Gender Differences in the Use of GeoGebra and Grapes in Teaching Mathematics in Secondary Schools in Kenya.

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ABSTRACT

This study was carried out to examine the gender differences in academic achievement in mathematics by use of Grapes and GeoGebra graphing softwares. The objective of the study was to establish whether the use of GeoGebra and Grapes can improve the performance in mathematics for both boys and girls. This study was guided by Technology Acceptance Model (Davis, 1989). Technology Acceptance Model (TAM) explains computer-usage behavior that relates to reasons why some people use computers and their attitudes towards them. This study adopted Solomon four group experimental research design. The respondents were selected using both stratified and simple random sampling. Data was collected through the use of students' questionnaires, pre-test and post-test. Analysis of data was done using both descriptive and inferential statistics. For descriptive statistics, frequency tables and means were used. Anova and t-test were employed for the inferential statistics. The study found out that boys and girls had the same academic achievement when taught using Grapes and GeoGebra. It is recommended that the teaching and learning of mathematics should involve a lot of practical activities which engage both sexes of the learners equally throughout the lesson .This will make the learners to develop a lot of problem solving skills and critical thinking skills which required in mathematics.

Key words: GeoGebra, Grapes, achievement, gender, Mathematics.

INTRODUCTION

GeoGebra is a dynamic mathematics software for schools that joins geometry, algebra and calculus. GeoGebra is an interactive geometry system and enables learners to do constructions with points, vectors, segments, lines, and conic sections as well as functions while changing them dynamically afterwards. Equations and coordinates can be entered directly. Thus, GeoGebra has the ability to deal with variables for numbers, vectors, and points.

GeoGebra affords opportunities for mathematical investigation encouraging interaction and collaborative learning, making mathematics open, practical, accessible, tangible and manageable to more pupils (Hohenwarter& Fuchs, 2004). GeoGebra is designed specifically for educational purposes and has the added advantage of enabling students to visualize mathematical concepts, foster rich and active student-centred learning by affording opportunities for mathematical experimentations, interactive explorations, conceptual and visual feedbacks, support guided discovery learning, produces flexible results, enable multi-lingual classroom and generate mathematically accurate diagrams for problem sheets and does very well what it sets to achieve (Bruner, 1961; Sangwin, 2007; Preiner, 2008*).*

Grapes is graphing software developed at the Centre for Research on International Cooperation in Educational Development, University of Tsukuba, Japan. The graphing software can support a way of mathematical reasoning not developed before, and which may help different students to learn in different ways. The availability of easy-to-use graphing software highlights the role of the graphical representations

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of functions and relations.

Mathematics is a very important subject not only because of the types of skills and knowledge that learners acquire from learning the subject but also because of its use in the learning of other subjects of the curriculum. It is for this reason that mathematics is made compulsory for all learners in Kenyan secondary schools.

There is a general misconception and belief that mathematics is a masculine subject. Girls should overcome the myth that mathematics and sciences are masculine subjects. There is need to remove gender insensitive materials in the curriculum and teaching methodologies. Teachers should not only expect boys to do wonderfully well in mathematics and sciences while they expect girls to be just average or below. Girls should not be considered to be inferior in doing mathematics. The basic idea behind the gender issue is equity. The teacher should give equal opportunities to both boys and girls. At no time should the teacher be seen to be promoting one sex as opposed to the other. No one sex is superior to the other.

According to Ajai and Imoko(2015), their study showed that female students outperformed their male counterparts in mathematics achievements though the difference was not statistically significant. They argued that the reason for equal performance of male and female students may be connected with the fact that both see themselves as equals and capable of competing and collaborating in classroom activities. They pointed out that both sexes are capable of competing and collaborating in classroom activities.

Ajai and Imoko(2015) pointed out that there is need to give boys and girls exactly the same opportunities and challenges in mathematics. Male and female students need to compete, collaborate and gain from one another in mathematics teaching and learning. They recommended that teacher professional development programs should make more concerted efforts to advise teachers about the ways in which to approach the teaching of mathematics so as to avoid disadvantaging particular groups of girls or boys. They also pointed out that mathematics teaching and evaluation should be gender bias free. This way, boys and girls will tend to see themselves as equals capable of competing and collaborating in classroom activities. They also recommended that male and female teachers should work jointly with boys and girls and adopt a more socially just and inclusive approach to creating equal opportunities for all students.

According to the research conducted by Kaiser and Zhu (2022), boys performed better than girls in overall mathematics achievement but the difference was insignificant. On average, a Shanghai boy would achieve significantly higher marks than a girl in programme for International student Assessment 2012 mathematics test.

Research has shown that gender differences in mathematics performance are diminishing (Frost,Hyde & Fennema,1994; Hyde, Fennema & Lamon,1990). Piere, Moran and Lutkus (2005) found out that the gap has been narrowing in the United States of America. Research in Australia indicated that the gender differences in mathematics achievement are reducing and shifting (Forgasz, Leder & Vale, 2000).

According to Vale (2009), many studies conducted between 2000 and 2004 in Australia showed significant differences in mathematics achievement between male and female students though males were more likely to obtain higher mean scores.

Feminists researchers have tried to make meaning of the experiences of girls and boys in mathematics classrooms and to interpret male-female power relations (Jungwirth,1991; Waiden & Walkerdine,1985). Their findings revealed that girls are often marginalized and given subordinate status in the mathematics class. The findings suggest that perceptions of teachers are that girls' performances in mathematics are dependent on rote learning, hard work and perseverance rather than natural talent,

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flexibility and risk taking which are the learning styles of the boys.

The National Council of Teachers of Mathematics (NCTM), which is the world's largest association of teachers declared technology as one of the six principles for school mathematics. According to the National Council of Teachers of Mathematics position statement regarding technology, appropriate use of technology allows more students access to mathematical concepts (NCTM, 2008). Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning. According to Schifter and Fosnot (1993), students' mathematical understanding requires the provision of time and opportunities to participate in a process of concept construction and active interpretation within meaningful contexts.

ICT integration in education is a policy priority by the Ministry of Education (Ministry of Education, 2006; Ministry of Education, Science and Technology, 2005). The ICT options were based on Sessional Paper No. 1 of 2005 and KESSP and outlined among others, priorities on improving quality teaching and learning, improving educational policy and coordination and considering costs and benefits of educational interventions. There are eight options which included quality teaching and learning through ICT with a focus on e-content development; ICTs in teacher training colleges; computers in secondary schools; computers in primary schools cluster centres; ICT for in-service teacher training; and video for in-service teacher training among others.

According to Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA) (2017), CEMASTEA has made several initiatives towards effective teaching and learning of mathematics and sciences. One such initiative has been to embrace technology in all its training programmes. ICT integration in teaching and learning of mathematics and sciences has become a key and integral component of Activity, student, Experiment, Improvisation-plan do see and improve (ASEI-PDSI) teaching and learning of mathematics and science paradigm shift. In an endeavour to improve the quality of teaching and learning, CEMASTEA has been capacity building teachers on ICT integration at the county level. The facilitation is done by CEMASTEA trainers in selected county centres with adequate ICT facilities.

The training on ICT integration in teaching and learning and particularly in STEM was meant to enhance efficiency, effectiveness and innovativeness, provide interactive learning experiences, under difficult concepts and processes and enhance collaboration and group work. CEMASTEA hope that the training will go a long way in changing the classroom practices in making learning more meaningful, relevant and applicable to real life by promoting 21st century skills.

According to CEMASTEA (2017), effective teaching and learning largely depend on the teaching and learning strategies teachers adopt. One of the strategies is in designing appropriate teaching and learning activities that can enhance achievement of lesson objectives. The teaching and learning activities that can enhance the effectiveness of the teaching and learning process and achieving the intended lesson objectives. According to the Training Needs Assessment (TNA) report (CEMASTEA, 2015), majority of teachers did not adequately arouse learner's interest and curiosity through innovative and real life situations nor did they involve learners in developing creative ideas. Furthermore, a large number of teachers rarely develop activities that enable learners interpret, analyze and evaluate new information.

Technology use in mathematics teaching helps students to easily acquire basic mathematical skills. Organized and well planned supports as well as enough practice would greatly help students to improve their skills particularly in exploring their potential in information technology to the maximum (Zulnaidi & Zamri,2017). Students need guidance in applying the latest technology to solve various mathematical problems (Oldknow & Taylor,2000). The computer is now widely used as a teaching aid in mathematics in order to enhance students' self-motivation and self-confidence (Sivin-Kachala & Bialo,2000). The use of

computer in teaching and learning mathematics is actually a sophisticated method as opposed to conventional methods to produce a brilliant generation in the aspects of physical, emotional, spiritual and intellectual development (Norazah & Effandi, 2007).

Teachers should embrace the current changes and strive to realize the use of the latest technology in the classroom. Educators should try the hardest in making mathematics a very interesting subject in order to attract students' interest and at the same time to help them consciously focus on important mathematical concepts (Zamri & Zulnaidi,2017). It is the teacher's responsibility to prepare students to focus on the future world which undoubtedly would depend on mathematics, science and technology (Furner & Marinas, 2007). Technology based learning provides symbols , formula , tables , graphs , numbers , equations and manipulative materials to link them with various real life ideas and those are indeed parts of conceptual and procedural knowledge (Post,1998). Technology application in teaching and learning mathematics helps students to better understand basic mathematical concepts and to experience intuition in solving certain mathematical problems (Rohani et al, 2009).

PURPOSE AND OBJECTIVES OF THE STUDY

The main purpose of this study was to investigate the effect of Geogebra and Grapes in the teaching and learning of Mathematics in Kenyan Secondary schools. The objective of this study was to establish whether the use of Geogebra and Grapes can improve the performance in mathematics for both boys and girls.

The following research hypothesis, as derived from the research questions and stated in their null form, was tested using Anova at alpha level of significance 0.05:

$HO_{1:}$ There is no significant difference between the scores of boys and girls when they are taught using Grapes and Geogebra.

CONCEPTUAL FRAMEWORK

Conceptual framework provide a graphic presentation that is self-explanatory showing how various variables interact and the direction of the outcomes from such interactions. Below is the diagrammatic representation of the conceptual framework involving the variables that were considered in this study.

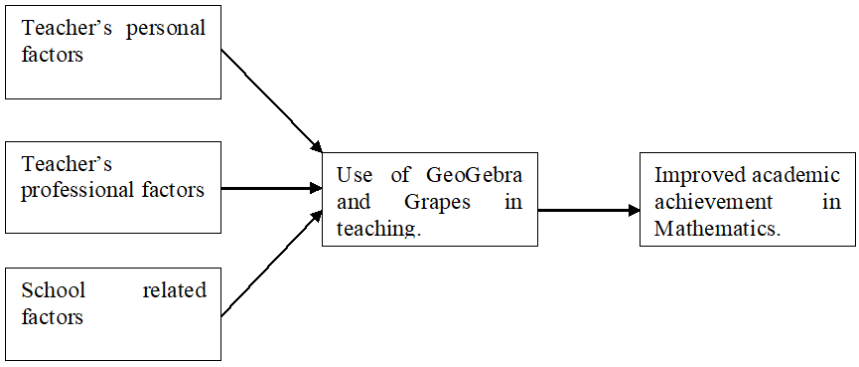


Figure 1.2. Conceptual Framework

For the use of GeoGebra and Grapes to be successful in the teaching of mathematics , several factors come into play. The most important are the teacher's personal factors. These are the factors which are inherent in the teacher. Interest in technology is an important factor which the individual teacher need to have so as to integrate technology in his /her teaching. The other factor is the technological knowledge the teacher posses on how to use technology. Without the prerequisite knowledge on the use of ICT it will be difficult for a teacher to use technology in planning for instruction. The other requirement for the teacher is oppeness to

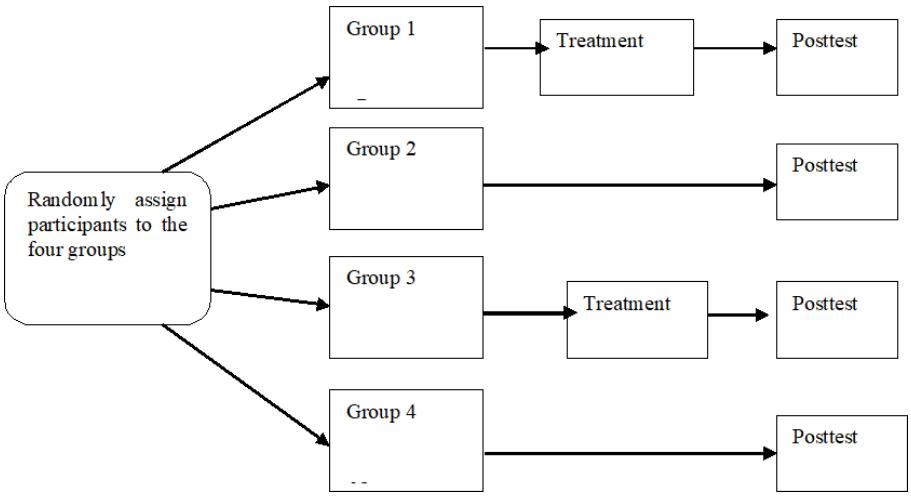
innovation. In the twenty first century , a teacher must be innovative in his/herteaching. A teacher can't use the old methods of teaching and expect their students to succeed in their academic work. Teachers must be adaptive in their teaching sytles. There has to be a paradigm shift in the way lessons are prepared and planned by use of the new technology such as GeoGebra and Grapes. Teachers can't teach the same way they were taught in high school. The other thing which is expected of a teacher is the self confidence when it comes to using technology and handling of ICT resources in teaching mathematics.

Teacher professional factors include awareness of technology, the purpose of using technology and the professional improvement of the teacher. Teachers are expected to be aware of the various types of the latest technology that can be used to teach mathematics such as GeoGebra and Grapes. At the same time a teacher is expected to know the purpose of integrating ICT in teaching mathematics. Certain topics in mathematics are abstract and therefore a teacher should be in a position to use ICT in teaching those topics that are considered to be abstract. Professional improvement is factor expected of every teacher if he/ she want to remain relevant in the teaching of mathematics. New knowdge is emerging every now and again and therefore the only way to get be updated is through teachers's professional seminars such as the ones organised by CEMASTEA at the national level. Seminars for mathematics teachers can also be organised at county or sub-county level. Such seminars equip teachers with the requisite skills on the latest and emerging trends in mathematics teaching such as the use of GeoGebra and Grapes.

RESEARCH DESIGN AND METHODOLOGY

This study adopted Experimental design. In an experiment, investigators may identify a sample and generalize to a population; however, the basic intent of an experimental design is to test the impact of a treatment (or an intervention) on an outcome, controlling for all other factors that might influence that outcome. As one form of control, researchers randomly assign individuals to groups. When one group receives a treatment and the other group does not, the experimenter can isolate whether it is the treatment and not other factors that influence the outcome (Creswell, 2011). The experimental method is a research plan conducted to determine the influence or impacts of a manipulation (Zulnaidi & Zamri, 2017).

Solomon Four-Group Design is a special case of 2×2 factorial design; this procedure involves the random assignment of participants to four groups. Pre-tests and treatments are varied for the four groups. All groups receive a post-test.



Both the experimental and the control groups are first being measured on the dependent variable (pretest). Thereafter the experimental group receives the new treatment or the intervention (the impact of which the researcher is trying to determine), while the control group receive an alternative form of treatment. Both

groups are subsequently measured on the dependent variable again (posttest). The answer to the question whether the new treatment had an effect is obtained when comparing the two groups on the posttest results. Randomization ensures that the two groups are equivalent on statistical grounds, while the pretest may be used as a check to see whether the experimental and the control groups are actually equivalent on the dependent variable. The control and the experimental group received the instructions covering the same concepts of the graph work. The only differences between the two groups were the manner in which the information was presented to the learners.

Target Population

The study was conducted in Bomet County. Form IV Secondary school students formed the target population. They were chosen for the study because there are many topics in Form IV that requires a lot of graphical work. Therefore the use of Grapes and GeoGebra software was handy in teaching graphical work.

Sampling technique and sample size.

Stratified random sampling was used to select the respondents. In this method, the population is divided into different strata (Segments). The items in each segment are homogeneous. Bomet County has got 5 sub counties namely Bomet East, Bomet Central, Chebalungu, Sotik and Konoin. Only four sub counties were picked at random. Schools in each sub county are stratified as per the performance in national examinations and gender. A school is picked at random from the homogenous strata. A total of 120 subjects randomly selected from four schools which are homogeneous were included in the research. The 120 subjects are assigned randomly to the four groups. Each group will comprise of 30 subjects. This design in its four-group form includes two control and two experimental groups, but the experimental groups receive the same experimental treatment. Only one of each of the two types is pretested and all four groups are posttested at the conclusion of the experimental period. The assignment of subjects to all groups is random. Two of the groups receive the treatment and two do not .Furthermore, two of the groups receive a pretest and two do not. Within each treatment condition, one group is pretested and the other is not. By explicitly including testing as a factor in the design, it is possible to assess experimentally whether testing threat is operating. According to Creswell (2011), there is need to control the variables that might influence the outcome in the experimental design. Procedures to place control into experiments involve using covariates (e.g. pre-test scores) as moderating variables and controlling for their effects statistically, selecting homogeneous samples, or blocking the participants into subgroups or categories and analyzing the impact of each subgroup on the outcome (Creswell, 2008).

Research Instruments

Quantitative data collection techniques were used for the study. The main data collection instruments include the following:

(a) Students' pre-test mathematics questions

(b) Students' post-test mathematics questions

Research Variables

The independent variable was the gender of the students. The dependent variables were the outcomes on the post test scores.

Validity and Reliability of the Research Instruments

Content validity is the extent to which the sample items on the instrument provides adequate coverage in the

topic under study. To ensure the content validity of an instrument, the researcher usually presents a provisional version to experts in the field for their comments before finalizing the instrument (Maree, 2016).This was done to ensure that the worksheet covered all the relevant areas on Geometry and graphical work.

Reliability refers to the degree of consistency or whether it can be relied upon to produce the same results when they are used by someone else (Scrimshaw, 1990:89). Reliability is the extent to which a test or procedure produces similar results under constant conditions on all occasions (Yin, 1994). The goal of reliability is to minimize the errors and biases in a study. The objective is to ensure that, if a later investigator followed exactly the same procedures, the same findings and conclusions would result.

The correlation coefficients between the scores of the responses from the questionnaire administered on the two different occasions were used to calculate the reliability coefficient using the Pearson product moment correlation coefficient formula. The reliability coefficient for two sets of the students' questionnaire was 0.70 and 0.72 respectively. According to Kerlinger (1973) and Koul (1984), a positive correlation coefficient, r of 0.5 and above is a strong one and hence the research instruments were deemed reliable.

4.6 Data Analysis

Quantitative data analysis techniques were used. Quantitative data was used to put figures on what existed and what was representative and provide a context for the cases. Quantitative data was processed by editing, coding and analyzed using the SPSS. For descriptive statistics, percentages, frequencies and means were used to explain proportions. Inferential statistics such as Anova, t-test and regression analysis were used to understand relationships between different variables.

FINDINGS

The findings are discussed according to the objective of the study:

The use of Geogebra and Grapes and the performance in mathematics for both boys and girls.

Table 5.1: Results of post test of the experimental group for males and females.

Group	N	Mean	SD
Males	30	76.4000	6.46773
Females	30	73.2000	4.85148

From the table above, it can be seen that the mean for males is 76.40 whereas the mean for females is 73.20. The mean for the boys is slightly higher than that of the girls. It seems the performance of boys is slightly higher than that of the girls.

Table 4.5: One way ANOVA for the experimental group as per Gender Posttest

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	102.400	1	102.400	3.133	.085
Within Groups	1242.000	58	32.684		
Total	1344.400	59			

On further analysis using one way ANOVA it can be seen that the p-value =0.085>0.05. This therefore shows that there is no significant difference between the scores of boys and girls. The students in the two

genders have similar academic ability scores when they are taught using GeoGebra. The findings showed that the improvement in mathematical achievement among the boys was not significantly greater than the improvement in mathematical achievement among the girls. Boys and girls are born with equal mathematical intellectual potential and the slight differences in mathematical achievement could be due to both environmental and cultural factors.

DISCUSSIONS OF THE RESULTS

The objective of the study was: To establish whether the use of Geogebra and Grapes can improve the performance mathematics for both boys and girls.

The use of Grapes and GeoGebra improved the performance of both boys and girls. However, the finding seems to suggest that the use of GeoGebra and Grapes improve the performance of boys more than that of the girls. The findings of the study show the mean for boys was 76.40 whereas the mean for girls was 73.20. The mean for the boys seems to be slightly higher than that of the girls. The difference between the two means is 3.2.

On further analysis using the ANOVA to find out if there was any significant difference between the scores of boys and girls when they are taught using Grapes and GeoGebra, the p-value =0.085>0.05. The null hypothesis was therefore accepted and the conclusion was that there is no significant difference between the scores of boys and girls when they are taught using Grapes and GeoGebra. Boys and girls are born with equal mathematical intellectual potential and the gaps that exist between the two groups are just environmental or cultural.

CONCLUSION

The findings of this study are contrary to what Klein (2008) found out. In his study, he found out that the improvement in mathematical achievement among the girls was significantly greater than the improvement in mathematical achievement among the boys. The findings of this study seems to be in agreement with the findings of Kaiser and Zhu (2022) who found out that boys performed better than girls in mathematics achievement even though the difference was not statistically significant. The findings of this study also seems to be on contrary to the finding of Ajai and Imoko(2015) who found out that female students outperformed their male counterparts in mathematics achievement even though the difference was not statistically significant.

There is a general misconception and belief that mathematics is a masculine subject. Girls should overcome the myth that mathematics is a masculine subject. There is need to remove gender insensitive materials in the curriculum and teaching methodologies. Teachers should not only expect boys to do wonderfully well in mathematics while they expect girls to be just average or below. Girls should not be considered to be inferior in doing mathematics.

RECOMMENDATIONS

1. Teachers should move away from the traditional methods and embrace the use of the new technology in the teaching and learning of mathematics. Use of new technology makes the teaching and learning to be easier. The teaching method used by the teacher should be gender friendly.
2. The teaching and learning of mathematics should involve a lot of practical activities which engage the learners throughout the lesson. The practical activities should be the same for both boys and girls. Teachers should mix boys and girls when they are working on group activities.
3. The teacher should motivate both sexes during practical activities in mathematics. The teacher should

ensure that there is equal participation for both boys and girls and he/she should appreciate ideas from both sexes of the learners.

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