception towards learning of trigonometry using cooperative learning (Jigsaw) was positive.

However the respondents were uncertain on whether members of the group were all active at every point of interaction and could report the finding; the teacher valued students thinking than incorrect answers; andtrigonometric language was easier to understand through cooperative learningas noted at 3.4, 3.2, and 3.1 respectively.

2.6 Challenges Students Faced in Trigonometry using Cooperative Learning vis-à-vis Conventional Method.

2.6.1 Research Question Three: What Challenges Students face in Trigonometry using Cooperative Learning vis-à-vis Conventional Method?

The study sought to find out the challenges encountered by students in the learning of trigonometry. One of the research questions was to determine the challenges students faced in trigonometry. The challenges were observed through the written trigonometry test from 60 students in both groups (experimental and control). This was done after the post- test was administered. The table 2.6.1 shows the summary of the challenges that the students were experiencing during the learning of trigonometry

Table 2.6.1: The distribution of challenges students faced in trigonometry (N=60)

Challenges		**Cooperative Learning**	**Conventional Method**	**Overall percentage**
Trigonometry ratio	Identifying the trigonometry ratio	5%	8.3%	13.3%
Sine rule	Finding the angle using the formula	3.3%	6.7%	10%
Cosine rule	Finding the angle using the formula	8.4%	11.6%	20%
Area	1. Finding the area using trigonometry where the base and height are not known. 2. Finding the shortest distance using the formula of the area.	3.3% 5%	6.7% 8.3%	*23.3%*
Calculator	Using the calculator to find the inverse of a trigonometric function.	*5.1%*	*8.3%*	*13.4%*
Angles of elevation and depression	1. Finding the angle of elevation 2. Finding the angle of depression	*4.0%* *4.3%*	*5.8%* *5.9%*	*20%*

The table 2.6.1 shows the challenges experienced by students in cooperative learning vis-à-vis conventional learning groups while learning trigonometry. It has been revealed that 8.3% and 11.7% of learners from cooperative and conventional respectively had difficulties in solving problems involving angles of elevation and depression. Sine rule were challenging to 3.3% of cooperative learners and 6.7% were a challenge to conventional group. 8.4% of cooperative learners and 11.6% of conventional students had challenges with problem – solving questions involving cosine rule. Students who had challenges with finding the area using trigonometry were 8.3% for cooperative students and 15% for conventional students, while on the other hand 5.1% and 8.3 of the students had challenges relating to the use of calculators in the cooperative and conventional groups respectively. In the same vain, the research found out that 5% of the students had challenges with solving trigonometric ratios using the triangle in cooperative group, while 8.3% of the students in conventional students who took part in the research revealed that they had challenges with solving trigonometry ratios using the triangle.

III. DISCUSSION ON THE FINDINGS

Introduction

This chapter has endeavoured to discuss the findings on the subject of the effect of Cooperative Learning Approach on student's performance in trigonometry at Mukuba Boys Secondary School in Kitwe. The findings have been presented in the previous chapter. Overall and above, the findings seem to suggest strongly that there is need for education sector to explore more avenues of teaching and learning trigonometry, as most of the subject matter anchors on trigonometry. So in this chapter, in discussing the findings of the research, the chapter has been guided by the following pertinent study questions:

- What effect does Cooperative Learning have on students' performance in trigonometry?
- What are the students' perceptions toward learning of trigonometry using the Cooperative Learning Approach?
- What are the challenges that students face in trigonometry using cooperative learning vis-à-vis conventional method?

3.1 Effect of Cooperative Learning on the Performance of Students in Trigonometry

The effect of cooperative learning on the performance of students in trigonometry has come from the pre-test and post-test mean scores. A comparative study has revealed that before students were exposed to jigsaw cooperative learning approach, the mean score was 60.02 and 59 for control group and experimental group respectively. The results in the mean score fall in the same normality as it has been observed from table 2.1.1.1 and figure 2.1.1.1. After exposing students to cooperative learning approach, the mean score for the students swung from 60.02 to 43.2000 and 59 to 62.5667 for students in control group and experimental group respectively. This change that has come as a result of the treatment in the mean score after inducing cooperative learning approach to students is the effect that can be attributed to jigsaw cooperative learning approach. Thus to that extent, it is not erroneous to state that jigsaw cooperative learning approach has the capacity to improve the performance of students in trigonometry. Thus, Jigsaw cooperative learning approach has positive effect on the performance of students in trigonometry.Mbacho and Githua (2013) also agree with the proposition that jigsaw cooperative learning has positive effect on the learning of students. Students who learnt mathematics through the Jigsaw cooperative learning strategy performed significantly better than those who were taught through the conventional or traditional teaching methods. The assertion further also confirms what Burns` (1984) alluded to, that jigsaw cooperative learning approach results in higher achievement of students as students engage in challenging tasks in their expert groups with enthusiasm and anxiety because they know they have to convey the discovered information when they get back to their respective home groups. In short, cooperative learning approach is a necessity in order for students to develop a variety of problem solving techniques, explore new possibilities and transform the learnt lessons for better use now and in a life ahead of them in their respective communities at various times.

3.2 Students' Perceptions toward Learning of Trigonometry using Cooperative Learning Approach

The perception of students toward learning of trigonometry using cooperative learning approach was derived from the questionnaires given to students. The findings from the questionnaires by 30 students were answered in the experimental group were faithfully recorded in tables 4.5.1 and 4.5.2 as shown in the previous chapter.

The findings showed that 70% of the students strongly agreed that trigonometry was difficult, involving and too abstract while 2 students representing 6.7% of the 30 students asked disagreed to trigonometry being difficult, involving and too abstract. This is in line with the findings of Gur (2009), who also observed that trigonometry is an area of mathematics that students believe to be difficult and abstract compared with the other subjects of mathematics. An area where very few students liked and succeed at, as a result unfortunately most students hate and struggle with trigonometry. The results of the study by Gur revealed that most errors committed by students irrespective of the method used are transformation errors and process skills errors. To that effect, Gur recommended that, teachers who are facilitators of the teaching–learning process should encourage the students to concentrate on one point at a time and proceed stepwise in a logical manner to reduce attendant difficulty faced in trigonometry. Furthermore, teacher should make trigonometry lessons exciting by encouraging group work (jigsaw cooperative learning approach) with frequent activity-based demonstrations so as to demystify the difficulty encountered in problems involving trigonometry as our findings reveal that 86.7% of the students agreed that cooperative learning approach helped students to understand trigonometry better (confer table 2.5.1). The findings discovered that students should be given enough time as 56.7% of students in our study felt more students were active and 63.3% participated (talked) more. In short, Usman and Hussaini (2009) concludes it nicely that opportunities to do regular problem exercises should be given to students in order to assist them practice and increase their reasoning skills.

3.3 Challenges Students face in Learning Trigonometry using Cooperative Learning Approach Vis-à-vis Convention Learning.

As educators, learners and other stake holders, there is room for everyone concerned to look at challenges that students are facing in trigonometry using cooperative learning approach for an appropriate solution to come by. Table 2.6.1 highlights the challenges students face in learning trigonometry using cooperative learning approach vis-à-vis conventional learning approach. 13.3% of the students had challenges on trigonometric ratios using right angle triangles comprising of 5% and 8.3% from cooperative learning and conventional learning respectively, with 10% and 20% having challenges solving trigonometric questions using the sine and cosine rule formula respectively summing up to 30%. 23.3% had challenges finding the area in trigonometry and surprisingly in this computer era 13.4% of the students had challenges solving trigonometric questions using a calculator. These challenges are not just unique to this research according to Kagenyi (2016), 21% had challenges with the terminologies used, 79% had challenges with trigonometric ratios, and again 79% had challenges with solving problems involving sine and cosine rules. The findings on calculators were consistent with other findings, in that our findings revealed that 13.4% had challenges using a calculator while Kagenyi found that 71% had challenges with solving problems using logarithms and calculators. The paradox lies in the fact that in this computer era when one would easily assume that most people are conversant with modern technological advancements, one does not expect students to be having much challenges with calculators, more so that almost everything is computer related. This suggests that more needs to be done in order to integrate computer world in mathematics, in this way, it would help a lot in making mathematics more friendly and familiar.

The emphasis by teachers on Mnemonics of acronym SOHCAHTOA to students does more damage because students do not learn the skill but instead just memorises these acronyms. The right way (solution) to this challenge of mnemonics would be teachers emphasising on the prerequisite topics such as Pythagoras Theorem so as to build up a strong mathematical foundation where trigonometry could be laid. The findings of a research done by Liew and Wan Muhammad (1991) pointed out that emphasis on algorithmic skills at the expense of the principle explanations of the concept has contributed greatly to the difficulties that students face in learning trigonometry which evidently shows itself in poor examination results in mathematics. Teachers should aim at educating the whole individual student not just helping one to pass the examinations, because there is life after even the examinations.

Clearly, table 4.6.1 indicates that most of the students had challenges with problem-solving questions relating to the application of trigonometry concepts and sine and cosine rule representing 10% and 20% respectively.The challenges could be attributed to students in most cases memorizing formulas but failing to move to the level of applying such formulas to the day-to-day living.

Taking the sum totalnumber of challenges faced in each group, it was noted that students from cooperative learning grouphad 38.4 % of the total challenges while students from conventional learning group encountered66.6%. Over and above, one thing that is succinctly clear is that students in the conventional learning group had more challenges as compared to students in cooperative learning group who encountered fewer problems. Through cooperative learning, the development of the concept and methods in trigonometry was developed thereby helping students create and build up the fundamental principles of the topic. The findings have shown that Trigonometry just like any other Mathematics topic is properly discussed in depth in smaller groups, taking to account principles of development of concepts and methods of trigonometry; the teacher as the overseer has to recapitulate the topic for the whole class, in this way the hints would be easy comprehended by students themselves (Orhun, 2015).

Looking at the above pertinent findings on the effects, perceptions and challenges of students learning program experience, jigsaw cooperative learning strategy remains very interesting, since it is highly interactive in nature. And in substance students actively learn in such a manner that triggers students to become more responsible with their learning programme (Baird & White, 1984). The strategy encourages students to take their education in the hands as the main drivers of their destiny promoting a sense of responsibility. Thus, in order to fully perfect the strategy, there is need to pay attention to the effects, perceptions and challenges as experienced by students. Once attention has been paid involving many stakeholders as possible to these key areas, correct remedy may be found that would be correct and effective to the daily needs and precipitates. Among other things, the relevance of education is in it being responsive to the current needs of the society. Good education must provide solutions to the daily problems, or else education risk being irrelevant to society.

IV. CONCLUSION AND RECOMMENDATION

Introduction

After an intensive study on *the Effect of Cooperative Learning Approach on student's performance in Trigonometry: A case study of Mukuba Secondary School of Kitwe District.* The researcher in this chapter has taken a step further by looking at the conclusion emanating from the findings and results observed during the research, and recommendations made to that effect.

Conclusion

Modernity entails modern challenges thus a new way of handling the unlike situation is foreseen as a must. There is need for educationists and other related agencies to revolutionise education system as a way of answering to the current and foreseeable future challenges. Jigsaw cooperative approach tries to fill in the gaps as demanded by the current quest for an effective learning approach in comparison to the conventional way of teaching and learning. Jigsaw cooperative approach has not only produced positive results as an educational tool to teach and learn trigonometry as noticed in this study; but the latent resultant observed by the researcher is that the tool could be used to reduce or eradicate misconceptions and prejudice by both students and teachers as they mingle and learn from each other. When members in their small groups interact, prejudices and misconceptions are washed away and reduced while members learn to trust and respect others. Members come to appreciate the fact that the success and downfall of the group depends entirely on individual members in the group. In this era where the world is demanding education to be friendly, interactive, trusting the fact that no person is a *tabula rasa* but that every member is vital and has a lot to offer, thus, cooperative learning is a way to go to a modern student. As such, banking method in education in this era cannot work as pupils and the teacher ought to cooperate mutually together and among themselves to achieve educational objectives(Freire, 1970).This means that cooperative learning might be the answer to modern quest for an effective education approach. Mathematics hematic being a discipline with integrated and hierarchical concepts and skills, there is need for an integrated and spiral approach to be used using the Zambian mathematics syllabus. Nonetheless, Cooperative learning approach is not a flawless approach just like any other strategy; hence the views of students on some grey areas (challenges) that need attention must be pondered upon in a view to improve on them.

Recommendations

According to this study, it is recommended that:

1. Teachers need to ensure that cooperative learning-oriented techniques are well integrated with heuristic approaches in order to make the teaching and learning of trigonometry stimulating to the motivating students thereby participating in the lesson more fully. The classroom activities should be reduced from practice exercises emphasizing mechanical drill to inquiry activities requiring more time on cooperative learning.
2. The teachers should make more use of teaching aids such as drawing of charts; make sure that students have basic instructional resources such as geometrical sets, graph books and calculators in order to create interest during the learning process of trigonometry concepts such as drawing of graphs.
3. There is also need to encourage teachers to embrace and sharpen cooperative learning skills through in-service trainings of serving teachers through educative forays such as CPD meetings. These meetings will help teachers develop a variety of instructional media that best befits the learning needs of their students such a media will enhance involvement of students in classroom interaction and participation in trigonometry teaching and learning. Efforts should be made to encourage mathematics teachers understand and appreciate the role of teaching media in teaching and learning process.
4. The ministry of education through free subsidized secondary education programme should incorporate provision of Information Computer Technology instructional resources such as computers, projectors, markers, white boards, etc., the programme that will meet the modern student at the point of need. This will help to maintain the quality and quantity of the modern instructional resources in our secondary schools that to our modern demands.
5. The improvement on the way ECZ produces the examination analysis, so that the analysis report may include analysis of each and every question of the particular subject that was in the examination paper. This analysis should be made public as a way to help teachers and curriculum developers on which specific topics need attention and the remedial measures that needs to be undertaken to prevent different students repeating same mistakes along the years.

REFERENCES

[1]. Abdulkadir, T., (2013). *A Conceptual Analysis of the Knowledge of Prospective Mathematics Teachers about Degree and Radian*, Turkey: Kastamonu University Press.

[2]. Baird, J. and White, R. (1984) *Improving Learning through Enhanced Metacognition: A Classroom Study*, Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA 1984.

[3]. Banda, G., & Musonda, A. (2018). *Effect of Cooperative Learning on Students' Attitude and Performance towards Probability Distributions*. In Statistics, Journal of Educationand Practice. ISSN 2222-1735 (Paper) ISSN 2222-288X (Online) Vol.9, No.14.

[4]. Victor J. K. (2009) *A History of Mathematics.* 3rd Edition. USA: Pearson Publishers.

[5]. Vygotsky, L. (1978) *Mind in the Society*. Cambridge, MA: Harvard University Press.

[6]. Weber, K., (2005) *Students' Understanding of Trigonometric Functions.* In Mathematics Education Research Journal, Vol. 17(3), pp. 91-112, October 2005. Netherlands: Springer Australasia.

[7]. World Education (2009) *Cooperative Learning: Theory and Practice: Schools for Life Program.* Boston: World Education, Inc.

[8]. Yasemin, K, Seda, O and Bilge, O (2013).*Effects of Cooperative Learning Model on Science Technology Laboratory Practices Lesson*. In International Journal on New Trends in Education and their Implication. October 2013 Volume: 4 Issue: 4 Article:04 ISSN1309-6249.

[9]. Victor J. K. (2009) *A History of Mathematics.* 3rd Edition. USA: Pearson Publishers.

[10]. Vygotsky, L. (1978) *Mind in the Society*. Cambridge, MA: Harvard University Press.

[11]. Weber, K., (2005) *Students' Understanding of Trigonometric Functions.* In Mathematics Education Research Journal, Vol. 17(3), pp. 91-112, October 2005. Netherlands: Springer Australasia.

[12]. World Education (2009) *Cooperative Learning: Theory and Practice: Schools for Life Program.* Boston: World Education, Inc.

[13]. Yasemin, K, Seda, O and Bilge, O (2013).*Effects of Cooperative Learning Model on Science Technology Laboratory Practices Lesson*. In International Journal on New Trends in Education and their Implication. October 2013 Volume: 4 Issue: 4 Article:04 ISSN1309-6249.