Teachers' perspectives towards use of technology, the case of GeoGebra in teaching Mathematics in Kenya

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***Abstract*- This study looks at GeoGebra as a type of technology and assesses teachers' perspective towards training and use of GeoGebra as a tool to enhance learning of mathematics. This paper is reporting the findings of a larger study that was conducted in Kajiado County in Kenya (Africa) on GeoGebra use in teaching Secondary School Mathematics. The study sought to relate teachers' perceptions towards uptake of technology and the actual uptake of technology as indicated by the Diffusion Innovation Model. The findings after training sessions with the mathematics teachers showed that the mathematics teachers were willing to use GeoGebra in their classes. The teachers said that among all topics, they felt that Geometry was the most complicated to teach and that GeoGebra was a welcome solution to this problem. Teachers' responses indicated that GeoGebra is useful for teaching and learning Mathematics and that it would help learners grasp concepts in Geometry.**

***Index Terms*—1. GeoGebra, 2. Geometry, 3. Technology, 4. Secondary school Mathematics- refers to high school math.**

I. Introduction and Literature Review

Some of the main areas of study in secondary school mathematics include Algebra, Geometry, Calculus, Trigonometry, Probability and statistics. Technology has been used in various areas in mathematics including Algebra (Wilson 2000), in statistics (Abrahamson and Wilensk, 2007) and in Geometry (Cobo, Fortuny, Puertas and Richard 2007). Some of the computer software available for teaching and solving mathematical problems include, Spreadsheets, Dr Geo, dynamic geometry software, Matlab, and GeoGebra among others. Since it is not possible to study all these available computer applications at the same time, the study will look at GeoGebra and how it can be useful in the Kenyan Mathematics curriculum, specifically in the area of Geometry.

GeoGebra is a community-supported open-source mathematics learning environment that integrates multiple dynamic representations, various domains of mathematics, and a rich variety of computational utilities for modeling and simulations. Invented in the early 2000s, the aim of GeoGebra was to implement in a web-friendly manner the research-based findings related to mathematical understanding and proficiency as well as their implications for mathematics teaching and learning. One can easily download the software on (http://www.geogebra.org) and hence use it in teaching A mathematically competent person has the ability of coordinating various representations of a mathematical idea in a dynamic way and further gain insight into the focal mathematical structure (Bu, 2011). This therefore makes GeoGebra very important to a teacher of mathematics as they have the relevant competence in mathematics. In the fields of learning sciences and instructional design there has been several highlights by researchers on the theoretical and practical implications of *mental models* and *conceptual models* involving complex human learning (Milrad, et al, 2003; Seel, 2003). GeoGebra comes in as an important tool to enhance visualization in Geometry.

Geometry has been defined by various scholars; "Geometry is a complex interconnected network of concepts, ways of reasoning, and representation systems that is used to conceptualize and analyze physical and imagined spatial environments" (Battista 2001a). Geometry is also defined as a branch of Mathematics that is concerned with shapes, sizes, relative position of figures and the properties of space. Geometry is the branch of mathematics concerned with lengths, areas and volumes (En.wikipedia.org/wiki/geometry). Geometrical definitions have to do with space and shape. Hence when defining a geometrical shape, properties such as angles and measurements are used. According to (Clements and Battista, 1990) "underlying most geometric thought is spatial reasoning which is the ability to see, inspect and reflect on spatial objects, images, relationships and transformations". In the process of teaching topics and concepts involving Geometry, the teacher expects his/her students to be able to visualize figures, shapes and planes that many not be very obvious to the student. This concept is what makes geometry unique and difficult to learn and teach. This is because spatial ability is not easy for all students. Complications experienced in teaching and learning of Geometry as sited in the second handbook of research on mathematics teaching and learning, Battista (2007), include:

i) Conception affects perception since what one sees is affected by what one knows and conceives.
ii) Diagrams as data or representations. It is through analyzing the geometrical diagrams that concepts are derived. According to (Chazan and Yerushlmy

1998), "diagrams are aids for intuition and are not necessarily the objects of study themselves" P70. The diagrams used in mathematics are representations of the actual object. In teaching the concepts of geometry therefore, the teacher is faced with the task of helping learners 'see' the objects represented in the image and further derive some meaning from it.

II. Theoretical framework

This research paper is based on the Diffusion of innovation model by Rogers (1995). DIM is a theory that seeks to explain how, why, and at what rate new ideas and technology spread through cultures. It explains four main elements that influence the spread of a new idea. These elements include: innovation, communication channels, time, and social systems.

Problem Statement

Looking at the Kenyan Secondary school mathematics, some of the topics that fall under this broad branch of Mathematics; Geometry include Area, volume, geometrical constructions, trigonometry, among others. According to Kenya National Examinations Council (KNEC) reports, Mathematics' mean scores have remained low over the years, despite the technological advancement. There has been development of technologies to enhance teaching and learning of Mathematics over the years but this trend of poor performance in Mathematics has not changed. A closer look at the KCSE reports, questions recorded as being difficult were mostly seen to be from the broader category of mathematics that is Geometry.

Table 1.1 Number of questions listed as difficult in KCSE.

Year of Exam	Paper	Number of Questions Listed as Difficult	Questions in Geometry	Percentage of the Difficult Questions in Geometry
2008	1	6	4	67
2008	2	7	4	57
2009	1	10	5	50
2010	1	7	4	57

Source: KNEC reports (2010,2011,2012)

It is observed that more than other areas in secondary school mathematics, questions in Geometry are poorly performed. This study tried to assess mathematics' teachers' willingness to embrace technology, specifically GeoGebra in teaching Geometry in secondary schools in Kenya.

III. Objectives

This paper sought

a) To find out mathematics teachers' training and competences towards use of technology
b) To establish Mathematics teachers perceptions towards the usefulness of GeoGebra in Kenyan Secondary school mathematics.

IV. Methodology

The study followed a qualitative approach and was conducted in secondary schools in Kajiado County, Kenya (in Africa). This paper was aimed at establishing the uptake of technology among the Secondary school Mathematics teachers in the county. Therefore, the target population was the Secondary school mathematics teachers who were 149 in number at the time this data was collected. Out of these, 22% was selected using simple random sampling. These teachers were trained on the use of GeoGebra for teaching Geometry. The teachers were then required to fill in a questionnaire on their experiences during training and their expectations in using the software. The findings were then analyzed and reported in form of a descriptive survey.

V. Findings

Gender of the Teachers in the county

Kajiado county had 149 mathematics teachers by 2nd term 2014, this number is however not static since there is high mobility of teachers from one school to another and also by exiting from the service. The researcher sampled 33 of these mathematics teachers, both male and female. This is 22% of the total mathematics teachers in the county. Table 1.2 shows the population of male and female mathematics teachers in the county.

Table 1.2 *Population of Mathematics Teachers in Kajiado County*

	Frequency	Percent
Male	107	71.8
Female	42	28.2
Total	149	100.0

SOURCE: TSC office Kajiado County.

Table 1.3 *Gender of the Sampled Teachers*

	Frequency	Percentage
Male	23	21.5 of male
Female	10	23.8 of female
Total	33	

As Table 1.3 shows, the teachers' sample was comprised of 23 male and 10 female teachers. These figures represent 21.5% of all the male teachers and 23.8% of the female mathematics teachers. This shows that there was a fair distribution in terms of percentage of the total male and total female teachers. The sampled teachers were proportionately picked through simple random sampling. Out of a total of 149 mathematics teachers in the county, only 28% comprised of female teachers while the higher percentage of mathematics teachers were male. This finding is important because it reinforces the notion that mathematics is a difficult subject that girls are not particularly good at, hence the lower number of female teachers. This seems to be in agreement with the report of AAUW (2008) on "Where the girls are:" the report shows that there are few women in STEM; Science, Technology Engineering and Mathematics. The notion that mathematics and STEM is not for girls needs to be dispelled by demonstrating to students that

both boys and girls can excel in the subject and GeoGebra is a tool that can be used by both boys and girls to learn mathematics on a common platform.

VI. Type of School Teachers were Sampled From

The study incorporated teachers from three types of schools, namely: boys' schools, girls' schools and mixed schools. Table 4.3 shows how the teachers' sample was distributed in the three types of schools

Table 1.4 ***Teachers' Distribution in the Three Schools***

	Frequency	Percent
Boys only School	9	20.0
Girls only School	9	20.0
Mixed gender School	15	60.0
Total	33	100.0

A look at Table 1.4 reveals that nine teachers were drawn from boys' schools, nine from girls' schools and 15 from mixed schools. Roughly one half of these teachers were teaching boys and the other half were teaching girls. This was important for the study because the researcher needed the perspectives of teachers teaching both male and female students.

Sampled Teachers' Teaching Experience

The study included teachers who had taught for varied periods of time in the sample. Figure 1.1 shows the duration for which the teachers had been teaching mathematics by the time the study was conducted.

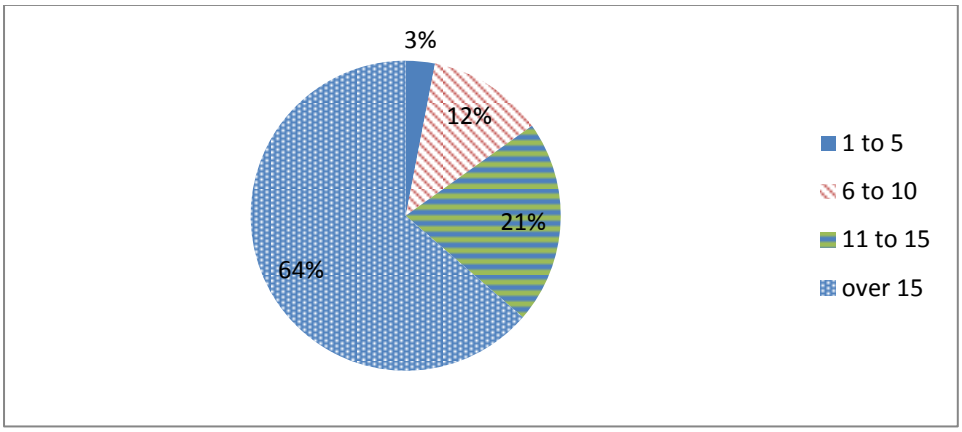

Figure 1.1 Duration ***Respondents had been Teaching Mathematics***

An examination of Figure 1.1 reveals that 21 of the teachers, accounting for 64% of the sampled teachers had been teaching mathematics for more than 15 years. Only four of the teachers had taught for less than ten years. The study benefited from the fact that the teachers sampled had many years teaching experience. They not only had teaching skills developed over many years, they also understood the challenges of teaching mathematics in secondary school and could identify the most difficult and poorly performed topics.

Teachers' Level of Professional and Pre-service Training

The teachers were requested to state the highest level of professional training they had undergone. Their responses are summarized in Table 1.5

	Frequency	Percent
Masters Degree	7	21.0
Bachelors Degree	25	76.0
Diploma	1	3.0
Total	33	100.0

Table 1.5 reveals that 25 teachers had bachelor's degrees while five had masters' degrees in various fields. Only one teacher had a diploma. Therefore, the teachers who participated in this study could be said to be sufficiently qualified to teach mathematics by virtue of their levels of training. In addition, all the teachers except on had computer related training and qualification. Figure 1.2 shows the computer related skills the teachers have mastered

Table 1.5 Teachers' Level of Training

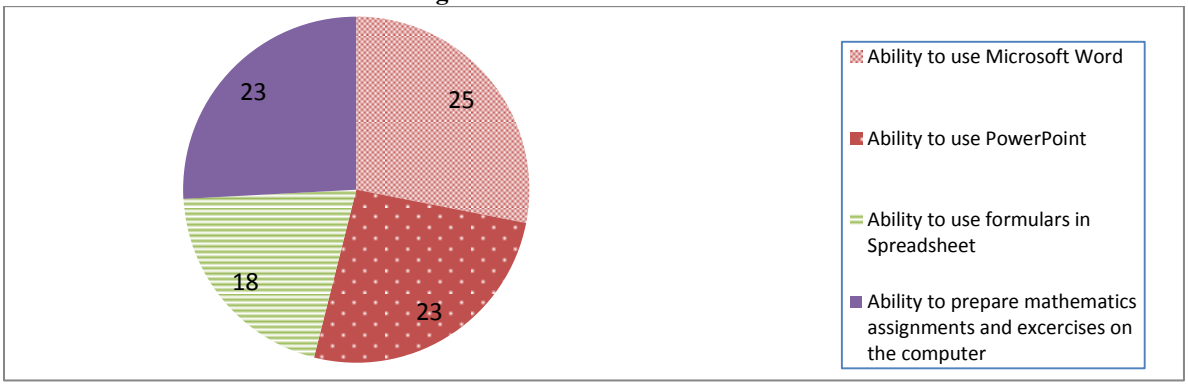

Figure 1.2 ***Teachers' Computer Skills***

Figure 1.2 reveals teachers computer skills. All the teachers capable of using Microsoft word and all but two are capable of using PowerPoint and preparing assignments and exercises on computers. Eighteen teachers were able to use formulas in spreadsheets. This information leads to the conclusion that most of the teachers are skilled in using computers therefore they would have no problems using teaching software such as GeoGebra.

Areas of Mathematics Teachers found Difficult to Teach

The teachers participating in this study were asked to state the areas of mathematics they found difficult to teach and note the reasons behind difficulty teaching those areas. Their responses are presented in Figure 1.3

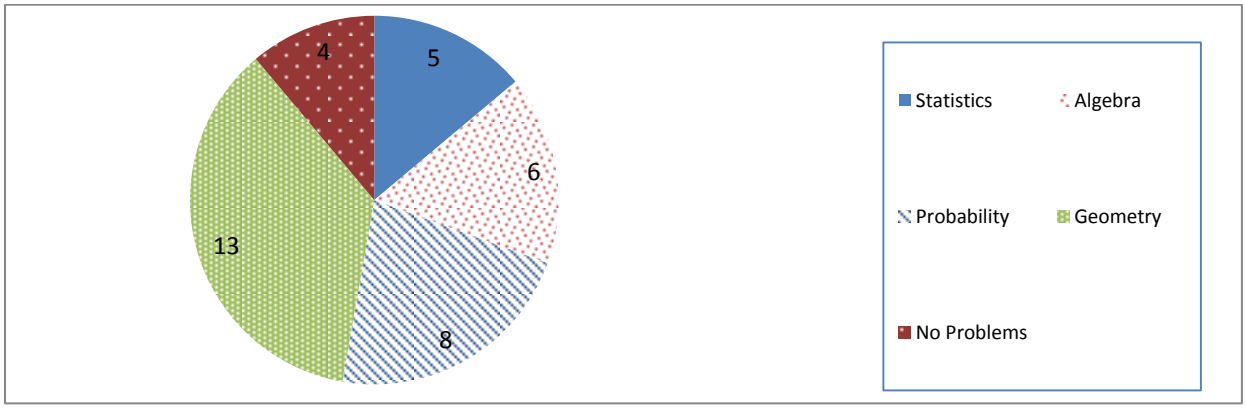

Figure 1.3 ***Teachers with Difficulties Teaching Mathematics***

The responses summarized in Figure 1.3 show that only four teachers are facing no problems teaching mathematics. Geometry is the most challenging area to teach followed by algebra. It is noteworthy that more than half the teachers face difficulty teaching geometry and six of them face difficulties teaching algebra –the two topics GeoGebra is designed to help teach. The teachers having trouble teaching geometry cited lack of resources for teaching, the abstract nature of geometry and students' inability to visualize 3-dimensional images as the main impediments. For algebra, they cited students' difficulties comprehending complicated expressions and the abstract nature of the topic.

Teachers' Perception of their Competence in using GeoGebra after Training

The study sought to find out teachers' perception of their competence with GeoGebra after they received training on how to use it to teach mathematics. The teachers were presented with five items to gauge their competence by responding on each item on a scale ranging from strongly disagree, agree, not sure, agree and strongly disagree. Figure 1.4 presents a summary of the teachers' perception of GeoGebra

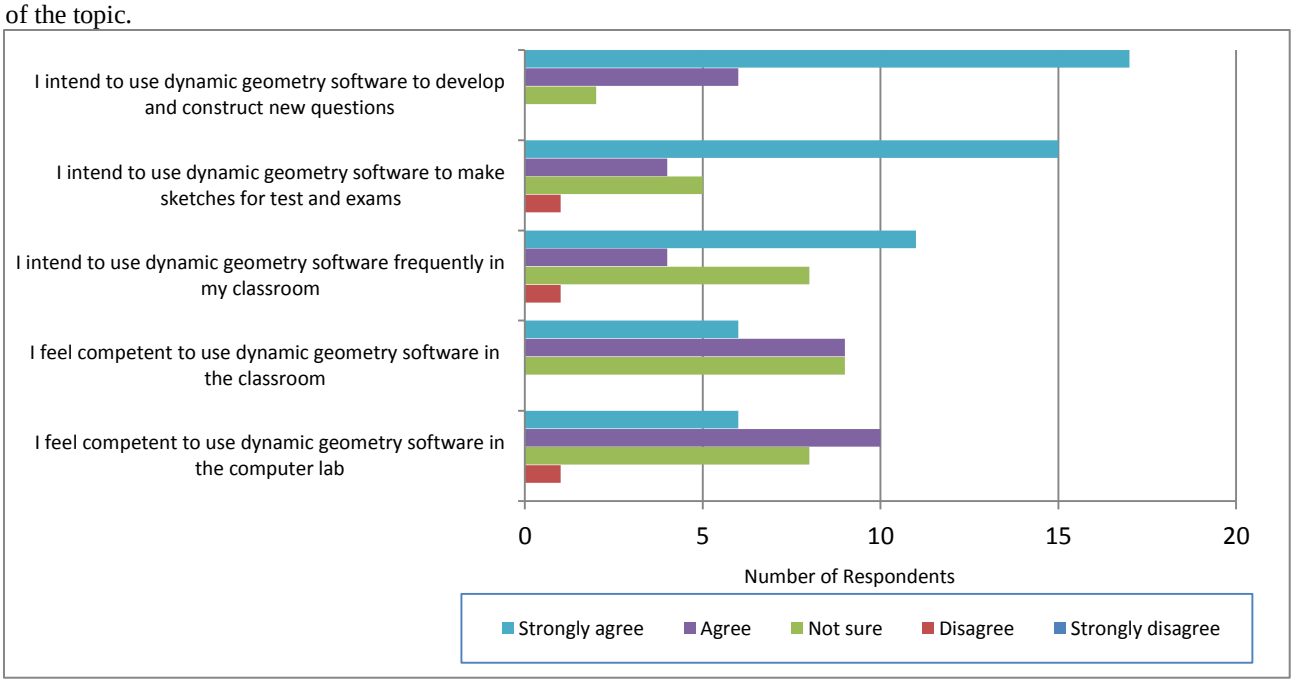

Figure 1.4 ***Teachers' Perceptions of their Competence with Dynamic Geometry Software***

The information summarized in Figure 1.4 reveals teachers' perception of their competence with GeoGebra after they received training on how to use it. It is possible to discern teachers' intentions for using the software and how competent they feel about using the software. To start with, 23 teachers intend to use the software to develop and construct new questions while two teachers are not sure, 19 teachers intend to use the software to make sketches for tests and exams with five teachers not sure and one disagreeing and 15 teachers intend to use the software frequently in class with eight not sure and one disagreeing. These findings lead to the conclusion that teachers who have been trained on using GeoGebra have noted its usefulness and are most of them are willing to adopt it.

Teachers' Perception of GeoGebras' Usefulness

After training the teachers on using GeoGebra to teach mathematics, the researcher sought to find out whether the teachers considered it useful. The teachers were asked to rate five items in a continuum in the questionnaires. Their responses are summarized in Figure 1.5

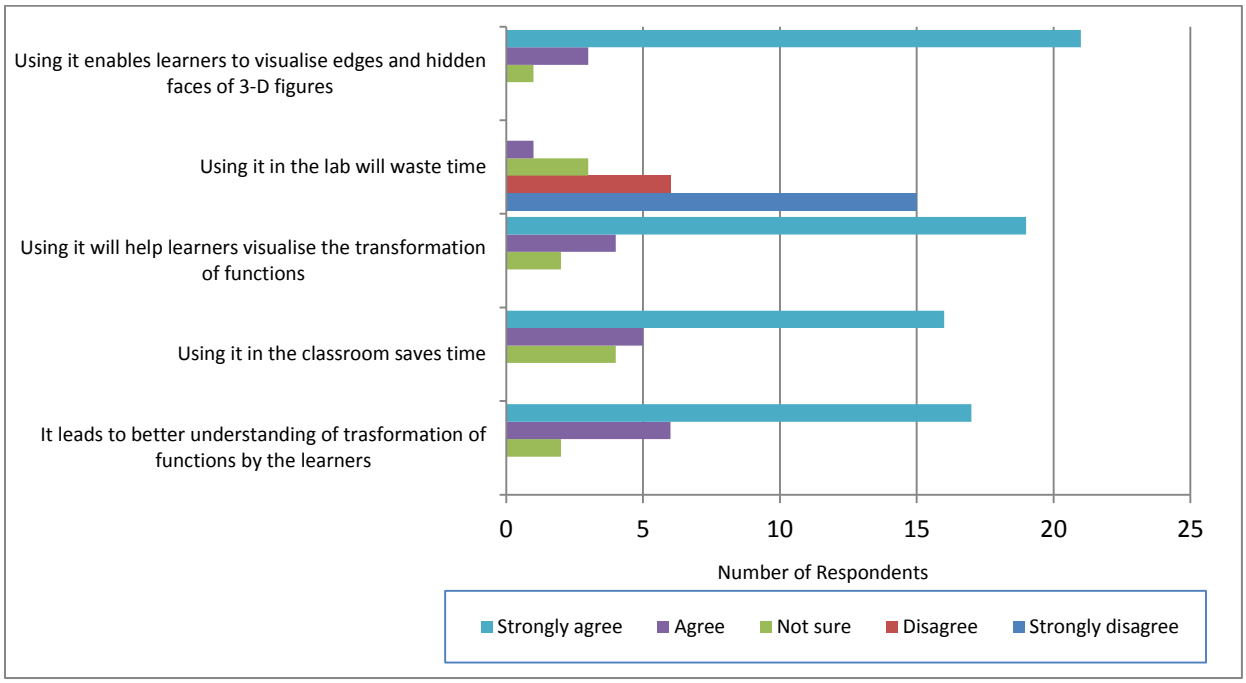

Figure 1.5 ***Teachers' Perceptions of GeoGebra's Usefulness***

The information presented in Figure 1.5 reveals how teachers rated GeoGebra's usefulness in tackling various aspects of geometry. Only one teacher was unsure whether the software would enable learners visualize edges and hidden faces of three dimensional figures, two teachers were unsure whether it would help learners visualize transformation of functions and two teachers were unsure that the software would help learners understand the transformation of functions. All the other teachers believed the software was useful in achieving these goals. This finding shows that the GeoGebra software has the potential to improve the learners' ability to grasp concepts in geometry that they have difficulty understanding.

The information in Figure 1.5 also reveals that teachers find the software to be efficient in that it does not consume too much time. Twenty three (23) teachers out of the thirty three 33 teachers (69.7%) felt that it would save time when used in the classroom and only one teacher felt using it in the lab would waste time. This quality of GeoGebra is important because it will enable teachers save time hence cover the syllabus more efficiently.

How Teachers felt about using GeoGebra in their Schools

The study sought to investigate whether the teachers thought GeoGebra could be successfully used in their respective schools, how the software would help in their school and whether any factors in their schools could aid or hinder the use of the software. All the teachers who were sampled for this study stated that GeoGebra would be useful in their school and classrooms. Table 1.6 presents the reasons why teachers felt GeoGebra would be useful in their schools

Table 1.6 ***Why GeoGebra would be Useful in Schools***

	Frequency	Percent of teachers
Improve understanding of abstract concepts	20	64.5
Introduce ICT to schools	6	19.3
Make mathematics interesting	20	64.5
Change students' attitude and increase participation	18	58.1
Improve students' manipulative skills	10	32
Assist in revision and making use of learning aids	4	12.9
Save time hence syllabus completion	4	12.9

As Table 1.6 shows, more than half of the teachers felt that GeoGebra could enable students comprehend difficult and

abstract concepts in geometry. The teachers were also of the view that using the software would help introduce ICT to school, make mathematics more interesting and change students' attitudes to mathematics.

The teachers were asked to note factors that could aid or hinder adoption of the dynamic geometry software in their schools. Their responses are summarized in Table 4.5

Table 1.7 *Factors that could Aid or Hinder Adoption of GeoGebra*

	Factors	Frequency	Percent
Factors that will aid	Availability of equipment like computers	15	48.4
	Availability of computer literate teachers	8	25
	Support from school management	25	83.9
	Positive attitude to ICT by teachers and students	5	16
	Computer literate students	2	6.4
Factors that will hinder	Insufficient resources like computers	16	51.6
	Lack of electricity	4	12.9
	Large number of students	20	64.5
	Teachers lacking ICT training	10	32
	Teachers reluctance to adopt ICT	1	3.2
	Computer illiterate students	1	3.2

As shown in Table 1.7, about on half of the teachers stated that availability of computers and other equipment would enable them use the software. The other half noted that absence of equipment as an impediment to implementing the software. Availability of computer literate teachers and a positive attitude towards ICT were also among the factors that teachers said would help them introduce the software to their schools. Absence of electricity and the large ratio of students to available computers were among the obstacles to using the software in some schools.

There was a 64.5% response that a large number of students would hinder the use of the software in teaching mathematics at secondary school level. A large number of teachers 83.9% felt that support from school administration would be necessary to facilitate use of GeoGebra in Kenya.

VII. Summary of Findings

The paper concludes that Geometry and Algebra are areas in mathematics that teachers find complicated and hard to teach. By introducing GeoGebra, the teachers believed that teaching and understanding would be enhanced. Some teachers were excited and got to explore its usefulness and to prepare material that would be used in teaching Geometry. The adoption of this innovation is likely to improve the teaching of learning of Geometry and algebra but this can only be tested after complete adoption of this innovation. These findings lead to the conclusion that teachers who have been trained on using GeoGebra appreciated its usefulness and are most of them are willing to adopt it. Training exposed the teachers to GeoGebra and the feedback from the training sessions showed a positive perception towards GeoGebra use. Further, research needs to be done to establish whether this excitement by teachers translated to better learning, understanding and hence better performance among the learners.

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