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Geogebra Instruction Software and Its Effect on Students' Achievement in Mathematics in Secondary Schools of Kakamega County, Kenya

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Abstract: **Mathematical knowledge and understanding is important not only for scientific progress and development but also for its day-to-day application in social sciences and arts, government, business and management studies as well as household chores. However, the general performance in school mathematics in Kenya has been poor over the years. The purpose of this study was to explore the effectiveness of using Geogebra Instruction Software as a pedagogical tool in secondary school mathematics, as contrasted to conventional teaching methods on student's achievement. The theoretical framework which guided this study was the information processing theory. The study adopted quasi-experimental, utilizing pretest posttest nonequivalent group design. The target population for the study was all the 240 form two students in the 8 secondary schools in Kakamega Central Sub-county. Purposive sampling, Proportionate stratified sampling and simple random sampling was used to select the schools and the students who took part in the study. Mathematics Achievement Test (MAT) was used to collect data. The data was analysed using both descriptive and inferential statistics. The findings revealed that there was a significant difference in achievement of students taught using Geogebra and those taught using conventional teaching methods. There was significant difference between the mean scores of the two treatment groups (E_1 and E_2), the mean scores of the control groups (C_1 and C_2) were significantly different from those of the former with respect to the mathematics achievement test (MAT). Based on the findings, it was concluded that Geogebra exhibited higher quality and optimum learning in present times. As a pedagogical tool it not only enhances mastery of content but also improves on learners' retention rate and increases their involvement in problem solving. These factors contribute heavily towards better performance in Mathematics.**

Keywords: **Achievement, Instruction, Software, Geogebra and cognitivists.**

1. INTRODUCTION

In the recent times, societies have experienced rapid and widespread technological change the world over. Information, Communication and Technology (ICT) permeates our whole life including work, learning, leisure and relationships. Allen (2007) observes that digital literacy undoubtedly plays a significant role in our future lives. Students nowadays live in a world where ICT plays a central role to their daily lives. They enter the classroom not only having encountered rich digital experiences but also being part of a society influenced by new technologies. In order for them to succeed in the digital culture, they need to be equipped not only with basic but also higher-order skills (Papert, 1994). Education and in particular mathematics education need to prepare today's learners for their adult lives in today's and tomorrow's world, so that they can contribute in activities not as passive but as active and empowered participants (Pachler, 2001). ICT and

especially computers are considered to be necessary tools in classrooms and their use is mentioned in several of the goals of many National Curricula. Davis (2001) argues that ICT can play many roles in education that will continue to develop ICT aspects of core skills; ICT as a theme of knowledge and ICT as a means of enriching learning. New applications of technology have the potential to support learning across the curriculum and allow effective communication between teachers and learners in ways that have not been possible before (Loveless, 1995). Technology therefore provides students with a sense of mastery over their environment; they think about their thinking, check their work and continue reflecting. The use of ICT promotes initiative and independent learning, with pupils being able to make informed judgments and develop the ability to be critical in their choices (DfEE, 1999).

Teaching with ICT in the classroom is thus seen as qualitatively different from the explicit, traditional teaching. While the need for effective use of ICT in teaching subjects across the curriculum is increasing, good practice remains uncommon especially in Kenya (Ofsted, 2001). According to Saye (2010), the traditional method for teaching mathematics has impacted negatively on the students, and this has largely contributed to their poor performance in the subject. In the words of Saye (2010), teachers of mathematics usually lecture when they teach their classes. Consequently a considerable number of students have inadequate understanding of mathematics and mathematical concepts and skills, which results in dismal performance in end year national examination every year (KNEC, 2011-2014).

Many reasons have been cited for this; first, in a Kenyan traditional classroom setting, the teaching of mathematics is basically teacher-centred. This makes the learning to be boring as the learner passively sit and watch the teacher solve mathematics problems on the board. Secondly the traditional method inhibits creativity. The student watches, listens, and copies what the teacher does. The student then begin to feel that mathematics is pointless and is of little value to them in real life. No wonder it is a subject they are not only forced to study in school, but one that is useless to them in real life. The contrast, however, is between the theoretical Math learnt in school and the practical math that our parents use in daily life. In the traditional classroom setting aforementioned, both student and teacher are often frustrated because students' individual needs are unmet. Students generally have difficulty listening and copying problems from the board at the same time, and so when they begin working on assigned problems at their desks, they become frustrated. Although there are attempts by the teacher to move round the room trying to answer student's questions, this is greatly hampered by lack of sufficient time. Students leave the classroom without having all their questions answered and unable to complete the assignment. The teacher is exhausted from moving about the room in an effort to answer all the questions, and is discouraged by lack of effort to effectively meet the needs of all the students.

Third, teaching and learning of mathematics is a complex activity whose success is determined by a number of factors such as; the pedagogical skills of the teacher, the learning environment, the nature and quality of instructional material, the motivation of both the teacher and the learner.

Teachers need to be involved in the actual curriculum implementation in order to cause some change in mathematics classroom. In this sense and for the aforementioned reasons, this study sought to look at the development of mathematical ideas and concepts through computer based teaching. The main aim of the research was to analyze the role of dynamic mathematics computer software called Geogebra, as a tool in the teaching and learning of mathematics in the Kenyan Secondary schools, by exploring its effectiveness in students' achievement. Geogebra is a relatively new software system that integrates possibilities of both dynamic geometry and computer algebra in one tool for mathematics education. It allows a closer connection between the symbolic manipulation and visualization capabilities and dynamic changeability (Hohenwarter & Fuchs, 2004). Introducing Geogebra in mathematics classrooms could be a way of providing opportunities for mathematical investigation, encouraging discussion and group work and generally it can make mathematics a more open and practical subject, which is accessible and manageable to more learners (Hohenwarter & Fuchs, 2004).

1.1 Statement of the problem:

Several efforts have been made in Kenya to improve on the quality of teaching and learning process in mathematics using conventional methods but still considerable number of students (about 40%) get a mean grade E, at KCSE (KNEC report, 2016). This is the worst grade in Kenyan Education system. It is the concern of secondary school mathematics teachers who disseminate knowledge as to why good results are always eluding the students. In Kakamega County out of 26,898 candidates in math, the mean Score in 2016 was 2.5118 (D-) (KNEC report, 2016). This was a drop compared to 2015 when out of 23135 candidates the mean score was 3.728 (D). Equally in Kakamega Central Sub-county with a

candidature of 1926 in mathematics, 1387 students scored mean grade D- and E (Ministry of Education, Science and Technology; Republic of Kenya, 2016). The sub-county mean score in Math that year was 2.151 (D-). With such poor performance in math the learners transit without the five paramount 21st Century skills (5C's) which are dependent on the subject. A SMASSE survey conducted in 9 districts in 1998 revealed that poor teaching methods and students attitude towards the subject contributed heavily to the poor performance. It has been observed that current standards in our schools are techo-savvy.

Thus use of an innovation such as Geogebra Software as a pedagogical tool in the teaching and learning of Math would go along in helping the students enhance their attitude, engagement and achievement in the subject. If the study is not done, then the status quo would be maintained. The results will continue to be poor and the teachers will continue to use conventional methods which are not counterproductive, and the good results would continue to elude them.

1.2 Purpose of the Study:

The purpose of the study was to explore the effectiveness of using Geogebra Instruction Software as a pedagogical tool on the student's achievement in secondary school mathematics. It is hoped that the findings of the study will create a paradigm shift in Mathematics pedagogy.

1.3 Research hypothesis:

The study sought to investigate the hypothesis:

There is no significant difference in the achievement of students taught mathematics using Geogebra (GIS) and those taught using conventional teaching methods.

1.4 Significance of the study:

The study was aimed at providing information with regard to the use of computers as pedagogical tools in secondary schools with respect to the teaching and learning of mathematics. The research hopes that the information so obtained would serve as a basis upon which the new effective teaching methodology would be implemented. The findings of the study, is invaluable to practicing mathematics teachers, school administrators, education planners, and the Kenyan community at large in instituting measures that could bring about a high degree of teaching/ learning experiences. The findings could also serve as a source of information for policy makers, education researchers as well as stakeholders in education. Parents, who are heavily laden in terms of education support, would be influenced by the finding as they make decisions on what support programmes their children should have, access and use on daily basis.

2. THEORETICAL FRAMEWORK

The underlying theory of this study is the information processing theory. The theory is based on the idea that human being process the information they receive, rather than merely responding to stimuli. This perspective equates the mind to a computer, which is responsible for analyzing information from the environment. According to the standard information-processing model for mental development, the mind's machinery includes attention mechanisms for bringing information in, working memory for actively manipulating information, and long term memory for passively holding information so that it can be used in the future (Gray, 2010). This theory addresses how as children grow, their brains likewise mature, leading to advances in their ability to process and respond to the information they received through their senses.

From 1950's onwards "cognitivists", wanted to look at the "interior" mental processes, rather than the observable "exterior" views that behaviorism held. This revolution had a huge impact on theory and research such as human-computer interaction, human factors and ergonomics.Overall, information-processing models helped reestablish internal thought processes. A central metaphor that was adopted by cognitivists at this time was the computer, which served to provide researchers with important clues and directions in understanding the human brain and how it processes information. Many psychologists and researchers believe that the Information Processing Theory was influenced by computers, in that the human mind is similar to a computer.

3. METHODS AND MATERIALS

The study adopted quasi-experimental, utilizing pretest posttest nonequivalent group design. A total of 240 form two students from 8 secondary schools were involved. Purposive sampling was used to select the eight schools from the available 24 schools while the students were selected using proportionate stratified sampling from their schools then

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randomly selected from their class. The study involved four groups; Experimental Groups (E_1, E_2) and Control Groups (C_1, C_2) each comprising of 60 students and making a total of 240 students. Two groups E1 and C1 were given a pre-test of MAT while all the four groups were given a post-test achievement test after the treatment.

4. RESULTS AND DISCUSSION

The study entails provision of empirical data that explains the extent to which the students' achievement in mathematics was related to Geogebra Instruction Software under review. The research data obtained was analyzed and presented using both descriptive and inferential statistics.

The MAT scores formed the basis of data analysis. After scoring the instrument (MAT), the data was coded and data files prepared for computer analysis. In descriptive analysis, means and standard deviations were used to show not only the level of achievement towards the subject within the four groups, but also the differences between the four groups under comparison. By computing the means and standard deviations and carrying out assessment the study was able to highlight important aspects of the trends of data observed. In inferential statistics, the statistical method employed was the t-test and one way analysis of variance (ANOVA). The t-score gives the direction of the difference while ANOVA shows whether there is a difference. ANOVA was employed to determine the significance of the difference in student's achievement in mathematics between the experimental and control groups. The hypothesis was tested at 0.05 level of significance.

Table 1: Comparison of Mean scores, Standard Deviations and t-test on the MAT for the control and experimental groups in pre-test

Analysis	No	Group E_1	Group C_1	Critical t-value	Calculated t-value	Result
Mean (Pre-test)	60	50.63	52.34			
Std.Dev.		*10.301	*10.816	1.89	0.0246	*0.0246
Highest Score		45%	59%			

$n_1 = 60$, $n_2 = 60$, $\alpha = 0.05$, df = 118, critical t-value = 1.89 *No Significance

The pre-test scores of the control group and the experimental group did not show any significant differences. The assumption made was that the two groups started out with equivalent means, which implies they had same ability and capacity from the beginning thus equal mathematical performance. In Table 2, the achievement scores of the control and experimental groups in post-test is shown.

Table 2: Comparison of Mean scores, standard deviations and t-test on the MAT for the control and experimental groups in post-test

Analysis	No	Group E_1	Group C_1	Critical t-value	Calculated t-value	Result
Mean (Post-test)	60	71.98	54.45			
Std.Dev.		*8.34	*9.88	1.89	9.633	*9.633
Highest Score		55%	79%			

$n_1 = 60$, $n_2 = 60$, $\alpha = 0.05$, critical t-value = 1.89 *Significant

The post-test results showed that the experimental group had higher scores than the control group. The t-test for the independent samples carried out for the two groups showed significant difference on the post-test. From Table 2, experimental group attained 71.98% while control group realized 54.45%. The calculated t-test value was 9.633 at degree of freedom of 118 ($n_1+n_2-2 = 118$) and was greater than the critical value of 1.89.

Table 3 shows that the degrees of significance of the four sample groups. The results showed that the scores of the experimental group were consistently higher than those of the control group while the standard deviation of the control group was lower than that of the experimental group, thus the significance level above the critical t-value of 1.89. When the means and Standard Deviations (SD) for E_1, C_1, E_2 and C_2 were compared in the pre-test and post-tests, the results were as shown in Table 3 below.

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Table 3: Comparison of the Means, Standard Deviations (SD) and Improvement Index on Mathematics Achievement Test (MAT)

Scale	E_1	C_1	E_2	C_2	Average
Mean (Pre-test)	52.63	52.45	-	-	52.54
SD	10.3	10.82	-	-	10.56
Mean (Post-test)	71.98	54.45	69.34	62.75	62.75
SD	8.34	9.88	8.97	8.06	8.81
Improvement	***19.35**	**0.94**	**-**	**-**	**10.21**

*Significant Mean Improvement

The results obtained in Table 3 showed that there is significant mean improvement by experimental group on MAT compared to that of the control group. The range of the highest and lowest scores also reduced significantly as shown by the value of the Standard Deviation. When the independent sample t-test for post-test scores on MAT were calculated, the results were as shown in Table 4.

Table 4: Independent sample t-test for post-test mean scores on MAT

Groups	t-values
E_1 Vs E_2	1.444
E_1 Vs C_1	*9.633
E_1 Vs C_2	*9.643
C_1 Vs C_2	0.372
C_1 Vs E_2	*6.891
E_2 Vs C_2	*6.994

*Significance at $\alpha = 0.05$, critical t-value = 1.89

It was observed from Table 4 that there was a significant difference between the achievement of students taught using Geogebra and those taught using conventional methods. The null hypothesis postulating that "There is no significant difference in the achievement of students taught using Geogebra (ICT) and those taught using conventional teaching methods" was therefore rejected. It was then concluded that students taught Math using Geogebra had better achievement than those taught using conventional methods. When a comparison was made between the independent t-test means on MAT of the different study groups the results were as shown on figure 1 below.

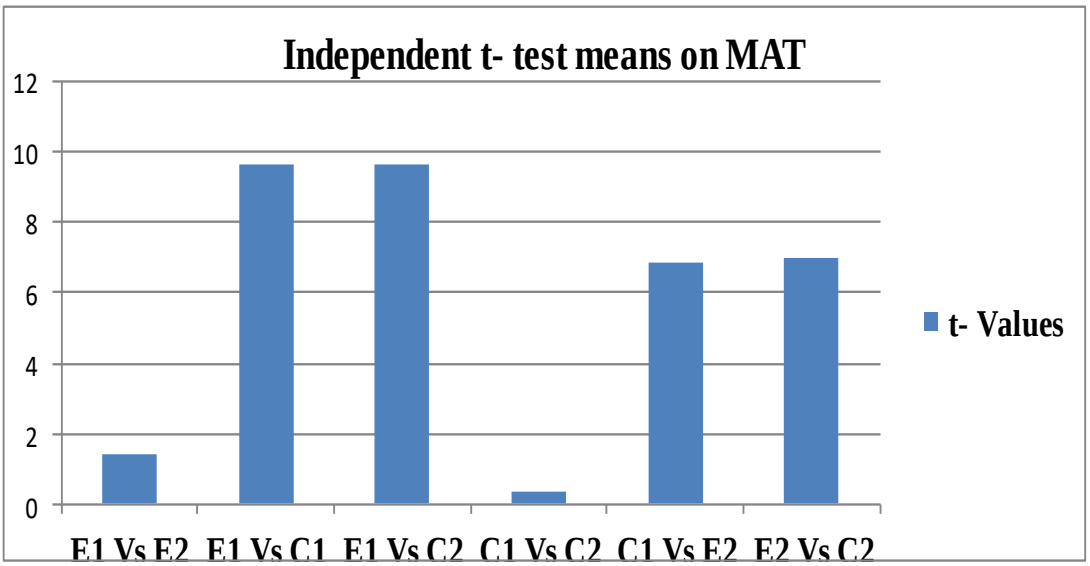

Figure 1: Independent sample t-test mean scores on MAT

The level of retention of the learnt concepts between the experimental and control groups were calculated. It was realized that the experimental group exhibited a positive deviation of +2.64 while the control group showed +0.4. It was then concluded that students taught using Geogebra had higher retention than those taught using the conventional methods. Among the studies in support of the findings are those by Dalton et.al. (1989); Kulik and Kulik, (1987); Mevarech et.al.(1987); Yeuh and Allessi, (1988) who maintain that, effective learning is more assured through a computer programmed instruction approach like GIS than with the conventional instructional approach. Further, it can be concluded from the findings that, the addition of media such as computer programmed texts to lectures, discussions, and demonstrations in the teaching and learning of mathematics is likely to enhance students' achievement. In general, the findings of this study are in accord with the views expressed in the aforementioned studies.

5. CONCLUSION

The central objective of the study was to investigate on the effectiveness of GIS and Conventional Method of Instruction on the students' achievement in mathematics at the secondary school level. The use of GIS method in this study demonstrated a great potential to promote cognitive, affective and psychomotor skills of Form II Secondary school students in the mathematics topic of transformation. Apparently, two major advantages stand out from this finding. The first is that the problem of the concept of transformation being a difficult topic to teach by conventional methods, may be resolved by the use of GIS programme that emphasizes on collaborative learning, creativity, self-paced and individual learning. The second is that the declining performance and students' interest in mathematics may be arrested by the use of GIS.

6. RECOMMENDATIONS

The use of Geogebra Instruction Software seems to enhance positive student's achievement towards the mathematics course. Teacher(s) should embrace and integrate the use of computer based instructional software in their lessons whenever the matter at hand requires positive students attitude towards the subject (mathematics) and a high level of creativity for effective learning.

Since the use of Geogebra Instructional Software seems to enhance higher ability in learning achievement, then mathematics teachers should make every effort to produce or obtain appropriate and well integrated instructional materials and use them in their lessons.

The Government of Kenya through the Ministry of Education and Kenya Institute of Curriculum Development should embark on a serious campaign to enable teachers understand and appreciate that the teaching of mathematics would be greatly enhanced in the event that they use GIS. Any teacher with the desire to enhance student's attitude, creativity and achievement in mathematics should be sensitized and capacity built on the use of GIS in mathematics.

The incorporation of mandatory computer studies in teacher education to equip teachers with the relevant skills is required in information driven society. However, capacity building for practicing teachers of mathematics should be encouraged to enable them cope up with the current computing demands and technological dictates.

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