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**THE EFFECT OF GEOMETRY SKETCHPAD ON THE ACADEMIC
ACHIEVEMENT OF STUDENTS: THE CASE OF BEDELE SECONDARY AND
PREPARATORY SCHOOL**

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ABSTRACT

The purpose of this study is to investigate the effect of using the Geometer's Sketchpad software on the academic achievement of students in mathematics among grade nine students of Bedele Secondary and preparatory school. The study utilized a quasi-experimental design using intact group of students from two classes in the indicated school. Two instruments were used to gather information:- the students' mathematics achievement and attitudes/perception of students toward learning Mathematics. A survey questionnaire was used to measure students' perception on the usage of Geometer's Sketchpad in the learning of Geometry and some other topics of mathematics.

In the study, the experimental groups used Geometer's Sketchpad-based topics and worksheets and for each student there is an access computer/plasma equipped with the Sketchpad software. The control group used only the textbooks and they were learnt by usual learning method. Both groups took the same pre-test and post-test. This study indicates that the result of experimental group had a significant mean difference compared to the control group on post-test. The use of Geometer's Sketchpad in mathematics classroom has positive effect on the students' mathematics achievement and attitude towards the learning of geometry and some mathematics topics.

KEYWORDS: Students achievement, Geometry Sketchpad software, student's attitude

INTRODUCTION

Teaching mathematics has progressed throughout time as new devices and methods have been introduced. The challenge has been to identify which devices and methods are helpful and which devices and methods are just different. Change for change's sake is not educationally correct but a change for education's sake is correct. Teachers need to find the most effective way to teach, whether it is "old way" or "new way".

From the abacus (used in 500 B.C. by the Greeks) to the slide rule to the calculator, there have been questions of when/how to teach using new "mathematical inventions", that go on today with the basic calculator and the new graphing calculator. Part of the reason is that everything is being improved upon; consider how many different calculators have been "invented" that do various things. In addition, remember that from the time the slide rule was first "invented" by William Oughtred in 1632, it took until the 1650s for Victor Mayer Amedee Mannheim to make it into its present form. Another eight documented changes were made to it by 1940, the last being in 1936.

The 1970s and 1980s saw calculators and computers entering schools and being placed into school curriculum. Educators' challenges since then have been to incorporate such tools in their curricula so that we are producing positive change. Every new program or calculator is evaluated for its educational usefulness in the classroom for that specific teacher. These changes and new programs will continue to be made to help education, just as the slide rule, etc... was changed many times.

Today, each school in Ethiopia has a goal of producing better students each year and teachers work very hard to raise achievement levels so that this goal can be accomplished. Dynamic software is important because it forces students to interact with it, which should produce a greater understanding of what is being worked on. One tool



that can be used to accomplish this goal is dynamic software. The software that I have found to be worthwhile at a variety of grade levels and subjects, while still being able to teach and reach students in a way that can't be done as effectively in any other way, is Geometer's Sketchpad, which is published by Key Curriculum Press.

The National Council of Teachers of Mathematics (NCTM), in its publication, Curriculum and Evaluation Standards for School Mathematics, states, "The new technology not only has made calculations and graphing easier, it has changed the very nature of the problems important to mathematics and the methods mathematicians use to investigate them." Later in the publication the NCTM says, "Students should learn to use the computer as a tool for processing information and performing calculations to investigate and solve problems".

With the emergence of computer technology in most homes, mathematics educators feel computer software is an effective tool to increase learning. Due to lower costs, more homes now have computers and computer software. Because of this, parents are seeing how their children can learn some things better with technology and want the schools to readily adopt this attitude also. The NCTM has even made Technology one of its six Principles of Mathematics, in its publication Principles and Standards in Mathematics, saying "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning."

One type of dynamic software that has been commonly accepted is dynamic geometry Sketchpad software, often referred to as DGSP. Geometers' Sketchpad provides a flexibly structured mathematics laboratory that supports the investigation and exploration of concepts at a representational level, linking the concrete to the abstract. Mathematical ideas can be explored from several different perspectives in an efficient manner, resulting in deeper conceptual understanding (Kaput and Thompson, 1994). Through repetitive experiences of exploring, problem skills and one's ability to assimilate ideas are enhanced (Cooper, 1991). Students should be viewed as active learners and teachers as facilitators of learning.

The GSP is an interactive and dynamic computer program that can be used to help students learn and understand geometrical concepts and principles. "The GSP lets the user explore simple, as well as highly complex, theorems and relations in geometry" (Giamatti, 1995, p.456).

It also "has the ability to record students' constructions as scripts. The most useful aspect of scripting ones' constructions is that students can test whether their constructions work in general or whether they have discovered a special case" (p.450). In addition, the GSP software provides the process of learning and teaching mathematics by a remarkable help because "the power of the GSP combined with the power of proof gives a complete illustration of the theorem involved and the aspects of "doing" mathematics" (p.458).

Students have many reasons for making a sketch with the GSP. "Their purpose may be to explore the behavior of a particular geometric figure, such as a rhombus, or to model a physical situation, such as a ladder leaning against a wall. They may want to make a beautiful pattern inspired by Navajo rug designs, or their goal may be an animation perhaps a Ferris wheel or a merry-go round" (Finzer and Bennett, 1995, p.128). The most important thing about the GSP Software is that GSP is an active dynamic program with a useful feature by using the mouse interface for graphics and high speed.

In our country most of the time the teaching and learning of mathematics has been reported to be too teacher centered and that students are not given enough opportunities to develop their own thinking in many secondary schools. This situation invariably results in students becoming passive receivers of information, which in many cases do not result in conceptual understanding. Many students are not able to comprehend what their mathematics teachers teach especially on the topic of geometry because mathematics content is taught with the intention of finishing the syllabus and preparing for examination. Little regard is given to how well the students understand geometrical concepts. On the topic of geometry, students encounter difficulties in applying what they have learnt as they were not given enough time to understand the geometry concepts. Instead they were just memorizing the concepts. Thus, the researcher wants to investigate the effect of using Geometry Sketchpad on the achievement of grade nine students in learning of geometry.

Statement of the problem

In our country learning geometry may not be easy, and a large number of the students fail to develop an adequate understanding of geometry concepts, geometry reasoning, and geometry problem solving skills. The lack of understanding in learning geometry often causes discouragement among the students, which invariably will lead

to poor performance in geometry. A number of factors have been put forward to understand why geometry learning is difficult geometry language, visualization abilities, and ineffective instruction (Cangelosi, 1996; Noraini, 2006).

Poor reasoning skills are also another area of concern among secondary school students. Many are unable to extract necessary information from a given data and many more are unable to interpret answers and make conclusions. Usual approaches in learning geometry emphasize more on how much the students can remember and less on how well the students can think and reason. Thus learning becomes forced and seldom brings satisfaction to the students. This study designed to explore the effects of Geometers' Sketchpad on the achievement of grade nine students in geometry.

The questions answered in this study are as follows:

- Is there significant mean difference between the comparable and experimental group on Pretest and Posttest?
- Is there significant difference between the mean scores of high and low achievers of control and experimental groups on Pretest and posttest?
- Is there significant difference between the mean score of high and low achievers of the control and experimental groups on retention test?
- What are the perceptions of students about learning by using GSP?

Hypothesis of the study

There were four hypotheses in the study:

- There was a significant difference between the means of the pretests and the posttests for the experimental group.
- There was a significant difference between the means of the pretests and the posttests for the control group.
- The mean of the pretest results for the experimental group was equal to that for the control group.
- The mean of the posttest results for the experimental group was greater than that for the control group.

Purpose of the study

The purpose of this study was to analyze the effect of using Geometry Sketchpad on students' mathematics achievement in teaching of some units of mathematics of grade 9.

The objective of this study was:

- Determine whether learning by Geometry Sketchpad is more effective than the actual method of teaching with respect to academic achievements of students in mathematics.
- Examine the effect of using Geometry sketchpad on the academic achievements of students in Mathematics.
- Identify the effect of using Geometry Sketchpad on the retention of students in Mathematics.
- Examine the general perceptions of students towards Geometry Sketchpad.

Significance of the study

Some of the benefits obtained from this study were:

- ❖ The participating school will be benefit because the results of the study used as a guideline for other teachers in their classrooms. So the result of the study will contribute much to help teachers to structure their previous experience so as to make the lesson more practical and student centered.
- ❖ The curriculum workers will also benefit out of this study because it helps them to get some information using this study as a stepping stone.
- ❖ Students will also benefit from the study since they learned by using an improved method which enhances their achievement scores as well as their social skills.
- ❖ Finally, the results from the study could serve as a springboard for other researchers.

Operational Definition

Geometer's Sketchpad: A computer program allowing the user to design, manipulate, and measure geometrical figures.



RESEARCH DESIGN AND METHODOLOGY**Research Design**

Since the classes existed as intact groups and could not be reconstituted for research purposes, the study was quasi-experimental that uses pretest posttest non-equivalent group design. In this study the researcher used quantitative approach to compare the pretest as well as the posttest scored of the two groups namely the students who learnt through Geometry sketchpads and the students who learnt through usual classroom instruction for grade nine students. In addition to this, questionnaires were used to investigate the perception of the participants towards using Geometry Sketchpad instruction quantitatively.

Symbolically the design looks like

Experimental	O1	X	O2	
			
Comparable	O3		O4	

Where, O1 and O3 represented the pretest for experimental and comparable group respectively and O2 and O4 represented posttest for experimental and comparable group respectively. X indicates Geometry Sketchpad.

DATA SOURCE**Target Population**

The target populations of this study were grade 9 secondary school students in Bedele secondary school in Illu Abba Bora zone which is located at Western part of Ethiopia in Oromia Regional State. The researcher selected the school purposely because it is convenient to conduct the research by giving a treatment in a school which has available computer lap and experienced teachers about the study area.

Sampling technique

Random cluster sampling techniques were used to identify the two sections participating in the study for this grade level from the population. The researcher used random sampling technique since at the start of the academic year; the school has assigned the students into different sections of grade 9 based on their previous performance of students. So the researcher taken by mixing high, low and medium achievers as well as male and females students almost with equal proportions in all of the sections according to data obtained from the school. Again random sampling techniques used to assign the selected sample sections in to the experimental and comparison group.

Method and Instrument of Data Collection**Method**

Three steps were used to collect data for the study. First, relevant literature revised to get adequate information on the topic. Second, objectives and research questions formulated to show the direction of the study. Third, data gathering tools developed and piloted. Then after the treatment and comparison groups randomly assigned, the students in both groups were pre tested on their previous knowledge of course content.

After the treatment, the researcher prepared posttest for both experimental and comparison groups at the end of each unit treated to find out whether there is any achievement difference between the marks of the posttest scores of both groups of students. Questionnaires was also distribute and collected from the students which treated in a Geometry Sketchpad at the end of treatment.

Instruments of data collection

Two instruments used to collect data. These are Mathematics Achievement Test and questionnaires.

Procedure of the study

Two teachers having equal qualification, equal teaching experience in teaching mathematics and comparable GPA selected from the selected secondary school purposely. For The teacher who thought the experimental group some sort of training was provide on Geometry Sketchpad by the researcher for two days. The training contained about Geometry Sketchpad, experience with Geometry Sketchpad activities, and implementation of Geometry Sketchpad.

Then after the implementation the method was go on for two months.

Method of data analysis

As an experimental research, there were dependent and independent variables associated with this research.

Dependent variables: The dependent variables need to be focused and measured in this research was the students' mathematics achievement, although the intervening variable such as varying motivation of students towards each of the methods. It was one of the treats to experimental research consisting of human subjects.

Independent variables: The independent variables of this research were the dynamic Geometry software. The cofounding extraneous variables as sex, age, and students' achievement level (low or high achiever) were thoroughly take care of by the researcher.

In order to analyze the collected data the researchers used the independent sample T-test for comparing experimental and Comparison groups of grade 9 students in terms of their pretest as well as posttest achievements separately.

Selection and training of teachers for the experiment

One volunteer teacher selected from the mathematics teachers of this secondary school. After that, for this volunteer teacher training was given for two days about Using Geometry Sketchpad by the researchers. Contents of this training include:

- i. The General Concept of Geometry Sketchpad.
- ii. Experience with Geometry Sketchpad activities.
- iii. Class climate building techniques.
- iv. Team building techniques.
- v. Strategies for students centered learning
- vi. Lesson planning.
- vii. Social skills and Implementation of Geometry Sketchpad.

DATA ANALYSIS AND INTERPRETATION

Table 1: Significance difference between the mean scores of the experimental and comparison groups on Pretest

Group	N	M	SD	S E	t
Control Group	40	34.14	13.54	2.76	-0.3 66*
Experimental Group	40	34.88	12.59		

t at 0.05=1.98

Table 1 indicates the difference between the mean scores of the experimental and comparison group on pretest was found to be insignificant (t calculated < t critical, p > 0.05) at 0.05 levels for. Hence, both of the groups were almost to be equal.

In order to check for the dependence of the effectiveness of using GSP on the achievement level of students', it is necessary to see whether there is a significance difference in mean scores of high achievers as well as low achievers of the two groups on pretest. This was a necessary condition so as to compare the results of the posttest score of the two groups. The obtained data's from the pretest are presented as follows

Table 2: Significance of difference between mean scores of high achievers of experimental and comparison group on pretest

Group	N	M	SD	S M	t
High achievers for Experimental Group	20	45.25	4.15	1.24	-0.42*
High achievers for Control Group	20	45.77	4.11		

t at 0.05= 2.03

Table 2, reflects that no significant difference (t calculated $< t$ critical, $p > 0.05$) was found between mean scores of high achievers of the experimental group and high achievers of the comparison group on pretest. Hence, there was no significant difference in the performance of high achievers of the experimental group and the comparison group on the pretest.

Table 3: Significance of difference between mean scores of low achievers of the experimental group and comparison group pretest.

Group	N	M	S D	S M	t
Low achievers for Experimental Group	23	24.96	9.48	2.76	0.709*
Low achievers for Control Group	23	23	9.22		

t at 0.05= 2.02

Table 3 shows that there was no significance difference between the performance of low achievers of the experimental and comparison group on the pretest.

In general, comparison of pretest scores of both the experimental and comparison groups by applying statistical analysis reflected the existence of no significance difference between the two groups (Table 1) and hence, both the groups were almost equal with respect to the mathematics units treated in this study. Moreover, the comparison between mean pretest scores of high achievers of the experimental and comparison groups shows that the difference between mean scores on pretest was in significant at 0.05 levels (Table 2) indicating that those high achievers of both the experimental and the comparison groups were almost equal at the beginning of the experiment for the mathematics units treated. Similarly, the difference between the mean scores on pretest of low achievers of both the experimental and comparison groups was also insignificant at 0.05 levels (Table 3). This also shows that low achievers of both the experimental and the comparison groups had almost equal mathematics base at the commencement of the experiment.

After using GSP in order to cover some mathematics units for grade 9, the academic achievement of the comparison group and experimental group was examined through a researcher made posttest. The obtained results are presented as follows.

Table 4: Significance of difference between mean scores of the experimental and comparison group on posttest

Group	N	M	SD	S M	t
Control Group	45	32.69	19.66	3.58	-12.78*
Experimental Group	45	78.4	13.75		

t at 0.05= 1.98

Table 4 reflects that at the end of the using GSP, the difference between the mean scores of the experimental and comparison groups was significant on posttest.

Students who are learn by using GSP were significantly higher test scores than students in the comparison group.

Table 5: Descriptive Statistics for the Control and the Experimental Group on post-test

Group	N	M	SD	S M	t
Control Group	45	30.93	19.25	3.51	-13.55*
Experimental Group	45	78.56	13.61		

t at 0.05= 1.98

Table 5 reflects that at the end of the experiment, the difference between the mean scores of the experimental and comparison groups was significant on retention test which was distributed for both comparison and experimental groups after three weeks. This result indicates that the students taught by using GSP internalize the concept and those students learnt by usual approach taught the concept for the sack of memorization.

Table 6: Significance of difference between mean post-test scores of the experimental group and comparison group

Group	N	M	SD	SM	t
High achievers for Experimental Group	22	90.73	5.33	3.47	12.12*
High achievers for Control Group	22	46.5	16.26		

t at 0.05= 2.03

Table 6 reflects that at the end of the experiment, the difference between the mean scores of high achievers of experimental and comparison groups was significant on retention test which was distributed for both comparison and experimental groups after three weeks.

Table 7: Significance of difference between mean scores of Low achievers of experimental group and comparison group on Retention test

Group	N	M	SD	S M	t
Low achievers for Experimental Group	23	66.91	7.32	1.72	29.6*
Low achievers for Control Group	23	16.04	3.78		

t at 0.05= 2.02

Table 7 reflects that at the end of the experiment, the difference was significant at 0.05 levels between the mean scores of low achievers of experimental and comparison groups on retention test in favor of experimental group.

Table 8: Significance of difference between mean scores of high achievers of experimental group and comparison group on posttest

Group	N	M	SD	S M	t
High achievers for Experimental Group	22	90.73	5.32	3.77	11.22*
High achievers for Control Group	22	48.5	16.84		

t at 0.05=2.03

Table 8 indicates that, there was a significant difference (t calculated > t critical, $p < 0.05$) for experimental group students between posttest achievement score averages of high achiever of the experimental and comparison group students after the experiment.

Table 9: Significance of difference between mean posttest scores of low achievers of the experimental group and comparison group

Group	N	M	S D	S M	t
Low achievers for Experimental Group	23	66.61	7.32	1.69	29.01*
Low achievers for Control Group	23	17.52	3.50		

t at 0.05=2.02

According to table 9, at the end of the application, the difference was found significant at 0.005 level between the mean scores of low achievers of the experimental and comparison group on posttest.

Hence, the comparison of mean scores of high achievers of the experimental and comparison groups on posttest (Table 8) reflects a significant difference at 0.05 levels. Similarly, the comparison of mean scores of low achievers of both the experimental and comparison groups on posttest (Table 9) shows a significant difference at 0.05 levels in favor of the experimental group.

RESULTS AND DISCUSSION

This research was designed to study the effect of using the GSP on students' understanding of some of the geometrical concepts. From the results obtained, a number of implications can be forwarded in the interest of improving the effect using geometry sketchpad in academic achievement of secondary school students.

Firstly, the significant differences in geometry achievement of the experimental group as compared to the control group indicate that the Geometer's sketchpad shows promising implications for the potential of using the Geometers' Sketchpad improving academic achievement students at the secondary school level. This observation can therefore encourage classroom teachers and even curriculum developers of the potential of the Geometer's sketchpad as effective tool in learning geometry.

The significant improvement of geometry achievement on account of the specially Geometers' Sketchpad used in this study also suggest that there is a need to provide more interactive and hands-on learning activities for geometry learning at the secondary school level.

From the results obtained, a number of implications can be put forward in improving mathematics teaching and learning.

Firstly, the significant difference of the pretest and posttest mathematics achievement test indicates that Geometers' Sketchpad is possibly contributing in the learning Mathematics. This will further encourage teachers on the potential of using Geometer's Sketchpad as an effective tool in learning mathematics. These result is consistent with the Teoh & Fong (2005) study among high school algebra students, which reported that the mean post-test scores of the experimental group was significantly different with the control group. They also found out that the effects of using Geometer's Sketchpad in teaching and learning of quadratic function does enhance the students learning. According to the same study, the researcher encouraged teachers to continue using the software or to start if they have not. The only issue is about teachers' enthusiasm and willingness in the usage of Geometer's Sketchpad. Almeqdadi (2000), Embse (1996) and McClintock (2002) have also found Geometer's Sketchpad to be effective in learning by the way of visualization in the various areas in mathematics. Almeqdadi further suggested the increase usage of Geometer's Sketchpad in investigating mathematical problems. His study also had proven that Geometer's Sketchpad had positive effects on students' understanding of geometrical concepts. The result of this study also supports the findings of Lester (1996) which mentioned that Geometer's Sketchpad provides intelligent capabilities for improving teaching and learning. Noraini Idris (2001) also conducted a quasi-experimental research on the effects of a van-Hiele based instructional activities with Geometer's Sketchpad on van Hiele levels. The result she obtained indicated a significant difference between the treatment and control groups in rank on van Hiele levels from pre-test to post-test. The researcher concluded that the significant improvement of geometry achievement using the specially prepared van Hiele based instructional with Geometer's Sketchpad indicated the need to provide more interactive and hands on learning activities for geometry learning in lower secondary schools.

In addition, the increase in scores from the pretest and posttest also indicates that the students usage of Geometer's Sketchpad does help in graphing of functions. Geometers' Sketchpad will be a tool in improving students understanding in mathematics concepts in relevant topics. According to NCTM (1999), "Calculators don't think, students do". This also applies to the Sketchpad. Students need to understand the mathematics problem they are solving.

With that information, then only they can decide what operations to use and take the next action. Therefore, software like Geometer's Sketchpad does make students to think and explore to find the solutions. Purdy (2000) also discovered that in a maximum-volume problem, Geometer's Sketchpad helps in the practical exploration of the problem. Furthermore, he discovered that his students have been lead to a deeper understanding of the problem and its solution as a result of their exploration.

Secondly, the significantly better results in the Attitude Test (perception of students) achieved by the experimental group of students implied that the learning of graphs functions with the Geometer's Sketchpad had been beneficial and useful for the students. The students seems to have a more positive attitude in the graphing of algebraic functions, trigonometric functions and absolute value functions while using Geometer's Sketchpad. Students are enjoying the lessons of graphing functions and also able to interpret the properties of the graphs of the functions better with Sketchpad. These findings support the results of Groman (1996) that students reaction is overwhelmingly positive on using Geometer's Sketchpad in mathematics class. Furthermore, the usage of Geometer's Sketchpad indicated a more positive reaction from both the students and instructors in developing conjectures and constructions. Garofalo and Bell (2004) showed how Geometer's Sketchpad sketches could be extended and expanded to different levels to enrich the teaching and learning of mathematics.

According to Rahim (2002) in his study on classroom use of Geometer's Sketchpad by pre-service teachers showed that the attitude of the teachers range from uncertainty to overconfidence about the potential of the software. Most of the teachers agreed that the software is useful in investigating and discovery and it would be useful to use in other areas of mathematics such as trigonometric, geometry and algebra.

CONCLUSIONS

Initially, there was no significant difference in the pre-test scores for experimental or control group achievements. However, throughout the study, the experimental group had higher geometry achievement than the control group, and the difference was statistically significant. The research question has clearly been answered positively. In addition, the current research shows that the stratification of students groups according to their improvement in the testing (*low, medium, high*) is inversely proportional to the level of their success.

The *Geometer's Sketchpad* provides a unique way of investigating geometric notions that will undoubtedly assist some students. It might take the form of enrichment or a classroom demonstration but students should have some exposure to technology in their high school geometry class. Failing to use such powerful technological tools in a society, where computers permeate the culture is a missed opportunity in showing the relevance of geometry to modern life.

In conclusion, this study suggests that the use of Geometers' Sketchpad in the mathematics classroom is useful in helping students perform better in Geometry and some other mathematics topics. Furthermore, students have a positive attitude towards learning of Geometry and other topics of mathematics with the usage of Geometer's Sketchpad. Consequently, the Geometers' Sketchpad also encourages students to learn the Geometry in a more enjoyable and interesting way.

RECOMMENDATIONS

According to the results of this study, the researcher had some suggestions and recommendations:

1. This study had the sample from students in the 9th grade. This means that there is a need for further studies in other grades and levels.
2. Since this study as well as other previous studies concluded that there was a significant effect of using the GSP software, the researcher recommends more emphasize on the use of computer and its programs in mathematics and in education.
3. The GSP is one of the latest computer programs in the mathematics area. It is recommended to evaluate its features and capabilities.

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