Effects of Teaching Using GeoGebra Software on Learners' Academic Achievement and Motivation in Geometrical Transformations in Chinsali District of Muchinga Province in Zambia

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***Abstract*: This study investigated the effects of teaching using GeoGebra version 6.0.574.0 on learners' academic achievement and motivation in Geometrical Transformations. Quasi-experimental was used in the study, that is, pre-test post-test control group design. The research sample consisted of two intact Grade twelve classes. Experimental group (n = 38) and control group (n = 37) a total of 75 learners studying Mathematics 4024 at Kenneth Kaunda Provincial STEM Secondary School in Chinsali District of Muchinga Province in Zambia. Learners in the experimental group were taught using GeoGebra software and those in the control group were taught using traditional teaching methods (demonstration, discussion, question and answer and expository methods). A Geometrical Transformations achievement test was used to determine the effects of GeoGebra on achievement and a 5 point Likert scale motivation questionnaire was used to assess the effects of GeoGebra on learners' motivation to learn Geometrical Transformations. An independent samples t-test was used to compare academic achievement of the two groups at 95% confidence level. Data on motivation was analysed using descriptive statistics (mean). The findings of the study indicated a significant difference in academic achievement between the experimental group and the control group [t(df = 73) = 2.576, p = 0.012 $\alpha = 0.05$ two tailed]. GeoGebra software had positive effects on learners' academic achievement. The study also revealed that GeoGebra software allowed male and female learners to learn Geometrical Transformations at the same level and this led to a conclusion that GeoGebra software is not discriminatory and impacts positively on gender. The motivation results indicated that learners' motivation to learn Geometrical Transformations was enhanced more in the experimental group compared to the control group with motivation mean of 4.33 (SD = 0.785) and 3.66 (SD = 1.147) respectively. The following recommendations were made: (1) teachers of mathematics should be encouraged to use GeoGebra in their teaching of Geometrical Transformations; (2) the use of GeoGebra should be emphasised and teachers of mathematics to be trained by those with knowledge on how to use the software during continuing professional development meetings in schools so that teachers can get the much needed knowledge on GeoGebra; (3) since the use of GeoGebra in Geometrical Transformations proved to be effective, the research should be conducted on a large scale and in other topics in mathematics to see if the same results can be obtained.**

***Keywords:* GeoGebra, Learner, Achievement, Motivation, Geometrical Transformations**

I. INTRODUCTION

1.1 Background of the Study

Mathematics is an important subject on the Zambian school curriculum. It is featured as one of the core subjects in all options for both academic and practical career pathways. Secondary school mathematics enhances the learners' understanding of the world around them and prepares them for further education. Not only that, mathematics also plays a very critical role as a tool for learning other subjects and learning areas. Mathematics fosters the development and improvement of learners' intellectual competence in thinking, problem solving skills and logical reasoning (Curriculum Development Centre, 2013). It is also important in science and technological subjects which are vitally important for the development of any nation. Mathematics can also be an interesting subject when learners appreciate basic concepts and insights that would equip them to pursue mathematics at higher levels (Curriculum Development Centre, 2013).

Unfortunately, poor academic achievement in mathematics and other science related subjects has been a major problem faced by the Zambian education system for quite some time. The Government of the Republic of Zambia has expressed concern over poor performance in mathematics (Ministry of Education, 1996). The Examinations Council of Zambia (ECZ) performance review report for 2018 has shown that learners have continued performing poorly in mathematics. A total of 181779 candidates sat for school certificate examinations in 2018 and of the candidates that sat, 12076 (10.1%) got zero in paper one and 8633 (7.66%) got zero in mathematics paper two, the mean performance in paper one was 12.0 percent and 21.0 percent in paper two (ECZ, 2018). Other reports also indicate that the mean performance score in mathematics were as follows, 28.3% in 2017, 24.4% in 2016 and 17.4% in 2015 (ECZ, 2017, 2016, 2015). This state of affair shows that learners' performance has continued to be poor despite several interventions that the Ministry of General Education has put in place. As a country and the world at large, we are moving towards scientific and technological advancement, as such we need nothing short of good performance in mathematics at all levels of education (Adedeji, 2007). The academic performance of learners in mathematics in Chinsali district is not different from that at National.

Some topics of secondary school mathematics have proven to be more problematic to learners than others. One of such topics amongst many others, where learners are performing poorly is Geometrical Transformations. It is poorly to fairly done by learners in National School Certificate Examinations. Learners fail to draw required triangles, fail to give correct descriptions of Transformations, face challenges when it comes to finding the scale factors and matrices of transformations (ECZ, 2013, 2014, and 2017). This evidence is strong enough to conclude that learners fail to develop adequate understanding of geometrical concepts, geometrical reasoning and geometrical problem solving skills and this contributes to poor academic achievement in Mathematics as a subject (Battista and Barrows, 1997). There is need to learn this topic meaningfully in order to address this learner poor performance in mathematics. Meaningful learning of Geometrical Transformations is not by rote learning, or just learning definitions/ attributes of Geometrical Transformations concepts but enabling learners to analyse the properties of two dimensional and three dimensional geometrical shapes and developing mathematical arguments about geometrical relationships, to specify locations spatial reasoning and geometrical modeling to solve problems (National Council of Teachers of Mathematics, 2000).

Geometrical Transformations is defined as a branch of geometry which is concerned with geometrical shapes (objects) and their transformations (images). Geometrical Transformations is divided into six sub topics as follows; translation, reflection, rotation, enlargement, shear and stretch (Burger, 1992).

According to Geddes et al (1985), Geometrical Transformations is a dynamic approach to learning geometry in which learners use hands on activities with concrete objects in addition to using technology. Hollerbrands (2003), also added his voice on the three important reasons for learning Geometrical Transformations in schools; (1) it provides opportunities for learners to think about important mathematical concepts such as functions and symmetry; (2) it provides the context within which learners can view mathematics as an interconnected discipline; (3) it provides opportunities for learners to engage in higher-level reasoning abilities using a variety of representations. Further, Geometrical Transformations help learners to explore the mathematical concepts of symmetry, congruence, similarity and parallelism to enrich learners' geometrical experience, thought and imagination and thereby enhancing their (learners) spatial abilities (Peterson, 1973).

Learning Geometrical Transformations can prove to be challenging if methods used in teaching and learning do not promote meaningful learning. It has been observed that a number of learners fail to develop adequate understanding of geometrical concepts, geometrical reasoning and geometrical problem solving skills (Battista & Barrows, 1997, Noraini, 1999). As a consequence, learners tend to develop a negative motivation to learn the topic and this always lead to poor performance in Geometrical Transformations in particular and mathematics in general.

The use of ICT appears to be one of the possible solutions to the poor performance of the learners in Geometrical Transformations. If learners are allowed to use information and communications technologies in their learning process of Geometrical Transformations, they may be able to improve their achievement in the topic. Information and Communications Technology (ICT) may have the potential to impact positively on learner performance in Geometrical Transformations and mathematics as a subject in general.

Geogebra is one of the software that is used in teaching and learning of mathematics. This software integrates possibilities of both dynamic geometry and computer algebra in one program for mathematics learning and teaching (Hohenwater & Jones 2007).

Geogebra was created by Markus Hohenwater in 2001 and it was designed to combine geometry, algebra and calculus in a single, dynamic environment. It is an open – source software, a dynamic mathematics software Programme that was created by Markus Hohenwater for his masters project at the University of Salzburg, in Austria. The official GeoGebra website is located at http://www.geogebra.org. This website features the most recent version of the software download, access to GeoGebraWiKi and User Forum, related to publications, and information regarding regional GeoGebra institutes.

GeoGebra is a dynamic learning environment that enables teachers and learners to create mathematical objects and interact with them. Teachers and learners can use this environment to explain, to explore and to model mathematical concepts and see how they relate to each other or mathematics in general (Hohenwater and Jones, 2007). This software accepts geometric, calculus and algebraic commands and bridges the multiple representations. Markus Hohenwater aimed at enabling multiple representations and visualization of mathematical concepts. So, GeoGebra help teachers and learners to create activities, incorporating multiple representations of mathematical concepts that are dynamically linked.

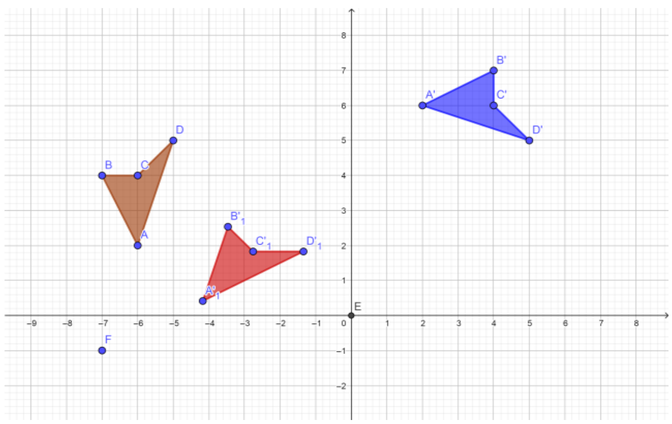

Figure 1: Snapshot of geometrical transformations performed using GeoGebra software

Many research studies have shown that ICT can help in motivating learners in many ways, for instance, ICT can result in increased commitment to learn and enhances learners sense of achievement, greater self-esteem, improved behaviour and support self-directed study.

Beeker (2000) stated that, if teachers provide their students with technology-enhanced lessons, there is always an increased commitment by learners. He further argued that learners are motivated to continue using computers at other times of the school day and outside school. Harris and Kington (2002) also observed that learners who used internet based resources were keen to work in their own time, before and after school, as well as during school hours. Learners developed autonomous style of learning, a valuable behavior for life.

1.2 Research Questions

1. What is the impact of teaching using GeoGebra on learners' academic achievement in Geometrical Transformations?
2. What is the difference between the achievement of male and female learners taught using GeoGebra software in Geometrical Transformations?
3. What is the impact of teaching using GeoGebra on learners' motivation in Geometrical Transformations?

II. METHODOLOGY

2.1 Research Design

Research design is the process of moving from 'here' to 'there' where 'here' may refer to the research questions and 'there' to the answers to research questions (Yin, 2003). Creswell (2009) also defines research design as "plans and procedures for research that span the decisions from broad assumptions to detailed methods of data collection and data analysis".

This research study used a quasi-experimental research design. Pre-test, post-test control group design was used in this study. Intact classes were used as opposed to random assignment of learners to experimental and control groups. This is because classes at the School where the research study was conducted existed as intact groups and School authorities would not allow putting them apart and rearranged for research study purposes.

The learners in both control and experimental groups were given a pre-test to determine the equivalence of the two groups (same level of achievement) and a post-test to assess the impact of the treatment on academic achievement.

2.2 Study Site.

This study was conducted in Zambia at Kenneth Kaunda Provincial STEM Secondary School in Chinsali District of Muchinga province. Kenneth Kaunda Provincial STEM Secondary is a rural boarding school with pupils running from grades 8 to 12. It was first opened in 1965 and named after the first Zambian Republican President Dr Kenneth Kaunda. The school is situated to the west of Chinsali Town, eight (8) kilometers from the town's main post office. The school was chosen for the study because it is one among other schools in chinsali district that has been recording fewer learners obtaining credit or better in mathematics school certificate examinations.

2.3 Sample and Sampling Procedures

Five (5) Grade 12 classes existed at Kenneth Kaunda Provincial STEM Secondary School as intact groups. Purposive sampling was used in the first place to obtain four (4) classes out of the 5 that were taking Mathematics 4024 syllabus only. This was done because one class (pure class) that was left out was considered more intelligent than the other four classes. If this class was made to be part of the study, it would have affected the internal validity of the study. The two classes that were involved in this study were selected using simple random with replacement. Each class was written on an identical piece of paper; the pieces of papers were folded and put into a box. The box was shaken and a piece of paper was drawn from the box, the first class picked represented a group to be part of the sample of the study. The piece of paper was then replaced and the box shaken for the second time and a piece of paper was drawn and it represented the second group to be part of the study sample. The two groups were then randomly assigned into the experimental group and the control group by a toss of a coin. The experimental group comprised 38 learners and control group comprised of 37 learners.

2.4 Data Collection Instruments

2.4.1 Geometrical Transformations Achievement Test (GTAT)

To assess academic achievement in Geometrical Transformations, a Geometrical Transformations achievement test (GTAT) was administered. The GTAT was made up of the pre-test and post-test for both control group and experimental group. To prepare the GTAT, questions were derived from the Examinations Council of Zambia (ECZ) School certificate and General Certificate examinations past papers. Mathematics 4024 syllabus-2013 and recommended mathematics textbooks were used as source of information.

2.4.2 Motivation Questionnaire

A five point Likert scale motivation questionnaire, ranging from strongly disagree (1) to strongly agree (5) developed by the researcher was used to collect data which was used to assess the impact of GeoGebra on learners' motivation to learn Geometrical Transformations. It was administered as pre-test and post-test to both experimental group and control group. The questionnaire consisted of 14 statements (items).

2.5 Instrument Validity

2.5.1 Geometrical Transformations Achievement Test (GTAT)

Face and content validity for Geometrical Transformations Achievement Test was done by the researchers and three qualified teachers of mathematics. This was done in order to make sure that the test had appropriate content and measured what it was intended to measure. The GTAT was piloted on one grade 12 class at a nearby school. This allowed for detection of weaknesses in the test items and corrected accordingly before the final form was prepared for administration.

2.5.2 Motivation Questionnaire

Face and content validity of motivation questionnaire was done by researchers. This was done in order to see if content was appropriate and measured what it was intended to measure. It was pilot tested at Mishishi Secondary School.

2.6 Instrument Reliability

2.6.1 Geometrical Transformations Achievement Test (GTAT)

Reliability of Geometrical Transformations test (GTAT) instrument was determined using Test-retest method of two weeks interval. The test scores that were obtained from the first and second administration was correlated using Pearson product moment correlation coefficient. With high index obtained, the instrument was declared reliable.

2.6.2 Motivation Questionnaire

The internal consistency of the motivation questionnaire was tested using Cronbach alpha and all the items appeared to be worthy of retention. With $\alpha = 0.72$ obtained, the instrument was declared reliable.

2.7 Data Collection Procedure

2.7.1 Pre-Study

What is the effect of teaching using GeoGebra on learners' academic achievement in Geometrical Transformations?

In order to check equivalency of the control and experimental groups in terms of knowledge, a Geometrical Transformations achievement test developed by the researcher was given to the respondents before the intervention as a pre-test.

3.1.1Pre-test Results

The researcher downloaded GeoGebra Software in advance and installed it on the school computers in the computer laboratory.

2.7.2 Experimental Group

Learners in the experimental group were introduced to GeoGebra software before the beginning of the intervention for the purposes of familiarising them with the software. This orientation took three (3) hours, one hour thirty minutes on the first day and the other one hour thirty minutes on the second day. The learners liked the software because of it being user friendly. During lessons in the experimental group, the learners manipulated and performed translations, reflections, rotations, and enlargements using GeoGebra software version 6.0.574.0.

2.7.3 Control Group

The control group was taught using traditional teaching methods. The content that was taught in the control group was exactly the same as that which was taught in the experimental group. All questions and tasks were the same for the two groups; the only difference was the methodologies used. Experimental group was taught with GeoGebra while the control group was taught using traditional teaching methods without GeoGebra. In the control group, learners primarily learnt by listening, observing, and discussions in small groups and as a whole class whenever question and answer strategy was employed in the teaching. Each lesson was one (1) hour 20 minutes long and teaching was done for 14 days.

2.8 Data Analysis

The data that was collected using GTAT was analysed using statistical package for social sciences version sixteen. The independent samples t-test was used to check if there were statistically significant differences in the academic achievement mean scores between the experimental group and the control group. The paired samples t-test was also done to check if there was a statistically significance difference in academic achievement within the group between the pre-test and the post-test.

Data that was collected using a five point Likert scale motivation questionnaire was analysed using descriptive statistics (mean) and results were presented in form of tables for easy description of trends in the data.

The level of significance for acceptance or rejection of null hypotheses was set at $\alpha = 0.05$, confidence level = 95%.

III. RESULTS OF THE STUDY

Table I. Independent samples t-tests

	Group	N	Mean	Mean diff	Std dev	t	df	Sig(2 tailed)
Equal Variances assumed	Experimental	38	35.868	1.004	15.401	0.309	73	0.758
	Control	37	34.865		12.530			

Table I shows the independent samples t-test results for the control and experimental groups. The t-value was 0.309 for 73 degrees of freedom, probability value was 0.758. The probability value is greater than the set α-level equal to 0.05. This simply means that there is no statistically significant difference in knowledge on Geometrical Transformations between the control group and the experimental group. This showed that the two groups were equivalent in terms of knowledge they had on Geometrical Transformations before the intervention.

3.1.2 Post-test Results

Table II. Independent samples t-test

	Group	N	Mean	Mean diff	Std dev	t	df	Sig(2 tailed)
Equal Variances assumed	Experimental	38	65.256	9.878	16.279	2.576	73	0.012
	Control	37	55.649		16.922			

Table II shows the independent samples t-test for the post test scores for the control group and experimental group. The t-value was 2.576 for 73 degree of freedom and probability value (p-value) was 0.012. This p value is less than the set α-level = 0.05($p<0.05$). This means that there was statistically significant differences in the post-test achievement mean scores between control group taught using traditional methods of teaching without GeoGebra and experimental group taught using GeoGebra software. This means that GeoGebra software had a positive impact on learners' academic achievement in Geometrical Transformations as compared to traditional methods without GeoGebra software.

3.2 What is the difference between the achievement of male and female learners taught using GeoGebra software in Geometrical Transformations?

3.2.1 Pre-test Results

Table III. Independent Samples t-test for Male and Female Learners in the Experimental Group

	Group	N	Mean	Mean diff	Std dev	t	df	Sig(2 tailed)
Equal Variances assumed	Male	21	39.283	7.532	16.028	1.526	36	0.136
	Female	17	31.706		13.932			

Table III shows an independent samples t – test results for the male and female learners. The t-value was 1.526 for 36 degrees of freedom, p-value was 0.136. This p-value is greater than the set $\alpha - level = 0.05$, meaning that there is no statistically significant difference in academic achievement between male and female learners in the experimental group. This showed that the male and female learners were at the same level in terms of achievement before the intervention.

3.2.2 Post-test Results

Table IV. Independent Samples t-test for Male and Female Learners in the Experimental Group

	Group	N	Mean	Mean diff	Std dev	t	df	Sig(2 tailed)
Equal Variances assumed	Male	21	64.143	-3.092	15.973	-0.58	36	0.568
	Female	17	67.235		16.980			

Table IV shows the independent samples t-test for post-test scores for male and female learners in the experimental group. The t-value was -0.577 for 36 degrees of freedom and the p-value was 0.568. This p-value is greater than the set $\alpha - level = 0.05$ ($p > 0.05$). This means that there was no statistically significant differences in the post-test achievement mean scores between male and female learners in the experimental group. This means that GeoGebra software had no effects on gender.

3.3 What are the effects of teaching using GeoGebra on learners' motivation in Geometrical Transformations?

The motivation of learners in Geometrical Transformations was investigated by using a questionnaire developed by the researcher with five (5) point Likert scale ranging from strongly disagree (1) to strongly agree (5) as a data collection instrument. The questionnaire was given as both pre and post-test. The information that was collected from this questionnaire was ordinal; however, the data was analysed using descriptive statistics such as frequencies, average means and percentages for the whole data set.

3.3.1 Pre-test Motivation Results

The motivation questionnaire was administered before treatment in order to determine the initial learners' motivation to learn Geometrical Transformations in the experimental and control groups.

The responses from the pre-test questionnaire were analysed and outcomes summarized in the following table. The motivation mean and standard deviation were calculated in order to show the mean for learners' motivation on the five point Likert scale. A mean score of above 3.0 meant a positive motivation (high motivation) to learn Geometrical Transformations, a mean score of 3.0 meant neutral (not decided) and a mean score of below 3.0 meant negative motivation (low motivation) to learn Geometrical Transformations.

Table V. Pre-test Motivation Results

The following are the column heading codes:

SD – Strongly Disagree, D – Disagree, N – Neutral, A – Agree, SA – Strongly Agree, MM – Motivation Mean, STD.D – Standard Deviation.

Group	SD (%)	D (%)	N (%)	A (%)	SA (%)	MM	STD. D
Experimental	17.29	24.98	27.85	21.43	6.21	2.77	1.154
Control	13.30	28.74	34.55	17.16	4.44	2.71	1.035

Table V shows that the two groups were comparable in terms of their motivation to learn Geometrical Transformations as seen from motivation mean (MM) responses of $2.77_{\text{Experimental}}$ and 2.71_{Control} , which on the 5 point Likert scale both groups had negative motivation to learn the topic.

3.3.2 Post-test Motivation Results

The motivation questionnaire was administered after treatment in order to assess the impact of GeoGebra software on learners' motivation to learn Geometrical Transformations. The post-test questionnaire responses were analysed in the similar manner as in the pre-test and the results were summarized and presented in the following table.

Table VI. Post-test Motivation Result

The following are the column heading codes:

SD – Strongly Disagree, D – Disagree, N – Neutral, A – Agree, SA – Strongly Agree, MM – Motivation Mean, STD.D – Standard Deviation

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Group	SD (%)	D (%)	N (%)	A (%)	SA (%)	MM	STD. D
Experimental	0.38	2.84	12.04	33.26	51.50	4.33	0.785
Control	6.75	10.22	21.60	35.87	23.72	3.66	1.147

Table VI shows that the two groups were different in terms of their motivation to learn Geometrical Transformations as seen from motivation mean (MM) responses of $4.33_{\text{Experimental}}$ and 3.66_{Control}, which on the 5 point Likert scale meant positive motivation to learn the topic.

IV. DISCUSSION OF THE RESULTS

4.1 Effects of teaching using GeoGebra on learners' Academic Achievement in Geometrical Transformations

The findings of this research study revealed that there was statistically significant differences in the academic achievement mean score of the post Geometrical Transformations test results of learners in the experimental group which was taught with GeoGebra software.

When the average scores in the post Geometrical Transformations Achievement Test (PoGTAT) were compared using an independent samples t-test, it was revealed that there was a statistically significant difference between the mean academic achievement score of the experimental group, which was taught with GeoGebra software and that of the control group, which was taught using traditional methods without GeoGebra software.

Table II shows an independent samples t-test of Geometrical Transformations Achievement post-test, t (df= 73, p=0.012) = 2.576, α = 0.05 two tailed. Since the p-value is less than

0.05($p < 0.05$), then there was a statistically significant difference in the Geometrical Transformations Achievement mean score of learners in the post-test results for the experimental group taught with GeoGebra software and control group taught without GeoGebra software. The result shows that GeoGebra software had positive impact on learners' academic achievement in Geometrical Transformations.

This difference in Geometrical Transformations Achievement post-test between experimental and control groups (in favour of experimental group) is as a result of the use of GeoGebra software which facilitated easier understanding of Geometrical Transformations concepts in the experimental group. These results also show that GeoGebra software allowed learners to participate actively in their learning; hence the concepts of Geometrical Transformations were understood better.

The findings of this study is in line with the study conducted by Bwalya (2019), who investigated the influence of GeoGebra on students' achievement in Geometric Transformations and Attitude towards learning Mathematics with Technology. The findings were that GeoGebra software had a positive influence on students' achievement.

The findings of the study also supported Yilmaz, Hasan &Tarmar (2011), who conducted a study on the effects of dynamic mathematics software GeoGebra on students' achievement in teaching trigonometry in South Africa. The findings were that GeoGebra software had a positive impact on students' achievement in trigonometry and further, the study showed that computer assisted instructions as a supplement to constructivist instruction is more effective than constructivist teaching method.

4.2 Effects of GeoGebra on Gender in relation to Academic Achievement in Geometrical Transformations.

The findings of this study with regards to gender revealed that there was no statistically significant difference in academic achievement between male and female learners taught using GeoGebra software (experimental group).

Table III in chapter four shows that male and female learners in the experimental group were equivalent in academic achievement in Geometrical Transformations before the intervention. This is evidenced by an independent samples t-test for pre-test in table 15 whose t[df = 36,p-value =1.36] = 1.526. Since the $p > 0.05$, then male and female learners were equivalent in terms of achievement in Geometrical Transformations before they were exposed to GeoGebra software.

Table IV also shows an independent samples t-test for post-test, t[df = 36, p = 0.568] = -0.58, $\alpha = 0.05$ two tailed. Since the p-value is greater than 0.05 ($p > 0.05$), then there was no statistically significant differences in the post-test mean scores of male and female learners taught using GeoGebra software (experimental group).

Male and female learners taught in the experimental group (taught Geometrical Transformations using GeoGebra software) performed the same on average in terms of mean scores in both PreGTAT and PoGTAT. When the independent samples t-tests were done for learners with respect to gender in the experimental group, there was no statistically significant difference in achievement between male and female learners ($p = 0.136 > 0.05_{Pre\text{-}test}$) and ($p = 0.568 > 0.05_{Post\text{-}test}$). One possible explanation to this finding is attributed to the fact that both male and female learners were exposed to same software-rich learning environment. GeoGebra software gave both male and female learners in the experimental group the same opportunities to work on Geometrical Transformations concepts through exploration and visualization. The software encouraged a more teacher to learner and learner to learner interactional environment, where learners worked as a team to assist one another in order to achieve the intended learning objectives.

GeoGebra acted as an important scaffold for both male and female learners to bridge the gap in the zone of proximal development as advanced by Vygotsky's social development theory. This finding showed that GeoGebra software created an enabling learning environment that accorded equal chances of learning to both male and female learners. The study also revealed that GeoGebra software allowed male and female learners to learn Geometrical Transformations at the same level and this led to a conclusion that GeoGebra software is not discriminatory and it impacts positively on both male and female learners.

The findings of this study supported Bwalya (2019), who conducted a study titled, influence of GeoGebra on students' achievement in Geometric transformations and attitude towards learning Mathematics with technology. In his study, he looked at how the software impacted on gender and the findings were that GeoGebra allowed male and female learners to learn Mathematics at the same level and that gave equal chances of learning to both genders.

4.3 Effects of teaching using GeoGebra on Learners' Motivation to learn Geometrical Transformations

Based on the findings from table VI, it was evident that there was positive impact of GeoGebra on learners' motivation to learn Geometrical Transformations. Tables 20 and 21 showed that the post-test overall motivation mean for experimental group was 4.327 (SD = 0.785) and that of the control group was 3.660 (SD = 1.147).

The motivation mean response of 4.327 for experimental group on the five point Likert scale showed a positive motivation to learn Geometrical Transformations ($4.327 > 3$) and the motivation mean response of 3.660 for control group also showed positive motivation to learn Geometrical Transformations on the five point Likert scale ($3.660 > 3$). This means that both experimental and control groups developed positive motivation. Nevertheless, the motivation mean response in experimental group is higher than the motivation mean response in the control group (mean = 4.327 $_{experimental}$ and 3.660 $_{control}$). These results showed that GeoGebra had more positive impact on the motivation to learn Geometrical Transformations in the experimental group as compared to control group which was taught using traditional teaching methods without GeoGebra.

This rise in positive motivation for learners in the experimental group showed that using GeoGebra software in teaching and learning Geometrical Transformations enhanced learners' motivation to learn the topic. On the other hand, the marginal rise positive motivation developed by learners in the control group was as a result of group discussions that were done during lessons.

The results discussed above are in accordance with the study which was conducted by Shadaan & Leong (2013), who investigated the effectiveness of using GeoGebra on students' understanding in learning Circle Geometry. In their study they found out that technology is a great motivational tool as students confidence increased when GeoGebra was used to enhance the students' learning process.

V. CONCLUSION

This study investigated the effects of teaching using GeoGebra software on learners' academic achievement and motivation in Geometrical Transformations and the findings showed and provided evidence that teaching using GeoGebra software in learning Geometrical Transformations has positive effects on learners' academic achievement and motivation to learn Geometrical Transformations. The results have also shown that teaching Geometrical Transformations using GeoGebra software is more effective to teaching without GeoGebra in enhancing achievement and motivation of the learners. Learners who learnt Geometrical Transformations with GeoGebra had improved in academic achievement after the treatment as it was shown in their higher scores than those who learnt the topic without using GeoGebra. The software also allowed male and female learners to learn Geometrical Transformations at the same level and this led to a conclusion that GeoGebra software is not discriminatory and it impacts positively on both male and female learners.

Further, the results obtained from the questionnaire indicated that learners who were taught using GeoGebra developed more positive motivation to learn Geometrical Transformations than their counter parts that were taught without using GeoGebra.

From the findings of this study, it can therefore be concluded that using GeoGebra in teaching and learning of Geometrical Transformations is an effective way of improving learners' academic achievement and enhance motivation of learners to learn Geometrical Transformations.

VI. RECOMMENDATIONS

1. Teachers of mathematics should be encouraged to use GeoGebra software in their teaching of Geometrical Transformations.
2. The use of GeoGebra should be emphasised and teachers of mathematics to be trained by those with knowledge on how to use GeoGebra during continuing professional development meetings in schools so that teachers can get the much needed knowledge on GeoGebra.
3. Since the use of GeoGebra in Geometrical Transformations proved to be effective, the research should be conducted on a large scale and in other topics in mathematics to see if the same results can be obtained.

REFERENCES

[1] Adedeji, T (2007). The impact of motivation on students' academic achievement and learning Outcomes in Mathematics among Secondary School Students in Nigeria, Eurasia Journal of Mathematics, Science and Technology Education, 2007, 3(2) 149-159.

[2] Baggott La Velle, L., McFarlane, A., & Brawn, R. (2003). Knowledge Transformation through ICT in Science Education: A case study in teacher-driven curriculum development British journal of Educational Technology, 34(2) 183 – 199

[3] Baker, L.E., Cooley, G. &Triqueros, M (2011) the schema triad – A Calculus example. Technology assessment in education and training, 17(3), 71 – 109

[4] Barrow, R. & Woods, R. G. (1987).An introduction to philosophy of education. London: methuem.

[5] Battista, M. T. & Barrow, C. V. A. (1997), 'shape markers: A computer micro word for promoting dynamic imaginary in support of geometric reasoning'. In Glass, B. D and Deckert, W. (2001). Making better the use of computer tools in geometry, mathematics teachers, 94 (3) march, 2001, 222 – 229.

[6] BECTA. (2013, July 6). BECTA.Retrieved from www. Becta.org.uk: www. Becta.uk/Publications/harnessingtechnologystrategy.

[7] Bwalya, D. (2019). Influence of GeoGebra on Students' Achievement in Geometric Transformations and Attitude towards Learning Mathematics with Technology 10(13), 25- 36.

[8] Chimuka, A. (2017), effect of integration of GeoGebra software in the teaching of Circle Geometry on Grade 11 Students' achievement, University of South Africa.

[9] Cullata, R & Adams, B (2014).Learning Technology Effectiveness. New York: U.S Department of Education, Office of Educational Technology.

[10] Dawes, L. (2001). What stops teachers using technology? In M. Leask. (Ed.) Issues in teaching using ICT (PP. 61 – 79). London, Routledge.

[11] Dendane, A. (2009). Skills need for Mathematical problem solving. The 10th Annual Research Conference in UAE (pp. 47 – 61). AlAin: UAE University.

[12] Donevska – Todorova, A (2015). Conceptual Understanding of Dot Product of Vectors in a Dynamic geometry environment. The Electronic journal of Mathematics, 59 – 73.

[13] Ertmer, P.A.(1999). Addressing first- and second order barriers to change: strategies for Technology Integration. Education Technology Research and Development, 47(4), 47– 61.

[14] Ertekin, E (2014). Is Cabri – 3D effective for the teaching of special planes in analytic geometry? International Journal of Educational Studies in Mathematics, 1 (1), 27 – 36.

[15] Fluck, A. (2010). From Integration to Transformation. In A. McDougall, J. Murnane, A. John and N. Reynolds (Eds), Researching IT in Education Theory, Practice and Future Direction. London and New York: Routledge.

[16] Foster, A & Shah, M (2015). The play curricular activity reflection discussion model for game Based learning. Journal of research on technology in education, 47(2), 71 – 88.

[17] Furner, J. M. & Marinas, C. A. (2014). Geometry Sketching Software for Elementary Children Easy as 1, 2, 3. Eurasia journal of Mathematics, Science and Technology Education, 3(1), 83 – 91.

[18] Hohenwater, M. Jarvis, D., &Lavicza, Z. (2009). Linking Geometry, Algebra and Mathematics Teachers: GeoGebra software and the establishment of the international journal for Technology in Mathematics and Science Teaching: Association for advancement of computing in education.

[19] Hohenwater, M., & Jones, K. (2007). Ways of linking Geometry and Algebra: the case of GeoGebra, proceedings of British Society for Research into Learning Mathematics, 27(3).

[20] Hohenwater, J., &Hohenwater, M. (2009). Introducing Dynamic Mathematics software to Secondary School Teachers: The case of GeoGebra. Journal of Computers in Mathematics and Science Teaching: Association for advancement of computing in education.

[21] Hollebrands, K. F. (2007). The role of a Dynamic software program for Geometry in the strategies. High School Mathematics Students Employ. Journal for Research in Mathematics Education, 38(2), 164-192.

[22] Kanshal, K. B. & Chun-Yen.C. (2014). Incorporating GeoGebra into Geometry Learning-A lesson from India. Eurasia journal of Mathematics, Science and Technology Education, 11(1), 77-86.

[23] Kathryn, R. W & David, B. M (2016) Handbook of Motivation at School. Second Edition: Routledge, New York, NY 10017.

[24] McAndrew, A (2015). Using CAS Calculators to teach and explore numerical methods. The Electronic journal of Mathematics and Technology, 9(1), 6.

[25] MESVTEE.(2013). O level Mathematics Syllabus Grade 10 to 12. The Curriculum Development Centre. Lusaka, Zambia: MESVTEE.

[26] MoE.(2013). Teachers' Curriculum Implementation Guide. ZESSTA. Lusaka, Zambia.

[27] Shadaan, P & Leong, K (2013). Effectiveness of using GeoGebra on Students' Understanding in Learning Circles. The Malaysian Online Journal of Educational Technology.1 (4).

[28] Soon, A, M (2015).Introducing queuing theory through simulations. The Electronic journal of Mathematics and Technology, 9(2), 45 – 61.

[29] Strausova, I &Hasek, R (2013). Dynamic Visual Proofs Using DGs. The Electronic journal of Mathematics and Technology, 7(3), 1.

[30] Vajda, R (2015). Chebyshev Polynomials as extremal Polynomials with Computer algebra. The Electronic journal of Mathematics and Technology, 9(3), 60 – 78.

[31] Vankataraman, G (2012).Innovative activities to develop geometrical reasoning skills in Secondary school Mathematics with the help of open resource software 'GeoGebra' National Conference on Mathematics Education.(pp. 20 -22).

[32] Voorst, V. (1999).Technology in Mathematics Teacher Education. Retrieved on October 9, 2020 fromhttp://www.icte.org/T99_Library/T99_54PDF.

[33] Yilmaz, Z., Hasan, F., & Tamer (2012). The effect of dynamic Mathematics software GeoGebra on student achievement in teaching of trigonometry: social and behavioral Sciences, 31(2012), 183-187.

[34] Wastiau, P. et al. (2013). The use of ICT in education: A survey of schools in Europe. European journal of Education, 48(1), 11-27.