An Investigation of the Difference in Performance in Geometry Between Students Taught Using the Cooperative Instructional Method and Those Taught Using the Conventional Instructional Method

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ABSTRACT

Cooperative instructional method is heuristic and mainly learner-centred involving student team learning while Conventional instructional method is expository and teacher-centred. The objective of the study was to investigate the difference in Geometry performance between students taught using the Cooperative instructional method and those taught using the Conventional instructional method. A quasi-experimental design was used. The target population was students and teachers from secondary schools in Meru County, Kenya. Purposive sampling was used to arrive at a sample of six (6) secondary schools, two (2) for boys only, two (2) for girls only, and two (2) co-educational schools. The sampled schools were grouped into two, a control group and an experimental group. The data collection instruments were pre- and post- Geometry Achievement Tests (GAT). To ensure validity of the instruments senior examiners and Mathematics educators in the County reviewed the pre- and post-tests. Quantitative data was analysed using Version 27 of the Statistical Package for Social Science (SPSS) thereby generating graphs, analysis Tables and frequency charts for inferential and descriptive statistical analysis. The results showed that there is a difference in Geometry performance between students taught using the Cooperative instructional method and those taught using the Conventional instructional method. The hypothesis was examined with a significance level set at $\alpha = .05$. The mean score for the control group was 26.27 and a standard deviation of 10.926 which differed significantly from those in the experimental group, which had a mean score of 74.02 and a standard deviation of 12.495. The results indicated a significant statistical difference ($t(195) = -28.493$, $p < .05$) between the two groups. From the results it is concluded that using the Cooperative instruction method leads to improved students' performance in Geometry. It is suggested that secondary schools Mathematics teachers should use Cooperative instructional method in secondary schools as a way of enhancing students' performance in Geometry.

Keywords: Cooperative instructional method, Kenya, Geometry performance, Social constructivism

INTRODUCTION

Mathematics serves as the foundation of all fields of knowledge as it enhances mental discipline, encourages logical reasoning, and fosters mental rigor (Kamil & Acharyulu, 2020). Implementing practical methods, strategies, and active teaching and learning strategies for Mathematics is crucial to ensure students develop a positive attitude toward the subject and the learning process (Maluni, 2021; Umugiraneza & Bansllal, 2017). These approaches encompass various activities, including group projects, role-playing, peer teaching, demonstrations and Cooperative instruction. Abramczyk and Jurkowski (2020) assert that these strategies prompt students to employ critical thinking, peer discussions, problem-solving and the application of knowledge across different concept areas within Mathematics. Numerous studies have attested to the effectiveness of active learning strategies across diverse mathematical disciplines. For instance, Klang et al. (2021) discussed their effectiveness in Geometry in Asia, Fasasi and Istifanus (2022) demonstrated their efficacy in Algebra in Nigeria, Umugiraneza and Bansllal (2017) explored Probability and Statistics in South Africa, yielding positive outcomes for active learning strategies, and Mwangi (2015) evaluated Logarithmic functions in Kenya, with the active learning strategy proving effective. This study specifically focused on investigating the effect of the Cooperative instructional method on students' performance in Geometry.

Cooperative instructional method is a style of active instruction whose primary purpose is improving student academic achievement and social engagement since it involves student team learning (Abrami & Chambers, 2004; Johnson et al., 2000; Kagan & Kagan, 2017). Students working in small groups learn effectively when a teacher incorporates the five key characteristics of the Cooperative instructional method into a classroom session (Abrami & Chambers, 2004; Johnson et al., 2000; Johnson & Johnson, 2005). These characteristics include the dependency in a good way, individual and collective responsibility, communication, and the ability to work in small groups and evaluate performance as a whole. These five characteristics serve as guidelines in a classroom to enhance the efficacy of the Cooperative instructional method. Multiple research studies determine Cooperative instructional method as an effective strategy for instructively improving students' academic achievement (Edekor et al., 2020; Johnson & Johnson, 2019; Mwangi, 2015; Slavin, 2014; Yemi et al., 2018).

Amaele et al. (2015), Maluni (2021) and Mwangi (2015) assert that Conventional instructional method is a systematic teacher-centred method of instruction that relies mainly on lectures for content delivery. They further affirm that in this method of teaching, the teacher acts as the primary source of the knowledge used in demonstrating and lecturing, while the students are the passive recipients of the information being delivered with limited or no interaction within themselves. Conventional method is the most common teaching strategy in secondary schools.

Studies conducted by Slavin (1989) and Slavin (2013) in New Jersey, and further affirmed by Johnson et al. (2014) and Slavin (2014), demonstrated the effectiveness of Cooperative instructional method when compared to Conventional instructional method in improving students' performance in Mathematics. Edekor and Agbornu (2020), in a study in Ghana's Volta Region, determined Cooperative teaching and learning as an excellent way to learn Mathematics, promoting students' social interaction abilities and improving their performance in the subject when compared to the students in the conventional instructed group. Studies in Kenya's Tharaka Nithi County by Maluni (2021) and Nakuru County by Makini (2022) indicate that learners who were instructed using the Cooperative method performed better in Mathematics than those who were instructed using the conventional method.

The findings from the aforementioned studies collectively underscore the significant positive effect of Cooperative instructional method on students' Mathematics performance. The study in this paper seeks to address a knowledge gap on Geometry, a strand of Mathematics in Meru County Secondary Schools in Kenya, aiming to provide further evidence on the difference in performance in Geometry between students taught using the Cooperative instructional method and those taught using the Conventional instructional method.

Statement of the problem

According to the Kenya National Examinations Council (KNEC, 2022), the Kenya Certificate of Secondary Education (KCSE) mean grades indicate, there is a performance challenge in Mathematics in Meru County, Kenya despite the County having enough trained teachers and resources (Maluni, 2021). Reviewing the previous KNEC reports on KCSE Mathematics performance revealed that many candidates performed poorly in Geometry questions. This study was necessary to determine the effect of the Cooperative instructional method on the Geometry performance of secondary school students in Meru County, Kenya. The study was conducted in the Imenti South sub-County of Meru County in Kenya. The study intended to mitigate the knowledge gap regarding the effects of secondary school Mathematics teaching and learning methods on students' Geometry performance.

Objective of the study

To investigate the difference in Geometry performance between students taught using the Cooperative instructional method and those taught using the Conventional instructional method.

Hypothesis of the study

$H_0$1: There is no significant statistical difference in Geometry performance between students taught using the

Cooperative method and those using the Conventional method.

Theoretical Framework

This study adopted the Cooperative instructional method based on the Social constructivism theory developed in 1978 by Lev Vygotsky, a Soviet psychologist. According to Vygotsky's Social constructivism theory, learning is fundamentally a Social process and is enhanced through interaction and cooperation between the teacher and the students. Cooperative instructional method is firmly founded on Social constructivism such that students and teachers scaffold each other's understanding through explanations and discussions. Social constructivism in teaching supports learners by providing necessary assistance to move through their Zone of Proximal Development (ZPD). Vygotsky (1978) noted that the ZPD includes tasks that a learner cannot do alone but can accomplish with support from teachers or peers. The Social constructivism paradigm emphasizes that interactions among students and teachers are more critical in determining effective learning outcomes than the conventional organization of the learning environment, where the Lecture method is used widely (Brito, 2019). According to (Brito, 2019) and Johnson et al., 2018 teachers should design learning objectives that foster desirable student and teacher interaction processes, leading to improved learning outcomes when these desired processes interact.

REVIEW OF RELATED LITERATURE

Several studies have investigated the impact of using Cooperative versus conventional teaching and learning methods on students' performance. Gomleksiz (2007) studied the effect of the Cooperative instructional method on teaching Engineering students a foreign language. The study sample included 66 engineering students from Firat University in Turkey. Students were randomly divided between experimental and control groups. ANOVA and t-tests revealed a statistically significant variance in favour of the Jigsaw Cooperative teaching and learning.

Amaele et al. (2015) in Nigeria investigated the effect of conventional instruction against the Cooperative instruction on students' learning accomplishments and experiences in Mathematics under experimental conditions over six months. They employed proportional stratified random sampling to obtain a study sample of 120 students from 10 senior secondary learning institutions in Omuma and Etche local governments of River State, Nigeria. ANOVA demonstrated a significant difference in accomplishment scores favouring Cooperative instruction regarding students' learning experience and Mathematics achievement.

Mwangi (2015) conducted a three-week quasi-experimental study on the effects Cooperative instructional method on secondary school pupils' Mathematics performance. In order to get a sample of 128 students from four co-educational institutions, purposeful sampling was used to get a sample of 67 students for the experimental group and 61 students for the control group. The study's results showed that the experimental group using the Cooperative instructional method, outperformed the control group using conventional methods.

While the existing literature provides insights into the effectiveness of Cooperative instructional methods, there is a need for further investigation into the specific conditions and subjects under which these methods are most effective. The existing studies have not comprehensively addressed the Cooperative instructional method and its impact on student performance in Mathematics, particularly in Geometry. Hence, this study aims to address this gap in knowledge and methodology by investigating the difference in the effect of using Cooperative instructional method and Conventional instructional method on the performance of Geometry.

METHODOLOGY

The quantitative research methodology was selected for this study. A systematic approach to data collection and analysis involving descriptive and inferential statistics was used. The target population was County Secondary Schools in Meru County, Kenya. This was considered because of their consistent low performance in Geometry questions for the past five years according to KNEC (2022) Reports. Form two Mathematics classes were selected because this is where most of the topics in Geometry at secondary school level are taught

(KICD, 2002). . The Form Two Mathematics classes that formed the sample of the study were determined using purposive sampling. The sample of schools was determined using the simple random and stratified sampling strategies to arrive at six (6) schools; two (2) boys', two (2) girls' and two (2) co-educational schools. The sampled schools were grouped into two, a control group and an experimental group. Each group consisted of three (3) schools; one (1) boys', one (1) girls' and one (1) co-educational school. This enabled the research study to cover a diverse section of respondents thus ensuring a rigorous examination of variables and the generation of reliable numerical data. Simple random sampling was used to sample students and teachers of Mathematics. The total study respondents were 197 students and six (6) teachers.

The control and the experimental groups that were taught the Geometry topic, Equation of a Straight Line, for a period of two weeks. Data was collected using the pre-test and post-test performance scores from the Geometry Achievement Test (GAT) in both experimental and control groups.

FINDINGS

Experimental and control groups test means before intervention

The treatment and control groups were given a Geometry Achievement Pre-test which was out of 25 marks and later converted into percentages. The descriptive statistics of the pre-tests are displayed in Table 1.

Table 1: Descriptive Statistics for Geometry Pre-Test Performance Scores

Group	Type of Secondary School	Mean	Standard Deviation	Number of students
Control Group	Boys' School	20.85	12.480	33
	Girls' School	23.48	13.613	31
	Mixed School	23.50	13.847	32
	Total	22.58	13.234	96
Experimental Group	Boys' School	23.54	12.108	35
	Girls' School	24.40	15.445	35
	Mixed School	27.00	16.184	31
	Total	24.90	14.548	101

Source: Research data (2024)

Table 1 outlines that the experimental group's performance (M = 24.90, SD = 14.548) was slightly higher than the control group's mean (M = 22.58, SD = 13.234). To determine if the difference between the two groups' means were statistically significant, a two-way Analysis of Variance was carried out and, a post-hoc analysis using Tukey's Honestly Significant Difference (Tukey-Kramer HSD) statistical test was conducted and documented in Table 2

Table 2: Multiple Comparisons by Tukey-Kramer HSD

(I) Type of Secondary School	(J) Type of Secondary School	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Boys' School	Girls' School	-1.73	2.409	.752	-7.42	3.95
	Mixed School	-2.99	2.437	.440	-8.74	2.77
Girls' School	Boys' School	1.73	2.409	.752	-3.95	7.42
	Mixed School	-1.25	2.455	.866	-7.05	4.55

Mixed School	Boys' School	2.99	2.437	.440	-2.77	8.74
	Girls' School	1.25	2.455	.866	-4.55	7.05

Source: Research data (2024)

Table 2 shows that each p-value was greater than 0.05 (p > .05). This means that the difference in performance between the schools was not statistically significant.

Weissgerber et.al (2018) noted that for gathered scores to be suitable for a quasi-experimental design study, they should have normal distribution and homogeneity so as to be relevant in the t-tests and Analysis of Variance (ANOVA) statistical analysis method. A Kolmogorov-Smirnov test was ran to determine the Geometry pre-test scores' normality in Table 3.

Table 3: Kolmogorov-Smirnov Test for Normality

Group	Test of Normality	Kolmogorov-Smirnov[a] Statistic	df	Sig.
Control group Geometry performance	Boys' school	.106	33	.200
	Girls' school	.128	31	.200
	Mixed school	.143	32	.092
Experimental group Geometry Performance	Boys' school	.101	35	.200
	Girls' school	.135	35	.105
	Mixed school	.096	31	.200

[a] – Lilliefors Significance Correction

Source: Research data (2024)

Table 3 shows that Kolmogorov-Smirnov statistic ranges between – 0.1 to + 0.1 and data is normal when the p-values are higher than 0.05. As indicated in Table 3, the variables had their p-values more than 0.05 implying the assumption for normality was met. Consequently, data for each of the variables of the study was normally distributed.

Comparison of experimental and control group test scores after intervention

The teachers in the experimental group were trained according to the Training Guide to the Application of Cooperative instructional method, for duration of two days. After the training, the teachers of Mathematics in the control groups proceeded with teaching Geometry using conventional lecture-and-demonstration and chalk-and-talk methods of instruction while the teachers of Mathematics in the experimental groups proceeded to teach Geometry but just as facilitators of the Cooperative instructional method.

The two groups received a Geometrical Achievement post-test after a period of two weeks since the Geometry topic during the time of study was to be taught within the latter period (KICD, 2002). Table 4 shows the descriptive statistics of the two groups

Table 4: Group Statistics-mean scores of Geometry post-tests

Taught using Cooperative teaching and learning	Number of students	Mean	Std. deviation	Std. error mean
No	96	26.27	10.926	1.115
Yes	101	74.02	12.495	1.243

Source: Research data (2024)

Table 4 displays that the treatment groups' post-test GAT score (M =74.02, SD = 2.495) was relatively higher than the control groups' post-test GAT score (M = 26.27, SD = 10.926). An independent samples t-test on the

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post-test GAT scores assessed the difference in performance between the experimental and control groups. The t-test results are displayed in Table 5

Table 5: Independent Samples t-test Analysis

			Geometry post-test performance score	
			Equal variances assumed	Equal variances not assumed
Levene's test for equality of variances	F		1.396	
	Sig.		.239	
t-test for equality of means	t		-28.493	-28.590
	df		195.000	193.674
	Sig. (2-tailed)		.000	.000
	Mean Difference		-47.749	-47.749
	Std. Error Difference		1.676	1.670
	95% Confidence Interval of Difference	Lower	-51.054	-51.043
		Upper	-44.444	-44.455

Source: Research data (2024)

The results in Table 5 revealed a significant difference between the two groups ($t(195) = -28.493, p < .001$). This indicated that the mean score of 26.27 and a standard deviation of 10.926 in the control group and the mean score of 74.02 and a standard deviation of 12.495 in the experimental group were statistically different.

However, an intra-comparison of Tables 1 and 4 shows that, individually, both groups had an improvement in their Geometry performance after the respective guided learning. Figure 6 displays a plot of the estimated marginal means.

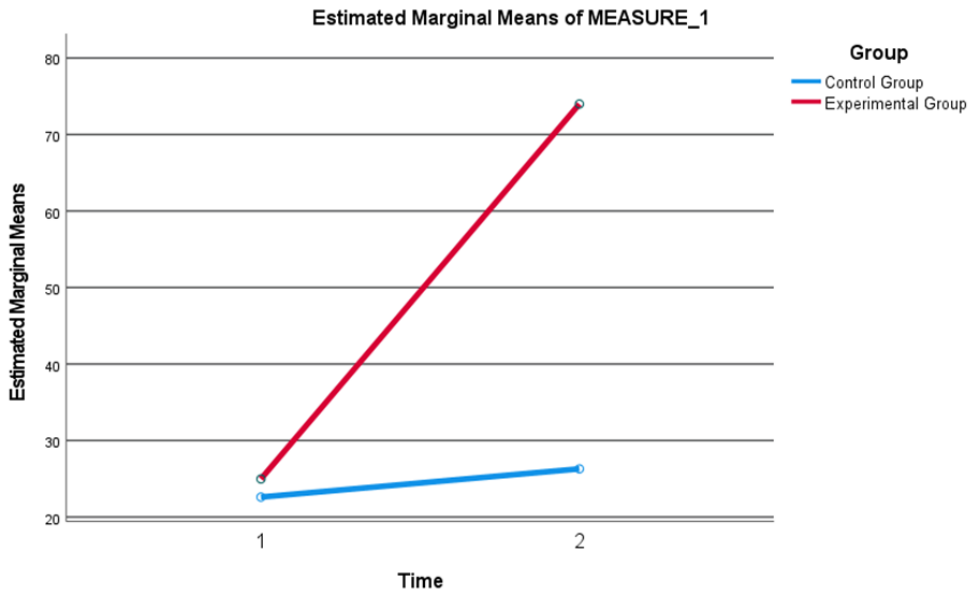

Figure 1: Estimated marginal mean

Note. For Estimated Marginal Means of MEASURE_1, the respective dependent variable for time 1 and 2 are the Geometry pre- and post-test performance score respectively.

Source: Research data (2024)

The plot in Figure 1 indicates that there was a gain in the two student groups' mean scores. It also highlights the gap between the experimental group, taught using Cooperative instructional method, and the control group, taught using conventional teaching and learning methods, having widened between pre- and post-tests. The line for the experimental group is however steeper, implying greater gain in the means of the experimental group students compared to that of students in the control group.

Hypothesis $H_0$1, was therefore rejected, thus asserting that there is a significant statistical difference in Geometry performance between students using Cooperative instructional methods over those using conventional teaching and learning methods.

DISCUSSION

The finding of this study is in agreement with the findings of Johnson et al. (2014) and Slavin (2014) study of the impact of Cooperative instruction on Mathematics performance in primary and post-primary schools in New Jersey which showed that Cooperative instruction could be a successful technique for improving students' performance in Geometry. The study showed that well-structured Cooperative learning methods are more effective than traditional instructional practices, such as using lecture method and innovative curriculum textbooks, especially for Geometry.

Cooperative instructional method improves students' performance in Geometry and metacognition skills as compared to conventional learning. This observation is in agreement with Amaele et al. (2015) in Nigeria which studied the effect of conventional instruction against the Cooperative instruction on students' learning accomplishments and experiences in Mathematics. The ANOVA statistics demonstrated a significant difference in accomplishment scores favouring Cooperative instruction regarding students' learning experience and Mathematics achievement.

In a similar study conducted by Mwangi (2015) in a three-week quasi-experimental study on the effects of Cooperative instructional techniques on secondary school pupils' Mathematics performance, in Murang'a County, Kenya indicates that students' attitudes towards learning Mathematics improved for those in Cooperative groups. This study's post HOC results using Scheffe's method of multiple comparisons showed that the experimental group, which was taught Mathematics using the Cooperative instructional method, had a higher performance in the Mathematics post-tests than did those in control groups using conventional methods.

It is evident from the results of studies conducted in various nations that there is great potential in the use of Cooperative instruction as a strategy to improve performance in Geometry in the Kenya Certificate of Secondary Examination (KCSE) not only in Meru County, but also in Kenya.

CONCLUSIONS

On the basis of the findings of the study, the following conclusions were made:

(a) There was a statistically significant difference in Geometry performance between students that adopted the Cooperative instructional methods over those instructed utilizing the conventional pedagogical approaches.
(b) The experimental group showed a statistically significant performance increase compared to the control group.
(c) The study determined that Cooperative instructional method as a suitable pedagogical approach for typically any topic in Mathematics that is related to Equations of a Straight Line such as Linear Inequalities in Form Two and Graphical Methods in Form Three as they primarily have a Geometry inclination.

RECOMMENDATION

Based on the findings and conclusions of this study, the researcher provided the following recommendation for the scholarly community and other stakeholders:

- There should be professional development opportunities for secondary school teachers to enhance their knowledge and skills in the Cooperative instructional method for effective implementation of the pedagogical methodology. This may involve workshops and training sessions involving collaborative learning communities focused on the Cooperative instructional method.

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