

**PEDAGOGICAL FACTORS AFFECTING THE LEARNING OF TRIGONOMETRY
IN SECONDARY SCHOOLS IN GATUNDU NORTH SUB-COUNTY,
KIAMBU COUNTY, KENYA**

BY

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university or any other award.

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DEDICATION

This thesis is dedicated to Miss Teresa W. Nderitu principal Ng'ethu secondary School for her support and encouragement towards my education. Second, to my wife Damaris and children Grace Margaret and Portia without whose support I would not have had the drive and motivation to complete the work.

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OPERATION DEFINITION OF TERMS

The following terms have been contextually defined to present meaning associated with the study.

Autocratic: where the teacher dominates the mathematics classroom

Attitude: the way students think and feel about trigonometry during the learning process or the way the students behave towards learning that show how they think and feel about it

Classroom atmosphere-it is the mood or feeling that the students have in a particular class during learning process.

Concept-A concept is an abstract idea describing some relationship within a group of factors and may be designed by some sign or symbol

Democratic classroom: where students participate actively freely in the mathematics classroom discourse.

Discourse patterns: chain of mathematics learning activities resulting from the use of verbal and non-verbal instructions

Direct teacher discourse: include where the teacher lecture/demonstrate, own ideas gives direction criticizes students behavior and justifies his authority.

Indirect teacher discourse: include where the teacher accepts clarifies and used student ideas praises and reinforces student asks convergent and divergent questions to engage students in teaching and learning.

Interaction in class-it is the communication that takes place in classroom setup between the teachers- student

Knowledge for teaching mathematics: acquired knowledge including principles and procedures used by teachers to demonstrate mathematical ideas and concept

Mathematics performance: mathematics performance is the out come of any assessment obtained by students or a group of students. The grade obtained can either be high or low depending on the specific criteria used to gauge such an outcome.

Mathematics knowledge for teaching: teacher knowledge that is used in context for mathematics content areas for example mathematics knowledge for teaching trigonometry.

Pedagogy: is the study of teaching methods.

Pedagogical; it is the teaching methods that a teacher engage in a classroom that focused towards achieving his lesson objectives.

Pedagogical content knowledge: It is the domain for specific knowledge of teaching that integrate content and pedagogy.

Pedagogical reasoning: the process by which teachers' transform subject matter knowledge to forms comprehensible to their particular student.

Proficiency in pedagogical content knowledge in mathematics: levels of teacher capability to enhance learning mathematics by incorporating in a balanced contextual way all the component PCK.

Problem solving: process of looking for solutions for mathematics problems in a classroom situation.

Subject matter knowledge-It is the mathematical knowledge of teachers.

ABBREVIATIONS

BERC: Basic Educational Research Centre

C.C.S.A: centre for curriculum studies in Africa

FIAC: Flanders Interaction Analysis Categories

F.S.D.S.E: Free Subsidized Day Secondary Education

I.D : The ratio of indirect and direct categories.

K.C.S.E: Kenya certificate of secondary education

K.I.C.D: Kenya Institute Curriculum Development

KNEC: Kenya National Examination Council

MTQ: Mathematics Teachers Questionnaire

MSQ: Mathematics Student Questionnaire

N.C.T.M: National Council of Teachers of Mathematics

P.G.D.E: Post-Graduate Diploma in Education.

SMASSE: Strengthening of Mathematics and Science in Secondary Schools Education.

T.S.C: Teachers service commission

U.T: Untrained Teacher.

ABSTRACT

Trigonometry topics are very important in mathematics education as trigonometric functions have many applications in fields such as adverse physics, mechanical and electrical engineering, music, astronomy and biology. Any challenges encountered by students in learning affect overall performance in the subject. The purpose of the study was to determine the pedagogical factors affecting learning of the topic in secondary schools and recommendation made. The objectives of the study were: To determine the teaching methods applied that enhance students' participation, the use of instructional resources available and adequacy, students' attitude toward the topic, challenges encountered by students when learning and kind of classroom interaction patterns. The study was descriptive statistical survey focusing on F3 students and their mathematics teachers. Stratified sampling technique was used to select the 7 secondary schools from the three categories of the 27 schools in the district. Simple random sampling was used to select a F3 stream where there were more than one stream. Otherwise it was purposively selected. Data was collected using the instruments: Mathematics teachers' questionnaire, Mathematics students' questionnaire, Head of mathematics interview schedule and Flanders Interaction Analysis Categories. The Reliability and Validity was done using Test-Retest method during piloting on two different schools which were not used for research actual data collection within time frame of two weeks. The correlation coefficient was 0.85 positive. Data from the questionnaires and classroom observation were analyzed both qualitatively and quantitatively. Qualitative analysis was involved in making inferences from open ended response questions. Quantitative analysis involved descriptive statistics indicating the factors affecting the learning of trigonometry by students. Results of the study findings indicated that teachers were not using teaching methods that encourage students' participation as indicated by 50% of respondents who preferred using lecture and demonstration compared 7% for discussion, the instruction resources were inadequate as indicated by 34% of students, students had negative attitude towards the topic as indicated by 71.4%. The main challenges encountered by students when drawing graphs were lack of understanding of the concept and failure to choose a suitable scale. The teachers' dominated classroom interaction pattern taking two thirds of the lesson and hence limiting students' participation. Recommendation: Teachers should integrate both expository and heuristic approaches thus increase students' active participation in teaching and learning. SMASSE activities need to be incorporated in the learning process. Students need both intrinsic and extrinsic motivation to help them change their attitude. School administrators should be ensuring the instructional resources for students are readily available and adequate. If the above recommendation can be implemented there will be improved performance in trigonometry topic and hence overall performance in mathematics at KCSE level

CHAPTER ONE

1.0 INTRODUCTION

This chapter presents the background and statement of the study of the problem. It also presents the research questions used to guide the development of research instruments and analysis of the findings

. The purpose and significance of the study is also explained in this chapter. In addition the theoretical and conceptual frame works for the study is out lined in the chapter.

1.1 Background to study.

Mathematics is taught because of its utility, cultural, social and personal reasons. It is an excellent vehicle for development and improvement of a person's intellectual competence in logical reasoning, spatial visualization and analysis and abstract thought. Students develop numeracy, reasoning skills and problem solving skills through the learning and application of mathematics. These are valued not only in Science and Technology but also in everyday life and at the work place. The development of highly skilled man-power in science and technology requires a strong grounding in mathematics. An emphasis on mathematic education will therefore ensure that we have an increasing competitive work force to meet the challenges of 21st century (Neunzert,2005).

The Mathematics that is taught in Kenyan secondary schools today has undergone various changes since early 1960s. These changes were due to either external or internal influence. Even after the changes that have taken place in mathematics education in terms of syllabus contents and time allocated to the subject, the performance in mathematics has remained poor. This calls for more research to find out whether the teaching methods applied by teacher in certain topics, resources availability and adequacy and teacher-student attitude towards certain topics contribute towards the overall poor performance.

KNEC reports (2004-2013) indicates that the topics in mathematics in which students performed poorly in KCSE included trigonometry, quadratic equations, statistics and scale drawing. When it came to the percentages of individual question analysis on topics that were poorly performed trigonometry questions dominated through out the period. This meant that there were certain factors/challenges affecting the learning of trigonometry by students which needed to be urgently address and the solutions found before any good performance could achieved. The effect of poor performance on trigonometry topics questions to overall performance in mathematics mean score at National level KCSE was evidence by the drop in mean score from 28.56%(2012) to 27.58%(2013) when the percentage of poorly performed trigonometry questions increased from 23%(2012) to 52.5%(2013) at the same period. This indicated that there were some factors/challenges affecting the learning of trigonometry by students that have had not been fully addressed and there was need for a research done to address the problem. The current research was aimed at determining the factors/challenges affecting the learning of trigonometry by student which was among the topics taught at three different levels in secondary schools.

Table 1.1 KCSE results –mean scores in mathematics performances in paper 1 and paper 2 from the year 2004 -2013 and analysis in percentages of poorly performed individual topics question over the period.

Year	Paper	Candidates	Max. scores	Mean score	No of poorly performed questions	Percentage of trigonometry questions	Percentage of quadratics equations	Percentage of statistics
2004	1	221295	100	14.51	10	34%	0	0
	2		100	22.63	9	26%	0	0
	Overall		100	18.6%	19			
2005	1	259280	100	14.87	11	27.3%	0	0
	2		100	17.04	12	25%	0	0
	overall		100	16.0%	23			
2006	1	238684	100	22.71%	6	50%	0%	20%
	2		100	15.36%	6	33.3%	0%	17%
	overall		100	19.04%	12			
2007	1	237504	100	19.09%	8	37.5%	13%	13%
	2		100	19.91%	8	31%	0%	0%
	overall		100	19.5 %	18			
2008	1	304908	100	22.37%	6	50%	0	0
	2		100	19.89%	7	29%	14%	0
	Overall		100	21.3%	13			
2009	1	33615	100	22.37%	6	33.3%	17%	17%
	2		100	19.89%	8	37.5%	13%	13%
	Overall		100	21.13%	14			
2010	1	356072	100	26.21%	5	40%	0	20%
	2		100	19.92%	4	25%	0	0
	Overall		100	23.04%	9			
2011	1	409887	100	21.56%	6	17%	0	17%
	2		100	28.22%	5	20%	20%	0
	Overall		100	24.8%	11			
2012	1	433017	100	29.46%	7	29%	0	0
	2		100	27.86%	6	17%	0	17%
	Overall		100	28.7%	13			
2013	1	444774	100	28.12%	7	45%	0	0
	2		100	27.03%	5	60%	20%	0
	Overall		100	27.6%	12			

Source: The Kenya National Examination Council (2013)

Table1.1 Indicates the National KCSE data analysis of candidates overall performance in mathematics for the last ten years and individual topics question analysis on which candidates performed poorly over the period.

From the Table 1.1, On the National KCSE mathematics result analysis on mean scores and the poorly performed individual question analysis for various topics report there was a clear indication that trigonometry questions were poorly performed. The general trend as indicated from the results was that as the percentage of poorly performed individual questions in trigonometry topics decreased, the National mean score improved. The problem of other poorly performed topics seemed to have been taken care of as indicated by general decreasing trend in their percentages over time. When it came to trigonometry topics the case was totally different as indicated by maintenance of high percentages of poorly performed individual questions. This was evidence between year 2012 and 2013 when the mean score of poorly performed individual trigonometry increased from 23% to 52.5% respectively. This indicated that there were some challenges that the students had been facing during the teaching and learning process of trigonometry in our secondary which had not been fully addressed. This study investigated the students' related challenges in terms of teaching method applied, use of resources availability, challenges encountered by students during the teaching and learning of the topic which led to poor performance in the question related to the topic at KCSE examinations and came up with recommendation. From the results of analyzed data of Table 1.1 it was that the importance of trigonometric concepts in mathematics course in secondary school could not be ignored. It was among the concepts of mathematics that was taught at three different levels (Form II-Form IV) and allocated a lot of time in the four years course. This was because of the total 714 lessons allocated to the four year mathematics syllabus course, 177 lessons were in trigonometry and related topics. This translates to 24.8% of the total time allocated to four years of secondary school education mathematics course. When it came to mathematics content syllabus coverage the trigonometry and related concepts were allocated 20.83% of the entire topic covered in four year course. Any challenges encountered during the learning process by the students in terms of teaching methods used,

resources availability, time allocated and so on means an overall poor performance in the subject. This research was aimed at determining the main challenges encountered by students during the learning process of trigonometry in terms of resources availability and adequacy during the learning of trigonometry. The research also aimed at finding out whether or not the technical terms used in trigonometry were difficult or challenge to many students in secondary schools in Gatundu North Sub-county, Kiambu County.

At the Sub-county level a similar trend in performance of mathematics could be observed in Gatundu North Sub-county of Kiambu County which was the focus of the study. There had been a low performance in mathematics compared to other compulsory subjects such as English and Kiswahili from (2009-2012) as shown in table 1.2.

Table 1.2 KCSE mean grade in mathematics and other compulsory subjects from 2009-2012 in Gatundu North Sub-county Kiambu County.

Subject	2009	2010	2011	2012
Mathematics	2.70	2.30	2.50	2.50
English	4.29	4.50	4.80	4.5
Kiswahili	3.70	4.40	4.30	3.89

Source: Ministry of Education Gatundu North District Education Office (D.E.O 2013)

Table 1.2 shows that the mean score for mathematics was relatively low when compared to other compulsory subjects. The cause of this relatively poor performance in mathematics has not been fully addressed. This meant that there were certain challenges encountered by students in the process of learning certain topics such as trigonometry and others which had been researched on and documented but yet the solution had not been found. This meant there was need for research done to investigate the challenges encountered by the students in learning process of trigonometry and recommendations made.

1.1.0 Trigonometry concept

Trigonometry is a branch of mathematics that studies relationships involving lengths and angles. The field emerged in the Hellenistic world during the 3rd century B.C from application of geometry to astronomical studies. Trigonometry functions are used to understand cyclic phenomena across many applications in fields such as adverse physics, mechanical and electrical engineering, music, astronomy and biology. Trigonometry is also the foundation of Surveying.

There is an enormous uses of trigonometry and trigonometric function. For instance the technique of triangulation is used in astronomy to measure the distance to nearby stars. The sine and cosine function are fundamental to theory of periodic function such as those that describe the sound and light waves(Source Wikipedia).

According to the Ministry of Education Secondary School Teachers' handbook (2006) in application of spiral approach to teaching and learning process, trigonometry concepts are taught at three different levels. The three levels include the following:

(a) Trigonometry (1) covered in Form two. The pre-requisite knowledge involves angles, right angle triangle, Pythagoras theorem, squares and square roots.

The suggested teaching and learning activities in this topic in order to enhance mastery of the contents include the following: Student introduction to trigonometric ratios using right-angled triangles of different sizes. Guiding students in finding trigonometric ratios of various angles practically using right angled triangles. The teacher is also required to initiate practical's involving use of trigonometric ratios.

From the suggested teaching and learning activities in trigonometry 1 topic in Form Two there was a clear indication that resources availability and adequacy were important. The current research was aimed at determining the challenges encountered by students during the teaching and learning process in secondary school as far as use of available resources was concerned.

(b) Trigonometry II covered in Form Three: The pre-requisite knowledge, knowledge of trigonometry I is assumed including, Cartesian graphs, properties of angles. The suggested teaching and learning activities include the following:

- Introducing the unit circle and how to use it. Leading students to compare the trigonometric ratios of angles in the first quadrant and those they obtain from tables.
- The unit circle should be developed and used to assist drawing trigonometric graphs.
- Problem solving involving bearings, angle of depression and elevation should be part of teaching and learning process in trigonometry two.

The teacher should guide learners on how to use calculators to verify the trigonometric ratios of angle.

Looking at the requirements of the suggested teaching and learning activities of trigonometry II as suggested in secondary mathematics teacher handbook 2006 teachers' guide, a number of issues concerning the classroom atmosphere and the attitude of students arises. For active participation by students in trigonometric lessons their attitude should be positive and at the same time that of a teacher. The time allocated to the topic must be adequate in order to help in construction of knowledge as far as trigonometry II is concerned. The current research investigated the attitude of the students toward the learning process of trigonometry in secondary school in Gatundu, North Sub-county, Kiambu County.

From the above recommended teaching and learning activities of trigonometry there was clear indication that class interaction pattern was very important. There was need for teachers to apply certain teaching methods that encouraged student active participation in the learning of trigonometry. The teaching methods which were heuristic would be more preferable than those expository. Heuristic methods are such as small group discussion and presentation, discovery, project work and field trips. The current research aimed at determining the influence of teaching methods on the level of students' participation in the learning of trigonometry.

According to Ministry of Education, secondary mathematics teachers Handbook January (2006) the general methods of teaching trigonometry were grouped into two categories, namely Heuristic and Didactic approaches.

(a) Heuristic approaches

This approach includes question and answer, investigations, probing, group work and discussion etc.

Heuristic methods of teaching encourage active participation and involvement of the learners in planned class activities. The activities are organized with the individual learners in mind and take into account their ability, aptitude and prevailing environment. As a result the activities capture the learners interest facilitating and encouraging reasoning through activity and problem solving. The learner actively seeks out new material and explores new areas more naturally and voluntarily. The trigonometry concepts are developed and allowed to evolve through a process clearly understood by the learner. Under such circumstances, transfer and application of trigonometric knowledge become natural for the learner and adaptable to familiar and unfamiliar tasks. Retention of trigonometry concepts learnt is higher and positively generates confidence among learners. Teaching and learning process becomes essentially learner centered enhancing sound teacher/learner relationship conducive to quality classroom interaction.

The current research sought to establish the teaching methods that enhanced class activities hence good interactions between teachers and students during a trigonometry lesson to quality class interaction. The main challenges was found that some of the methods such as discussion groups were time consuming and therefore many teachers were not using them. This was because the time allocated to trigonometric topics was not enough and need to be increased. The same report suggested two main methods of teaching trigonometry that are heuristic approach such as those which involve fixed responses and investigations by learners:

I. There are many methods which involving fixed responses that are recommended for teaching and learning of trigonometry such as programmed learning in which the teacher provides a sequence of activities so that the learner can reach a set objective in trigonometry. The role of the learner is to respond to the given instructions or question. The instructions may be given in work cards or worksheets. The activity may be a practical one like use of logarithm tables to find trigonometric ratios. Usually the learning is set in stages and the learners' responds to each one of them at their own pace. Finally the learners arrive at the conclusion or generalization. The current research sought to find out whether or not the teachers did apply these methods when teaching trigonometry and the challenges they faced in trying to implement them.

(b) **Methods of investigation by learners:** These methods involve discovery activities by learners. The teacher sets goals and provides the resources and ideas. The teacher may also initiate the task of discovery or encourage the students to initiate one. The role of the teacher is mainly to guide or direct in the exploration as the topic dictates. The method of investigation leads to understanding of a trigonometry concept or rules and establishing generalization. Students are likely to internalize the concept. The current research aimed to establish how often the teachers used these methods and the challenges encountered by both teachers and student in terms of resources availability and adequacy during the teaching and learning process of trigonometry in secondary schools so that necessary recommendation could be made on how to improve the situation.

(c) **Didactic Approaches:** They are characterized by expository teaching techniques in which the teachers assumes the role of the sole authority as far as knowledge is concerned. The role of the learner is that of a passive recipient of knowledge. The delivery is usually mechanical and fails to take into account of the learner's ability and environment. The current research sought to establish the extent to which the teaching methods applied by the teachers

limited the teaching/learning process of trigonometry by students and the necessary recommendations were made. The study found that many teachers had tendency of applying these didactic approaches because they help them in coverage of the wide content within a short time although they were counter –productive on the side of students as they led to many being passive most of the time. This has led to many students developing a negative attitude towards the topics.

1.2 Statement of the problem

Secondary schools students continued poor performance in KCSE mathematics examination in Kenya has been an area of concern to all the stakeholders in the field of education. Studies carried out attribute poor performance in mathematics to factors such as poor teaching methods, lack of teaching resources and students attitude towards the subject among others (Thuo 1985, Kathuri 1986, Eshiwani 1993). In response to these problems the Ministry of Education Science and Technology in Kenya, through the Teachers Service Commission and the Kenya Institute of Curriculum Development have tried to provide trained mathematics teachers in secondary schools and develop the relevant mathematics learning instructional resources respectively. Despite of these

efforts, the performance of mathematics is still low (KNEC 2004-2013). This means that there were other crucial factors relating to students performance in mathematics which needed to be investigated in the Kenya context. The study contended that one of such factors could be linked to pedagogical factors affecting the teaching and learning of some topics in mathematics such as trigonometry, quadratics equations and statistics whose performance through the analysis done were found to have had influence on the mean score of mathematics at KCSE. When it came to individual question performance analysis report based on syllabus coverage content analysis within the same time the study revealed that trigonometric topics related questions

were poorly performed. The topics contributed to an average of 37.5% of all the difficulty questions in both papers encountered by the students. At the same time there was evidence of the to KSCSE mathematics mean score (2012-2013) result. This showed that performance in trigonometric questions at national level by students played an important role in overall performance in mathematics which meant the role played by trigonometry topics based questions in overall poor grades in mathematics could not be ignored. This was because the topics were allocated 20.83% of all mathematic content syllabus and 24.8% of the total syllabus coverage time of the four years mathematics course.

The purpose of this study was therefore to determine the pedagogical factors affecting the learning of trigonometry in secondary schools in Gatundu North Sub-county of Kiambu County Kenya.

1.3 The purpose of the study

The purpose of this study was to determine the main pedagogical factors affecting students' learning of trigonometry in secondary schools and came up with necessary recommendations.

1.4 Objectives of the study

The study sought to:

- a) Determine the influence of teaching methods on the level of students' participation in the learning of trigonometry.
- b) Establish the extent to which instructional resources were used in the teaching and learning of trigonometry.
- c) Determine the students' attitude towards the learning trigonometry
- d) Establish the challenges encountered by students in the learning of trigonometry.
- e) The type of classroom interaction patterns that took place between teachers –students and students -students during teaching and learning of trigonometry

1.5 Research questions

The research attempted to answer the following questions:

- i. What influence did the teaching methods applied by the teachers have on the level of students' participation in the learning of trigonometry?
- ii. To what extent were the instructional resources used in the teaching and learning of trigonometry?
- iii. What attitude did the students have towards the learning of trigonometry?
- iv. What challenges encountered by the students when learning trigonometry?
- v. What kind of classroom interaction patterns that took place between teachers- students and students-students during the teaching and learning of trigonometry?

1.6 Significance of the study

The finding of this study would be useful to the following:

Secondary school mathematics teachers: It is expected that the results of this research would be useful in improving the teacher's skill in teaching trigonometry. This is because teachers would become aware about the factors that teaching methods could bring about influencing the students' participation in a lesson. The teaching methods such as small group discussions and presentation of (4-6) students, Project work and field trips would be more appropriate in teaching and learning of trigonometry as they increase students' active participation. This is because as students share the ideas among themselves, there would be better understanding of the concept being learnt and hence improvement in performance. Also through small groups discussion students are given opportunity to verbalize their thinking, explain their solution and ask for clarification. This enable the students to understand the concepts in a problem and extend their conceptual frame work to accommodate alternative methods. Using social constructivism theory as referent teachers' teaching methods may be changed as they will be able to understand the importance of collaborative learning in trigonometry. The research

finding will help the school administrators in decision making on provision necessary teaching and learning resources of trigonometry as the result indicated the extent to which instructional resources used affected the learning of trigonometry. The results will not only help to improve the performance of trigonometry through students' active participation but also help teachers to cope with overcrowded classes through peer teaching and small group discussions. The research finding will help the students in changing their attitude towards learning of trigonometry. Through this research students will gain knowledge about the importance of collaborative learning where each individual has a voice promoting the construction of new ideas. This will lead to reduction in mathematics performance anxiety to an appreciation of active class participation. The curriculum developers (K.I.C.D) can also benefit by a way of re-examining their instructional objectives and curriculum content. Teacher's trainers: The study findings can be used by teacher trainers to improve the quality of training. This is because the study recommended possible solutions of dealing with difficulties associated with teaching and learning of trigonometry.

1.7 Scope and limitation

1.7.1 Scope of the study

The researcher was only interested with challenges encountered by students in teaching and learning of trigonometry topic when drawing graphs and geometrical constructions, use of instructional resources available such as graph books, geometrical sets and scientific calculators' in secondary schools. This was as result of KNEC (2004) report indicated that many students had problem with geometrical construction of angles when drawing figures such as parallel-grammes and loci. The study also focused on how the teaching methods applied by teachers influenced students' participation during the learning of trigonometry. The study also focused on how the students attitude toward learning of trigonometry influenced their lesson participation and hence their performance. It also focused on how teachers' use of teaching

aids and questioning technique influenced the students' participation in trigonometry lessons. This was important as it determined the classroom interaction patterns between teachers–students and students-students in secondary schools. The research focused on both the most frequently and rarely applied teaching methods in secondary schools, reasons behind their applications or failure which were very important to the study. Much attention was not paid to other variables such as content analysis in terms of the language used being appropriate to the level of learners, symbols used having more than one meaning thus bring confusion on the learners' side and revision practice exercise were enough for helping students to acquire conceptual frame work in trigonometry and hence avoid misconception. The quality of the text book was not considered and time allocated for the content in the syllabus which were also important in teaching and learning of trigonometry. Further research could be done on them.

1.7.2 Limitation of the study

Financial constraints limited the research to sample study to only secondary schools in Gatundu North Sub-county which meant generalization to other Sub-counties in the country could only be done through further research.

1.8 Assumptions of the study

The study was guided by the following basic assumptions, that all secondary schools under investigations

- i. Had students who were learning trigonometry or had learnt trigonometry in secondary schools
- ii. Were adhering to a uniform syllabus of mathematics.
- iii. Had their mathematics teachers adequately trained in the field of mathematics education.
- iv. Were adequately equipped with teaching/learning resources which included text books.

1.9 Theoretical framework

This study was based on constructivism theory. The theory was first developed by Jean Piaget (1960) and emphasizes that early growth of cognitive development in children take place when they interact with their environment in order to acquire logical, physical and social knowledge. Such knowledge is useful for students understanding and performance in trigonometry since, through active classroom participation and interactions with the teachers and with peers, the students are able to participate in problem solving strategies. This opportunity to interact allows students to verbalize their thinking, explain or justify their solutions and ask for clarification. This enables the students to understand the concepts in a problem and extend their conceptual framework to accommodate alternative methods of solving Trigonometry problems. Teaching techniques that apply social constructivism theory include teaching in contexts that might be personally meaningful to students, negotiating taken as shared meanings with students, class discussion, small-group collaboration and valuing meaningful activity over correct answer (Wood et al 1995). Constructivism-related strategies such as these are very important for student's involvement in learning process and need therefore to be used more in trigonometry lessons (classroom). Constructivist view mathematics teaching behavior in relation to how much it encourages student's construction of knowledge. They are concerned with how students derive concepts from their environment through which they make sense of the world around them and the means they use in their thinking and explorations. In support of the same (Glaserfeld 1990) noted "Students do not just passively absorb their environment, but rather they actively operate on It". This implies that the prior knowledge of the student is essential to be able to actively construct new knowledge. This view helps in creating a classroom atmosphere that is not teacher dominated, but one in which opportunities are available to students for mathematics negotiations based on which they already know. This meant the teachers main role in teaching and learning should be that of supervision, guiding,

creating the necessary atmosphere and provision of the necessary resources to students during learning process. It is the teachers' responsibility to make sure whatever content being taught is at the level of the learners strictly following the syllabus but not the class textbook.

Constructionist acknowledges the fact that;

Students come, to class with an established world view formed by years of prior experience and learning.

Students learn from each other as well as from the teacher.

Students learn better by doing.

Allowing and creating opportunities for all to have a voice promotes the construction of new ideas.

These facts were important in an attempt to improve the teaching and learning interactions in a trigonometry lesson.

Constructivist theorist views student as actively engaged in making meaning. Teaching trigonometry using the constructivist theory approach enables the teacher to assess what students can analyze, investigate, collaborate, share, build and generalization based on what they already know, rather than what facts, skills and processes they can produce. To do this effectively teachers need to be innovative in their teaching methods in order to take care of emerging issues in education such as use of ICT. This means teachers need to take researcher's roles to continually adjust their teaching strategies to engage students in learning using Constructionist theory as referent. Social construction theory was important to this research as it help in the identification of various pedagogical factors affecting/influencing the learning of trigonometry in secondary schools. This was because it highlighted important areas concerning how students construct mathematics knowledge through collaboration among themselves and their teachers. This made it essay for the researcher in identification of weakness in the teaching methods applied, use of instructional resources and students attitude toward learning

of trigonometry. The current research was done with an aim of changing current trend of poor performance in trigonometry to an Improvement through necessary recommendations.

1.10 Conceptual framework

Some scholar such as Welch,(1978) and Cockcroft (1982)identified both teachers and student factors that influenced the teaching and learning process of mathematics which led to students centered and less teacher dominated .These factors could be embedded in classroom interactions, which enhance the teaching and learning process in mathematics classroom. In support of the same Grouwns and Koechler(1988) identified teacher and student related factors affecting classroom processes. For instance, teacher-related factors were influenced by his knowledge of mathematics content, how students learn and teaching techniques of the particular content. Other influential factors included teacher's attitudes and, beliefs about Trigonometry and teaching. For instance, some teachers believe that students learn by explicit examples and repetition, while others believe that they learn by discovery or investigation, hence making teachers approach to teaching mathematics different.

Student related factors on the other hand were influenced by their attitudes and beliefs about mathematics, their confidence in their ability to learn mathematics, their gender and their feeling about their ability to discover problem solving strategies in mathematics. Some of these student and teacher-related challenges together with the resources used in trigonometry lesson were likely to determine the nature of classroom set activity between the teacher and the student and among the students. From theoretical frame based on social constructivist theory it was clearly indicated that for students knowledge construction in mathematics to take place there were number of classroom related pedagogical factors that needed to be considered first. Any challenge encountered due to these factors could have led to misconception on the side of students and hence poor performance. This gave a clear indication that the poor of performance

of trigonometry related questions at KCSE had originated from a number of pedagogical factors affecting the students in learning of trigonometry in secondary schools. These factors could have originate from: the teaching methods that were applied by teachers influencing students' class participation, the extent to which instructional resources were used in teaching and learning of trigonometry, the attitude of students toward the learning trigonometry, the challenges encountered by students in learning of trigonometry and class interaction patterns that took place during the learning of trigonometry. All these pedagogical factors affecting the learning of trigonometry could be conceptually represented as **Independent** Variable against the expected impacts as **Dependent** Variable. The relationships between the pedagogical factors affecting the learning of trigonometry and expected impacts can be summarized in the figure below. Their relationship was summarized in the Figure1.1

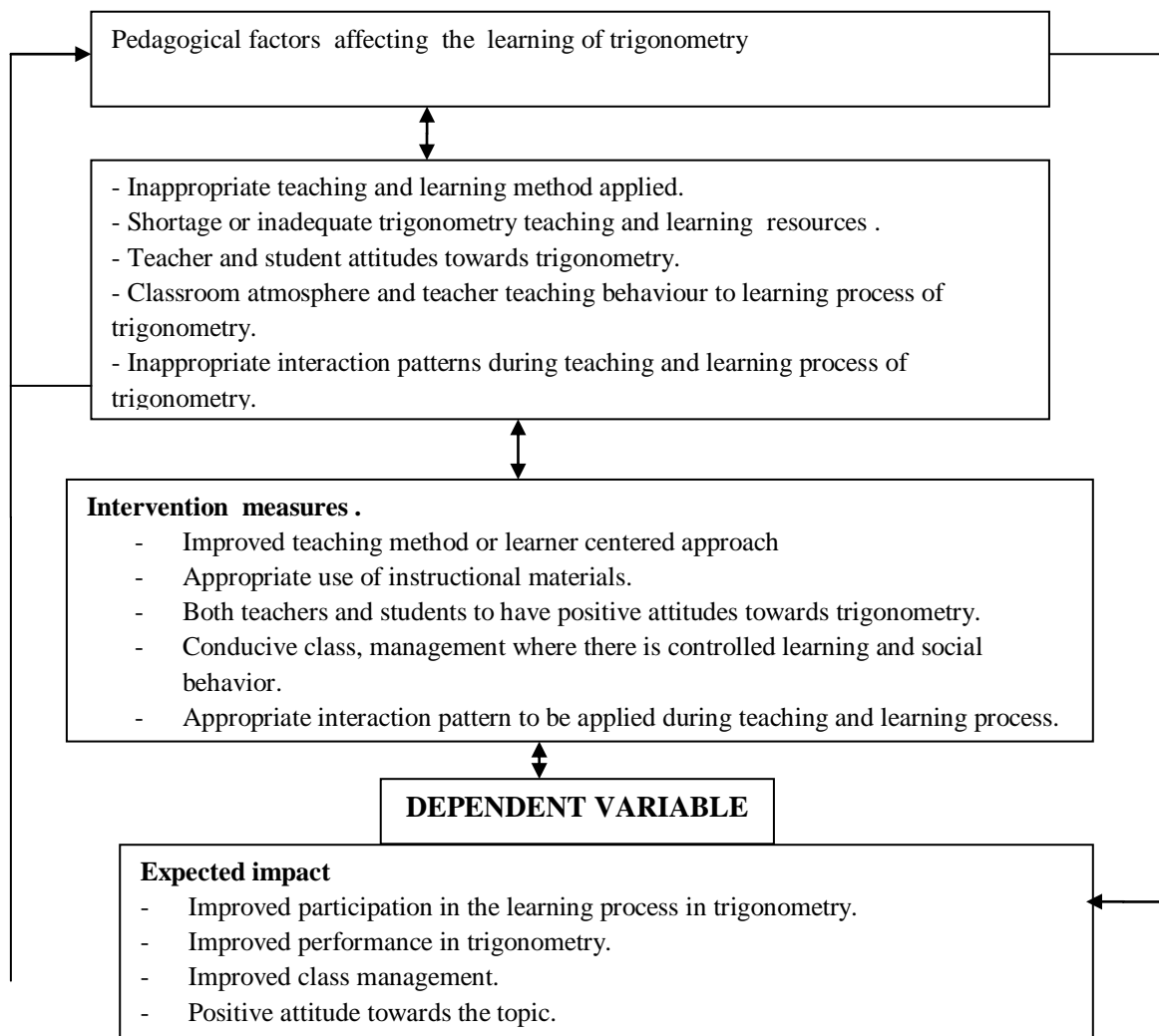




Fig 1.1 Pedagogical factors affecting the learning trigonometry

Source: Adapted from Mutai Jackson (2010), Njeru Lawrence (2010)

Fig. 1.1 Pedagogical factors affecting learning of trigonometry that led to poor performance at Kenya Certificate of Secondary Education Examinations.

Figure 1.2 Shows that the trigonometry learning challenges were focused to various activities that took place in the classroom and the teacher and the learner as the main participants. There were many challenges that the students faced during the teaching and learning trigonometry in secondary school in Kenya that led to poor performance in those topics but only a few were addressed here. The independent variable in this research were the inappropriate learning methods applied by teachers, inadequate trigonometry teaching and learning resources, both teachers and students attitude towards the topics, the kind of class atmosphere which existed during teaching and learning process and finally the type of classroom interaction pattern that took place during the teaching and learning process of trigonometry. All these variables were investigated to find out how they led to improved participation in the learning process, performance in trigonometry, class management and positive attitude towards the topic (dependent) variables.

Summary

Importance of trigonometry topics when it comes to determination of the quality grades achieved at K.C.S.E. performance cannot be ignored. This was because trigonometry learning process that involved had many applications in other subjects. Any challenges encountered in the process of learning by students determined the quality grades that student could get at the

end of course and hence the professional courses such as Medicine, Architecture and Engineering etc.

For to these reasons the current research was done to determine the main challenges that the students encountered in the process of teaching and learning trigonometry that led to poor performance in questions related to the topics in Gatundu North District, Kiambu county and came up with recommendations. This was because trigonometry topics were allocated 20.8% of all the topics in the syllabus and 24.8% of the total time allocated to mathematics four years course in secondary schools .This meant the importance of trigonometric related topics to poor performance at Kenya Certificate of Secondary Education could not be ignored when it came to overall poor performance in the subject at secondary school level as indicated Table 1.1 data analysis.

CHAPETR TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviewed relevant literature by considering the following important procedures of teaching and learning of trigonometry in secondary schools. The mostly applied trigonometry teaching methods, the use of instructional resources available in learning of Trigonometric concepts, students attitudes towards learning of trigonometry, trigonometry classroom climate and teaching behavior to the learning process and finally how classroom interaction between teacher and students affected the teaching and learning of trigonometry.

2.2 Trigonometry teaching methods.

Since Kenya attained its independence in 1963 there have been many education commission report and recommendations aimed at improving secondary education standards with respect to teaching methods, contents and resources availability. Among such reports we have the Gachathi (1976) and Mackays (1981) which suggested that teaching method applied should be learner-centered. This was meant to make learning more relevant to the learner and to make students self-reliant. The same report recommended that schools should teach basic computation skills for problem solving. Thus, it stressed much on the need for the students' participation in the classroom learning activities. This implies that the teachers role were to offer opportunities that will lead to students centered activities in class or heuristic approach to teaching and learning, which could lead to high performance in mathematics in general. Such opportunities could be realized if teachers use mathematical teaching methods which are more heuristic than expository, that encourages students participation in class rather than the student being passive. The study was aimed at determining the problem encountered by students as far as the teaching methods applied was concerned during the teaching/learning process of trigonometry that led to poor performance in the questions related to the topics at K.C.S.E

Mathematics examinations and came up with recommendation. For this helped to identify the core questions of poor performance in trigonometry related questions at KCSE exams which may have not been fully addressed by anybody.

The current teaching processes of mathematics encourage some classroom interactions that Welch (1978) rightly records by stating his experience “in all mathematics classes that I visited, the sequence of activities was the same. First answers were given for the previous day assignment. The more difficult problems were worked out. A brief explanation was given of the new material and the problem assigned for the next day. The remainder of the lesson devoted to working on homework while the teacher moved round the room answering questions”

Although Welch’s study was done in developed countries, it was likely that similar patterns could exist in developing countries. But no work has been done to establish the pedagogic factors in the teaching and learning of trigonometry in developing countries and especially on Kenyan context. This was therefore the reason as to why this study needed to be done.

From the center for curriculum studies in Africa course manual (1987), it is observed that there is no single particular teaching-learning strategy that gives optimum learning conditions to all students. In support of this Aichell and Rey (1971) for instance, gave heuristic and expository methods for teaching mathematics. In expository methods the teacher is controlling the passing of information and so he remained active during the teaching and learning process while the students acted as passive listeners. In heuristic methods the teacher plays a minimum role in exposing the new learning material and allows the students to find out, collect, get or create new materials to discover the concept being taught. In support of this Chapin, O’connor and Anderson (2003) argue that when students’ explains their thinking they are required to organize thoughts clearly in order to communicate them to others. However it would be impossible to adapt to the extreme form of expository or heuristic methods (Sidhu 1991). This

is because the extreme are either teacher centered or student centered. There is needed to strike a balance between the strategies. As we change from expository to heuristic methods, the students' participation in teaching and learning process increases. This suggest that in order to increase teaching and learning process, there is need for the teachers to reduce dominance in controlling the classroom activities and give every student maximum opportunity to participate in the learning process. The current study was intended to determine the extent to which teachers teaching technique affected the level of students' participation in learning of trigonometry in secondary school.

On the methods of teaching, Cohen (1976) recommended the use of small groups. He stresses that collaborative efforts by students allow problem solving to continue when an individual member might have encountered a difficult situation. The teacher provides external monitoring for individuals in a group and a less restrictive social environment in which students are enabled to pursue various mathematics strategies and ideas. From this information it is seen that Cohen gives the basics of the groupings in mathematics, but does not point out at the challenges encountered by the students arising from the groupings for effective learning of trigonometry in secondary schools. This was the reason for the study.

Further studies have shown that demonstration, lecture, games example and discussion methods are commonly used for teaching mathematics in classroom (Ochola(1985) and K.I.E(1985). However these studies did not establish the challenges encountered by students when teaching and learning trigonometry in our secondary schools when they use them. This study did put that into consideration.

Cockcraft report (1982) noted that mathematics teaching at all levels should include opportunities for exposition by the teacher followed by discussion between teacher and students and between the students themselves. This was meant to answer issues raised by schools council Document (1977) whose author's noted. Many classrooms were characterized

by their lack of discussion. PMM (1987) noted that many teachers do not see the value or even the possibility of discussion in mathematics as a consequence of the view of mathematics which they hold. This calls for some sacrifice on the part of the teacher whom according to Flanders (1970) spend two thirds of the classroom time talking. Teachers are known to dominate verbal exchange in the classroom making students to become passive listeners. Giving students an opportunity to discuss mathematics in class improves their mathematics conceptual competence because when they speak out their findings they end up constructing in their mind and have a better understanding behind the concepts or conceptual framework. In a synthesis of effective instruction strategies Baker Gerstein and Lec(2002) recommend that segments of mathematics instructions should target teaching students to generate explanations of mathematics concepts in their own words and to justify the methods they use to solve problems. This study was aimed at finding out the main challenges that teachers and student faced that made them avoid discussion in the teaching and learning process of trigonometry.

Bessim(1980), on his comment about an effective teacher, says that the teacher cannot assume that his acceptance of the roles and duties related to teaching will evoke automatic and reciprocal acceptance by students of his role as a teacher. He needs to motivate his students so that they will want to learn and develop their potentials. Omar (1996) argues that, teacher's statement during classroom verbal exchanges influences learning as they either encourage the student to participate in the teaching and learning process or discourage them from any form of interaction. Thus for full development of individual talents in trigonometry, teachers teaching methods need to encourage students to feel free to express their feelings and ideas as they participate in the teaching and learning process. In support to this Baker Gerstein and Lec (2002), on their comment about the synthesis of effective instructions strategies, recommend that segment of mathematics instructions should target teaching students to generate explanations of mathematics concept in their own words and to justify their methods they use to

solve problems. Whether the teachers of mathematics in Gatundu North District, Kiambu County did this during the teaching of trigonometry was the subject to investigation by the study.

2.3 Trigonometry Learning Resources.

Sidhu (1991) said that majority of students hold mathematics ‘as a dry’ and difficult topic full of abstract concepts’. This results in students taking little interest in it, and hence the use of appropriate teaching aids at every step is very crucial. The subject can be ‘softened’ when appropriate teaching resources gives rise to certain activities that enhance student’s participation in mathematics teaching and learning process. Such activities may include illustrations using a diagram, analysis of trigonometry structure or reading text questions. This implies that mathematics teachers should not only be informed of new instructional materials but also understand their roles and how to incorporate them in their lessons. The teaching aids need to be relevant in order to complete and enrich the teacher-student participation in trigonometry teaching and learning process. Although these aids may be used during the lesson, they may be inadequate or unsuitable in engaging the students in trigonometry teaching and learning process in a lesson.

In support of the same from the general comments based on the 2007 K.C.S.E mathematics examinations which revealed that candidates had difficulties in tackling questions such as those requiring trigonometric knowledge drawing and construction skill, scale drawing and bearing and use of tables and so on just as has been the case in previous years (Source K N E C 2008 report). This showed that the problem of teaching and learning trigonometry had persisted for along time without being addressed. This meant that there was need for a research done to address the problems related to teaching methods applied by teachers and the resources available for students.

Some studies have revealed that in cases where teaching and learning resources such as textbooks are sufficient and combined with other teaching aids student participation is better in the teaching and learning process and hence perform better in mathematics (Kiremb 1995; Ngechu 1985; Riungu 1988). Otieno (2010) in a study looking at the effects of teaching/learning resources on academic performance in secondary schools mathematics in Bondo District of Kenya, recommends INSETS for trained mathematics teachers and recruitment of more competent teachers to teach in secondary school. The study intended to establish how the resources used during the lesson enhanced teaching and learning of trigonometry in classroom.

According to Eshiwani (1983), the factors affecting the pupils performance in mathematics fall into two categories, social and environmental factors on one hand on the other class size, large classes contribute significantly to poor performance and low control of the class, the availability of adequate physical facilities as well as equipped libraries, essential equipment's and teaching materials are very important. However very little had been done to determine how the above factors influence the teaching and learning of trigonometry in secondary school. For it is well known that for any good performance in a subject the necessary instructional resources for teachers/students must be not only readily available but also adequate. When it come Gatundu North district, this had not been the case as the performance in mathematics has not been good. This meant there were certain factors influencing use of instructional resources by students during the learning of trigonometry which have not been fully addressed. The research was aimed at investigating how often the instructional resources were readily available for use by students during teaching and learning of trigonometry in secondary schools and the challenges encountered. According to Cockcroft (1982), in both primary and secondary schools, there should be supply of reference books for teachers related to teaching of mathematics. This should include publications of the professional mathematical associations

copies of teacher's guide which relates to textbooks used in the schools and other textbooks which serve as additional resources for the teacher. However no research had been done in Gatundu North District Secondary schools as to what challenges that students faced in the process of teaching and learning trigonometry concerning learning resources availability and inadequacy that led to poor performance in questions related to the topics at K.C.S.E examination. The study was aimed at finding out the challenges encountered by student due to shortage of these resources and came up with recommendations as to the way forward.

The importance of the use of teaching aids cannot be ignored in the teaching and learning of trigonometry in secondary schools as we are aware that the use of teaching aids helps to facilitate the teaching and learning of concepts, increases efficiency on information processing, gives meaning to words, help focus on student interests and assists the teacher to relate abstractness to concreteness. For the success of a lesson depend on the methods used in teaching with appropriate teaching aids. This research was aimed at investigating the main challenges encountered by the students during learning of trigonometry as far as use of instructional resources was concerned and came with recommendation on to over come them.

2.4 Students' attitude towards learning of trigonometry.

Many educators agree that attitudes play an important role in teaching and learning process in relation to teaching, Munguti (1984) in his study on "factors affecting teaching and learning of mathematics", has this to say.

"Teacher attitude towards mathematics is a factor that may affect the teaching and learning it. If the teachers' attitudes are negative towards trigonometry, this in turn will affect his teaching of the topic and is reflected in pupils' performance". Goswanus (2008), research conducted in Cambridge University revealed that typical barriers to learning, but specifically prevalent in the acquisition mathematics skills .The barrier include high levels of anxiety, emotions such as panic, switching off and feeling stupid, being teased by their peers, avoidance tactics and

frustrations when older pupils realized that their peers are able to do what they cannot. Another study conducted in Botswana by Mapolelo (2009) revealed that students consider learning and understanding mathematics to mean being successful in getting the correct answer. This meant there was need for a study to be done to determine the challenges encountered by students in teaching and learning of trigonometry that led to negative attitude and came up with recommendation.

According to Johnson and Raising (1972) the teachers' appreciation of trigonometry as an important dynamic topic must be real and deep. His/her attitude to students must be sympathetic and understanding, his/her interest in learning must be great. If the teachers' attitude/interest are less favorable or the same as those of the student, no transmission of enthusiasm can take place. The teacher should always make his students feel that his attitude will be friendly regardless of success or failure of student. The student with proper attitude will derive pleasure from his contact with trigonometry. This meant there was need for a study to be done to determine how student attitudes affect the teaching and learning of trigonometry as no research had been done on this area in Gatundu North Sub-county Kiambu County.

Many studies indicates some relevance to the assumption that teachers attitude influence the pupils attitude towards mathematics. Philip (1973) showed in his study that teachers attitude towards mathematics is significantly related to pupils attitude and achievement. Although this research was done on how teachers' attitudes influences students attitude and performance no research has been done as to how students' attitudes affect the teaching and learning of trigonometry in secondary school. This study was aimed to investigate the challenges encountered by students during the teaching and learning of trigonometry due to the attitudes of student and came up with recommendation.

Concroft (1982) notes that

“There is no area of Knowledge where a teacher has more influence over the attitudes as well as the understanding of his pupils than he does in mathematics. During his professional life a teacher of mathematic which include trigonometry may influence for good or ill attitudes towards mathematics of several thousand young people and decisively affect their career choices” this indicates that teachers attitude towards mathematics has great impact on the subject.

A study done by Tumbo (1991) on the attitudes of pre-service teachers towards trigonometry found that:

(i) About twenty five percent of pre-service teachers were afraid of trigonometry because they were poor with figures and feared word problems.

a. Many of the pre-service teachers were not looking forward to teaching trigonometry in this study; Tumbo recommended that further research be done as follow up of teacher’s after graduating from college to see whether there is a change in their attitudes towards the topic after some experience in teaching.

The researcher therefore aimed to investigate the students’ attitude toward learning of trigonometry concept in secondary schools in Gatundu, North district. Miheso K.M. (2002) investigated the factors affecting mathematics performance among secondary school students in Nairobi province Kenya. She noted that “Attitude is a tool that can be manipulated by a given environment to enhance certain goals. The students’ attitude is explained in this study as symptom of prevailing classroom-learning environment as created by the availability of textbooks and teaching approaches used by teachers. It is the propositions of this study that students attitude can be changed through a change in learning environment. Which was supported by Mutai (2010) research finding on attitude towards learning and performance in mathematics among students in selected secondary schools in Bureti District. He noted that “schools must be aware that there certain aspects of students learning mathematics that need to

be improved .In particular students should be given more opportunities to work on non-routine and challenging mathematics problems so as to maximize their thinking skills and value the intrinsic essence of mathematics. This will require teachers going the extra mile in teaching students in that path of learning,” this means that teachers who are teaching trigonometry topics should not limit their teaching to theory focusing on passing in examinations only but the topics should be demonstrated in a more practical way by which student can spontaneously associate trigonometric knowledge with their everyday environment. In support of this Kasimbu (2004) noted that mathematics learning and capability to achieve good grades in mathematics examination was not only attributed to some unique talents and interest in the subject but to the positive attitude. However the study did not determined the challenge that students encountered as far as their attitude was concerned during teaching and learning process of trigonometry topic which lead to poor performance in questions related to the topics at KCSE examination which was addressed the current research.

2.5 Classroom atmosphere and teaching behavior of a teacher to learning process of Trigonometry.

Studies on classroom interaction have indicated the existence of different teaching and learning patterns exhibited by the teacher and his students. Stubbs (1978), report that there are two types of teachers, the direct and the indirect. Direct teachers are those who discourage students’ initiation and freedom to participate in learning and who are more involved in lecturing and giving directions. Indirect teachers on the other hand allow students freedom of expression of ideas. They are less involved in lecturing and giving directions. This means that there are different classrooms created, by different teachers. Wragg and Keny (1979) identified two types of atmosphere created by different teachers in their classrooms. They are as follows:-

(a) Democratic classrooms where the teachers discourse patterns allow the students to participate freely in the classroom in discourse. In such classrooms, there is high degree of

permissiveness in the teacher-students relationship .The students feel free to express themselves and teaching/learning is mainly student-centered.

(b) Autocratic classrooms in which the teachers' verbal discourse disregards the students feeling and dominates everything. The students just listen and obey leading to lack of self-direction of the students. The teacher is looked upon as the sole source of knowledge. Since effective teaching-learning process is expected to produce observable changes in students/learners behavior. Type of classroom climate could either enhance or hinder students' participation and in turn affecting the classroom discourse pattern in trigonometry teaching and learning process. Whether this was evident in trigonometry classrooms or not was the contention of this study.

From the foregoing studies, it can be seen that teachers interact with their students differently in different areas of classroom teaching and learning. Some teachers may encourage or discourage some students from participating in the learning activities. However the need to encourage and involve all students in the learning process remains a major issue in teaching methodologies and especially in trigonometry because of students' poor performance in the topic. This necessitates more research in classroom teaching-learning processes that are student-centered or (Heuristic). Hence the research focused on challenges encountered by students during teaching and learning of trigonometry in secondary schools.

2.6 Studies on Classroom Interaction

Classroom observation research in general has not been widely done in many countries. Despite it's important in describing what happens in the classrooms very little has been done in Kenya and especially in the area of challenges facing students in teaching and learning of trigonometry.

Njuguna (2000), in her study on verbal classroom interaction patterns of home science teachers and their students found that most lessons were teacher dominated and that teachers vary their

teaching methods depending on the gender of the students they are teaching. She observed that more of the drill method was used in boys' school. This study considered the verbal interaction pattern only but did not consider the challenges that students were facing in engaging to the verbal interaction in teaching/learning process of trigonometry in secondary school, which was taken care of by the current research.

Nyambura(2004) carried out a research on determination of classroom discourse patterns that enhance mathematics learning in selected public secondary schools in Nakuru District, Kenya. She observed that “mathematics teachers have a tendency of using more than one technique. However they used more teacher centered techniques than student-centered ones”. It was found that teachers spent much of their teaching time demonstrating how to solve a given problem and asking questions and this made the lecture technique and question answer method to be dominant. This gave the students limited opportunities to participate.

The study did not however consider the challenges that the teachers were facing in applying other methods which was considered by the current study on the teaching and learning process of trigonometry in secondary schools.

Njui (1989) in his study on immediate feedback on teaching behavior patterns of secondary school music teachers noted that teachers used more of drilling teaching patterns. However, when the teachers took control of the class, she realized that the student's freedom was limited and they were denied the opportunity to be creative. The teacher dominated the class talk and controlled the classroom interchange most of the time by giving directions to students. This behavior inhibited student's participation in the teaching and learning process. The study did not however consider students factors that influenced their participation which was consider by the present study or teacher challenge that prevent them from using the various teaching-learning methods that support learner centered approach in teaching and learning of trigonometry.

2.7 Summary of research gap

The aim of the research was to determine the pedagogical factors affecting the learning of trigonometry concept in secondary schools in Gatundu North Sub-county of Kiambu County. This was as result of DEO (2013) report indicating the performance of mathematics compared with the others compulsory subjects in the year (2009-2012) was low which was related to KNEC results within the same period. The reasons given for this low performance were associated with pedagogical factors affecting the learning of mathematics in secondary schools. Results from KNEC (2004-2013) data analysis on the National KCSE mathematics mean score and individual question analysis of poorly performed topics indicated that there was correlation between increase/decrease in the percentage of the poorly performed trigonometry questions to the national mean scores. This was evidence between year 2012 and 2013 when the mean score decreased from 28.65% to 27.57% when the percentage of poorly performed trigonometry questions had increased from 23% to 52.5% respectively. When it came to Gatundu North the same trend was shown in mathematics performance. This meant there were number of pedagogical factors affecting learning of trigonometry in secondary schools which have not fully addressed and needed urgent attention before good performance could be achieved. The research took into account the following pedagogical factors affecting learning of trigonometry in secondary schools: Determine the influence of teaching methods on the level of students' participation in the learning of trigonometry. This was aimed at identification of the teaching methods that teachers applied which increased active participation by students in the learning of trigonometry so that necessary recommendation could be made in order to improve the performance. The research investigated the extent to which instructional resources were used in teaching and learning of trigonometry. The research was aimed at identifying the use of readily available instructional resources and adequacy for the students during learning of trigonometry. The instructional resources such textbook, graph books, calculators and geometrical sets were

important as they increased students' class participation. This was in studies done by Kirembu (1991); Ngechu (1985) and Riungu(1988) found that in cases where teaching and learning resources were sufficient and combined with other teaching aids students participation was better in the learning process and hence perform better mathematics. The situation in Gatundu North Sub-county was different as the performance in mathematics was not good at all. This meant that the issues of teaching methods applied and use of instructional resources available needed to be addressed before good performance could be achieved. The finding of this research would help in the effort of improving trigonometry performance as it gave the necessary recommendation about the state and use of instructional resources. The research was aimed at finding out the students' attitude toward learning of trigonometry so that it could be improved. This was important as students' active participation in lesson depended on the attitude they had on the topic. The research findings would help in coming up with necessary recommendation on how to improve the attitude of students toward the learning of trigonometry and hence improve performance. This was in line with Miheso (2002) Research finding on the factors affecting performance of mathematics in which she found that the attitude could be changed through the change in learning process. In support of the same Mutai(2010) research finding on attitude towards learning in relation to the performance in mathematics among students in secondary schools in Buret where he advocated for students being given more opportunities to work on non-routine and challenging mathematics problems as of increasing their intrinsic motivation. The study had an aim of determining the challenges encountered by students in the learning of trigonometry which was important before any improvement could be achieved through the necessary recommendation made. Another area which was of importance to the study was the determination of classroom interaction patterns that took place during trigonometry learning which limited students' active participation. This was important as it was determined by teaching methods applied by the teacher and therefore it

was necessary to identify these teaching methods before good performance could be achieved through the necessary recommendations

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter discusses the methodology used for the study. This is described under the following sections: study design, location of the study, population, sampling and sample size, Instrumentation piloting and ethical consideration.

3.2 Study design

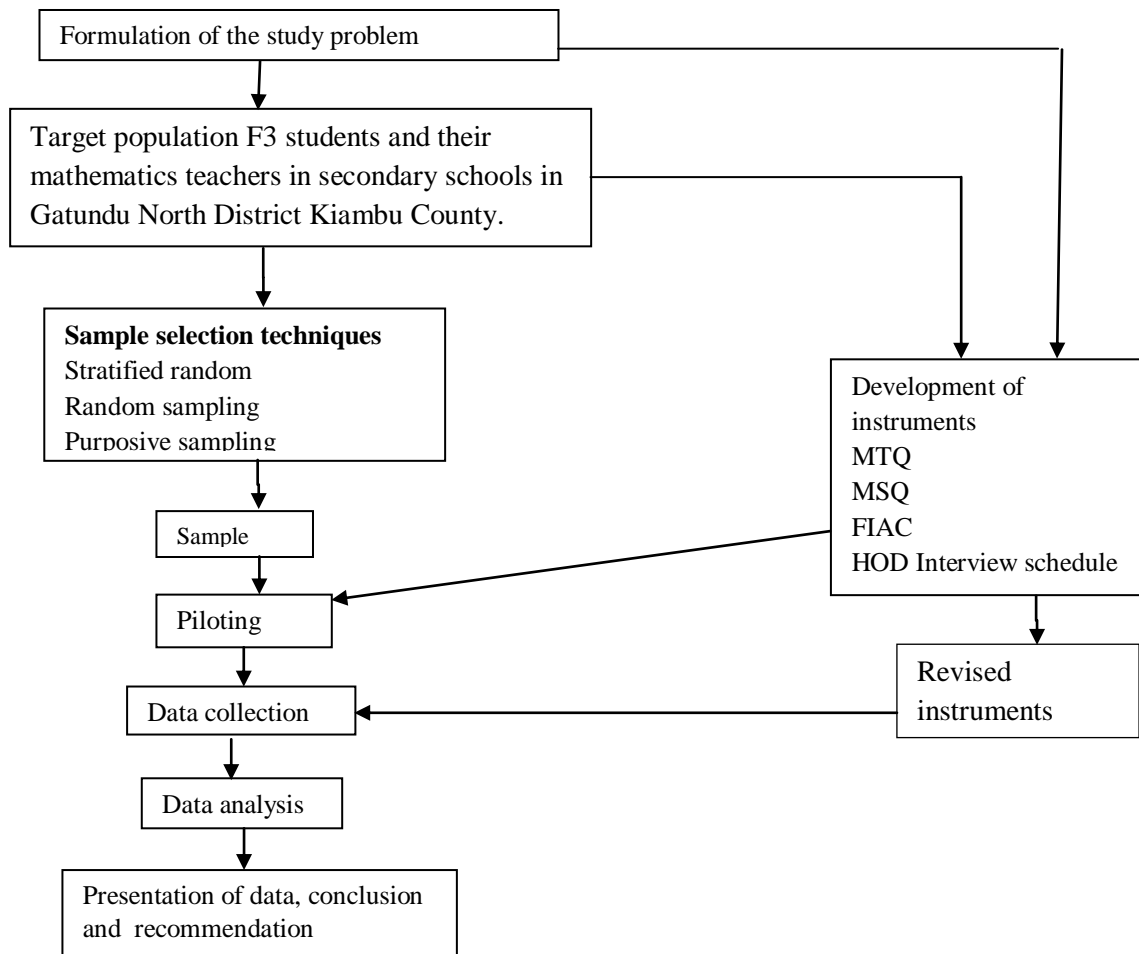
The selected research design was a descriptive statistics survey . This method was chosen because it describes and interprets what prevails, or conditions and relationships as they were with the intent of employing data to justify current conditions and practices or to improve them. (Koul1984). This enabled the researcher to determine the main pedagogical factors affecting the learning of trigonometry in secondary schools in Gatundu North Sub-county . The method was also used because it was useful in obtaining both qualitative and quantitative data regarding trigonometry teaching and learning in the classroom and which teaching methods were applied that influenced students' participation and came up with recommendations.

The first step involved development of research instruments. The researcher developed four types of instruments namely; Mathematics teacher questionnaire which was meant to collect the data concerning teachers general information such as their age, teaching experience and qualification. The second instrument was Mathematics student questionnaire which was meant to gather data concerning challenges encountered by students when learning trigonometry when drawing graphs. The third instrument Head of department interviews schedule which was meant in collecting data concerning administrative challenges encountered afar as students learning of trigonometry. The last instrument was a lesson observation for form three mathematics teachers which was aimed at collecting data concerning classroom interaction patterns challenges. The next step was piloting of all the research instruments so that they

could be tested for both reliability and validity. To test for reliability, which is a measure of the degree to which research instrument yield consistent results after repeated trials. The Test-retest method was used. To measure for both construct and content validity the same method of Test-retest was used where colleague teachers help in moderation

The four instruments were important as they helped to collect data required for identification of the pedagogical factors affecting learning of trigonometry by the students which helped in making the necessary recommendations. The last step was concerned with the analysis of the data collected from which conclusions and recommendations were made.

These steps are summarized in the figure 3.1

Fig 3.1 Study design

Source: Adapted from Njeru Lawrence (2010)

3.3 Location of the study

The study was carried out in Gatundu North District, Kiambu County in Kenya. It had been selected for the research as the District performance in Mathematics particularly in the last four years KCSE had been poor with average mean grade of D and hence required urgent solutions. At the same time although some researches about challenges encountered by students during the teaching and learning process of trigonometry may have been done elsewhere non had ever been done in Gatundu North District of late. The district had been selected for the study because the researcher was already working there which meant it was more convenient for him

to collect the data as he was familiar with the topography of the area. The researcher had been a Kenya National Examination Councils Mathematics examiner for more than 15 years and had noted the problem of poor performance in questions related to trigonometry topics for along time. The district was also selected as it had all the categories of schools targeted for the research.

3.4 Target population

The target population was all the form three students and mathematics teachers in the Sub-county 27 schools .Information from the DEO (2013) Gatundu North Sub-county indicated that the total population of form three students was 2165 and the number of mathematics teachers 62. The distribution of form three students and teachers in the Sub-county were as follows: The Sub-county had two Extra-county schools with Form three students enrolment of 311 and 7 teachers, 8 County schools with Form three enrolment of 504 and 19 teachers and the number of Sub-county schools were 17 with student enrolment of 1350 and 36 teachers. The form three students were targeted by the study because they had already covered trigonometry one in form II and at the same were mature enough to fill the questionnaires diligently. At the same time the other classes such as the Form IV could not have been used as they were busy preparing for their KCSE and the lower classes such as Form II were not competent enough to fill the questionnaires as they had covered only trigonometry I. The Sub-county students' population was 9363. This included 4616 boys and 4747 girls. The population of teachers' in secondary schools was 400 which included 213 male and 187 female teachers.

Table 3.1: Distribution of school categories, enrolment of students and staffing in mathematics in Gatundu North Sub-county, Kiambu county.

School type	Number of schools	Students enrolment	Form III students Enrolment	Mathematics teachers enrolment
Extra-County	2	1106	311	7
County	8	3026	504	19

Sub-County	17	5231	1350	36
Total	27	9363	2165	62

Source DEO (2013) Gatundu North Sub-county report

From the table 3.1 there is a clear indication that the majority of schools were either County or Sub-county schools. This meant many of the 27 schools were up- coming new schools which lack physical facilities such libraries where student could get reference materials while some classes were overcrowded. Which meant there were number of challenges encountered by the students in the process of learning trigonometry that needed to be investigated. This was supported by the fact that only 343 students in the Sub-county had managed to get grades of a C+ and above which was equivalent to 15.6% of transition rate in 2012 KCSE as indicated by DEO (2013) Gatundu North Sub-County report. Among the challenges highlighted as the main cause of this low rate were inadequate facilities in schools. This research was aimed at determining the challenges that students faced in learning of trigonometry in secondary schools and came up with necessary recommendations aimed at improving the situation.

3.5 Sampling methods

a) Sampling of School type

The sampling of schools was done using stratified random sampling technique. This was as a result of the Sub-county having three different categories of schools based on their KCSE performance and students enrolment. The schools were categorized as follows: Extra-County schools, which used to be called provincial schools. These were the schools whose performance in academics was above average, had better physical facilities such as well equipped libraries and had students enrolled from outside the county. The second category of schools was the County schools. These were schools whose performance at KCSE was average and slightly above average and had majority of students' enrolment from within the county. Many of these categories of schools have challenges in provision of physical facilities such the libraries. The last category was the Sub-County schools. These were schools whose

performance was average. The majority of students are enrolled from within the Sub-County. They have a big challenge as far as physical facilities provision is concerned. This method was used as it gave fair representation of all categories of schools depending on their students population as well as teachers. The number of students for each stratum was selected using simple random technique. For research purposes the only Extra- county girl's school and the one Extra-county boy's schools were considered for lesson observation using Flanders Interaction Analysis Category which aimed at identifying teaching methods and class activities that encouraged students active participation in a lesson. To take care of gender balancing one County girls and one boys' school were considered for the second category. The other three schools were randomly selected from Sub-County secondary schools.

b) Sampling of Mathematics teachers

Purposive sampling was used to sample the 7 mathematics teachers from the sampled school for classroom observation using modified Flanders Interaction Analysis Category System (see Appendix c). This represented 11.3% of the total population of the teachers in the district which stand at 62 as per District education officer report (2013). Where possible one of the two teachers in each category of the schools was a lady and when it came to filling the questionnaire four of the 14 teachers were females. The total number of teachers filling the questionnaire included the 7 observed and 7 other mathematics teachers which represented 22.6% of the targeted population of mathematics teachers. The method was chosen since mathematics teachers were the agents of teaching and learning of mathematics in these classes. To cater for the school types at least three mathematics teachers including the observed were given Mathematics Teachers Questionnaire to fill for each category of school in Gatundu North Sub-County, Kiambu County. As the number of Sub-County schools was almost double the sum of Extra-county and County schools, the number of teachers filling the question were about 36% of the sampled for a fair representation.

c) Sampling of Form Three Mathematics students

The sample of 40 students was selected using simple random technique if the number of students in a class were more than forty. Incases where there were more than one stream, the stream was either selected using simple random technique or purposively sampled. For the case of simple random selection some pieces of paper were marked with a number of” NOs” depending on the number of streams and one “YES”. The stream whose teacher picked the yes was used for lesson observation. For the case of purposively selection, this was where a stream was selected on the basis of a teacher volunteering for class observation or if the stream was already covering the topic among the others. A sample of 40 students was randomly selected from each of the seven sampled streams incases where there were more than 40 students to fill the questionnaires. In a stream the 40 students were selected by using simple random technique where the class teacher mark and folded 40 pieces of paper with the word ‘YES’ and the rest were left blank. The students who picked the paper with the word yes were provided with the questionnaire to fill. This was meant to give equal weight to all the schools that were considered for the research due variation on the number of students per class.

3.5.1 Sample size.

The number of the Sub-county schools considered for the study were 7, out of which 3 were used for lesson observations and the remaining 4 were used for MTQ .The number of students from Sub-county schools who filled the MSQ questionnaires was 120 and 7 mathematics teachers filled MTQ . The seven teachers included the three teachers who were involved in lesson observations and the remaining four were only involved in filling of MTQ questionnaire only. The research considered 5 County schools, two which were used for lesson observation while the remaining 3 were used for data collection using MTQ. The number of students involved filling the MSQ questionnaires was 80 and 5 teachers. The two Extra-county schools were also involved in both class observation and data collection using MTQ questionnaire. The

students who filled MSQ were 80 in number and two teachers filled the MTQ questionnaires. In total the questionnaires were administered to 280 students and 14 teachers from a sample of fourteen secondary schools in Gatundu North Sub-county, Kiambu county. The interview schedule involved the seven HOD in the schools which were involved in class observation

The 14 secondary schools represented 51.9% of the public secondary schools under consideration. The 280 students represented 12.9% of the targeted population of 2165 Form III students. This number was considered as it was within the recommendation of Nkpa (1997) and Gorard(2001) about sampling fraction of between 10-20% of the total population in descriptive research to be acceptable .It was also in support of Ary et al (1972) who observed that in descriptive research 10- 20 % of the targeted population was acceptable. The seven schools were also considered suitable due to the intensity of class observation method used and it was possible to sample two schools from each type. Due to the problem of students' failure to return the questionnaires after a week, the actual number of MSQ questionnaires dropped from 280 to 221 respondents. This was an indication that the challenges encountered by the sampled form three students' was a fair representation of the rest of students population in the district.

The distribution of respondents for the study was as follows:

School type	No of schools	Sample sch. for lesson observation	Sample teachers who participated in:		Form III sample students for:	Sample HOD for:
			mathematics Lesson Observation	Mathematics Teacher Questionnaire	Mathematics Student Questionnaire	Interview Schedule
Extra-County	2	2 (100%)	2(29%)	2(28.6%)	52(16.7%)	2(100%)
County	8	2 (25%)	2(11%)	5(26.3%)	52(10.3%)	2(25%)
Sub-county	17	3 (17.6%)	3 (8%)	7(19.4%)	117(8.6%)	3(19%)

Totals	27	7(26%)	7(12%)	14(23%)	221(10.2%)	7 (30%)
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Table 3.2 Distribution of respondents indicating school type and number, Form III

mathematics students, their teachers and their numbers per school.

3.6 Research instruments

Data was collected using the following instruments;

(a) Mathematics teachers questionnaire (see appendix A)

It was designed to investigate the teacher related challenges in teaching of trigonometry in public secondary schools in Gatundu North district Kiambu County. The MTQ was aimed at gathering data that would help in identifying the challenges that the teachers encountered during the teaching of trigonometry. This research was based on the following, teachers teaching experience, teaching methods applied, learning resources, learning activities and classroom set up. The information gained from the above would help to minimize the challenges that the teachers faced during the teaching of trigonometry in our secondary schools. It was newly constructed with some items adopted from Mutai Jackson (2010), used some of the items to find the relationship between the attitude towards learning and performance in mathematics among the students in secondary schools in Buret District and Njeru, Gitonga (2010), where some of the items in the instrument were used to find from the trained mathematics teachers the problems they experience in teaching mathematics using English as the language of instruction in secondary schools in Mara District.

(b) Interview schedule for head of department in the samples school (see appendix B).

It was designed to determine the administrative challenges encountered by head of mathematic department during the teaching and learning of trigonometry topics. This was looked into in terms of the teachers 'workload, resources availability, teachers' qualification and experience

and other administrative duties involving the teaching and learning of trigonometry topics in secondary schools. The information was very important for the school administrators as far as provision of necessary resources for the teaching of the topics is concerned.

(c) Mathematics student's questionnaire (see appendix C)

This was designed to determine the challenges that the students encounter during the learning of trigonometry in secondary schools. The instrument was aimed at gathering information concerning the students' attitude towards their teachers and the topics, whether or not students had necessary resources of learning trigonometry, main factors limiting student participation on trigonometry lessons and many others. The information gained would help in improving students' participation during teaching and learning of trigonometry topics.

(d) Flanders's interaction analysis category (see appendix D.)

This was one of the instruments that were used by the researcher to gather data as far as classroom interaction between teacher-student and student-student was concerned. The above instrument was used due to complexity of classroom observation which required use of appropriate research instrument to safeguard loss of any useful data (Webb et al 1966). In this study the main instrument that was used, was the modified Flanders interaction analysis category (F I A C)

The system was developed by Flanders (1965) to categorize both teachers and pupils talk. It was an observation schedule designed to permit systematic recording of instructions by taking into account small bits of interaction that took place in the classroom. The system had ten categories for categorizing teachers and pupils talk and had been found to be easy to train and use (Wasanga 1982)

It was used in current study with a modification of categories 4, 5, 6 and 10 in order to suit the study. There are many discourse events that take place in mathematics lessons. For the purpose

of the study further modification was done on F I A C so that the discourse events were categorized as follows;

- a) TEACHER –initiated interaction to include reacting, questioning, lecturing and directives categories
- b) STUDENTS-initiated interaction to include responses initiations and working in silence categories.

The interaction events were further sub divided into sub categories as illustrated:

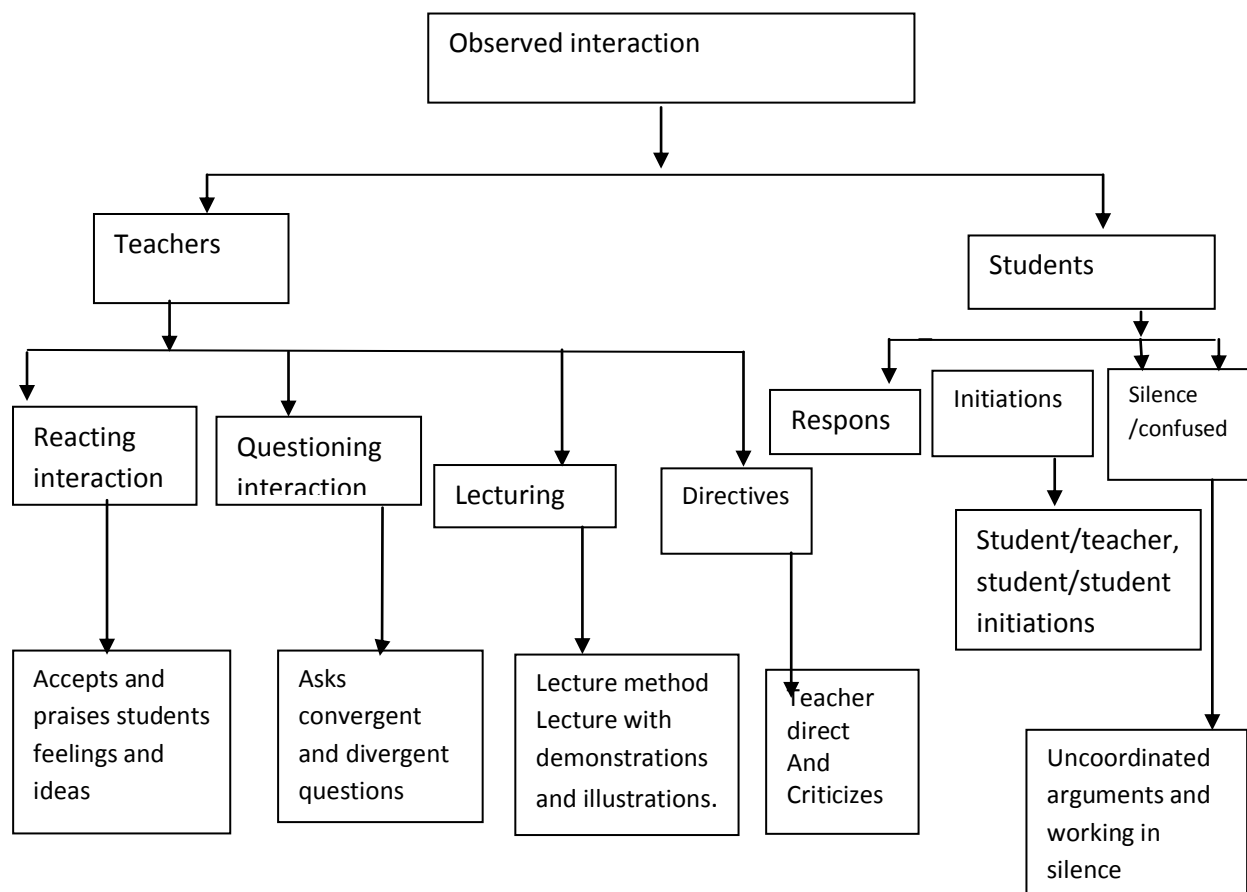


Fig 3.2 Sub-division of interaction events.

Source: Adapted Nyambura Gladys (2004)

The figure 3.2 above shows FIAC categories that were used to collect data on verbal trigonometric classroom interaction which showed the percentage of total time taken by

students and the teachers and also the source of the initiated trigonometric classroom interaction pattern during teaching and learning process.

Apart from using F.I.A.C for coding, free-hand observation notes were made to note down other non-verbal discourses such as the use of resources and teaching methods used during the trigonometry lesson. These activities could influence the trigonometry lesson classroom discourse patterns in various ways. Most important to the study was how these activities influence significantly the students during teaching and learning of trigonometry in secondary schools.

3.7 The pilot study

3.7.1 Validity and Reliability of the instrument.

(a)Content Validity of the instrument was done at the design stage. Some of the items in the questionnaire were adapted from Wasanga (1982), Nyambura Gladys (2004) and Oisebe M. Victor (2010). The pilot study was carried out in Gatundu North Sub-county, Kiambu County to check the appropriateness of the language used in the questionnaires and necessary modification of the tools were made. This was done by selecting two schools within the Sub-county which were not be part of the main study where all the instruments were administered to both teachers and students in Form Three. The piloting involved one County and a Sub-county school, each contributing 40 students, a teacher and head of department. Then the data was analyzed for necessary modification and improvement, the modified instruments were repeatedly administered to the same schools after two weeks for the second time and analyzed.

(b) **Reliability:** To test for reliability of the instruments the Test-retest method was used. This was done by visiting the same school which had been used in the first piloting after duration of two weeks and administering the modified instruments to the same students and teachers in Gatundu North Sub-county. The collected data was once again analyzed to verify reliability of

the instruments. The results were used for appropriate modification of the questionnaires. The modified and improved instruments were used in the main study.

The correlation coefficient or coefficient of reliability of the three instruments: MTQ, MSQ and HOD interview schedule was calculated using Karl Pearson's coefficient of correlation Formula. The formula is as indicated below:

Karl Pearson's coefficient of correlation(r)

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{n \cdot \sigma_x \cdot \sigma_y}$$

where:

x_i = *i*th value of x variable

\bar{x} = mean of x

y_i = *i*th value of y variable

\bar{y} = mean of y

n = number of pairs of observations of x and y.

σ_x = Standard deviation of x

σ_y = Standard deviation of y

The correlation coefficient of the three instruments was positive and 0.85. This was an indication that the data collected using the instruments was reliable and could help in drawing the conclusions of research data analysis.

(a) Reliability of F.I.A.C system was tested using Scotts (1959) formula. This was done by using the data collected during piloting of class observation by the researcher and his assistance. The collected data was analyzed and used to calculate Inter-observer reliability index. The calculation of the index was important as it indicated how much the researcher

and his assistance agreed in the proportional distribution within the within the categories thus ensuring competence in observation. The formula is as follows

$$N = \frac{Po - Pe}{100 - Pe}$$

Where:

N = Inter-observer reliability index.

Pe = Portion of agreement by chance.

Po = Proportion of agreement which is determined by subtracting the total percentage of disagreements from 100. Where Po = 87.2 and Pe = 60.35

A reliability index of about 0.7 was acceptable since it give a high degree of agreement. The validity of FIAC was established through pilot study. The detail of how this was done is given in the following section in data collection procedure.

3.8 Data collection procedure

The data for the study was gathered using the four instruments. The procedure for each data collection depended on instruments used:

- a) Data collection using questionnaires: the researcher made three visits to each of the schools selected for the study. The first visit was to familiarize himself with the school administration, HOD and mathematics teachers. The second visit was to familiarize with the students so that they were aware of his intention to collect data for research purpose. The third visit with the help of mathematics teachers the researcher administered the questionnaires to the teachers and students. The three visits were necessary in order to establish good rapport with both the teachers and students thus minimizing the hawthorn effect.

- b) Data collection using HOD interview schedule: the researcher made two visits to the selected schools. The first visit was familiarization HOD and booking the appointment for the interview schedule. The next visit was to conduct the interview.
- c) Flanders interaction analysis category for classroom observation the researcher entered the classroom with the teacher and sat at the back to avoid interrupting classroom interaction in any way. The researcher decided the best categories that suit the interaction events in trigonometry. He then coded numbers, on a coding sheet at the same time assessed the continuing interaction pattern. Each of the seven teachers from the sample schools were observed twice while teaching trigonometry making a total of 14 observations. Data from the classroom observations was used to calculate the percentage of total time spent by teachers interacting with students. The questionnaires were administered to the students with the assistant of the mathematics teachers after the last day of the classroom observations.

3.9 Data Analysis

The obtained from all the questionnaires: MTQ, MSQ and HOD interview schedule was both qualitative and quantitative. The two types of the data were analyzed using the SPSS computer package .This was a comprehensive statistical data analysis and management system. To do this, all the research instruments were given a serial number and the number then became the identification for each respondent. The data was used to generate tabulated reports, charts, plots of distribution and hence they reported in chapter four of the study.

3.10 Logical and ethical considerations

A permit to conduct the study was obtained from the Permanent Secretary in the Ministry of Education Science and Technology. The researcher further sought for permission from Gatundu North District Educational Officer. During the visits to each school, permission was sought from the Principal before involving the teachers and the students.

Further consultation was done with Mathematics teachers and agreed on the convenient time when lesson observation or interview schedule could be done. The consent of both teachers and students was sought before being given questionnaires to fill and before being observed in their classes in the teaching and learning process of trigonometry. The researcher established a good rapport with the teachers and their respective Form3 students. The respondents were assured of confidentiality of the research results.

3.11 Summary

The chapter had described the descriptive statistics survey design and the methods used in the study. It had also highlighted the related variable to be investigated. Four instruments MTQ, MSQ, HOD interview schedule and FIAC were used to establish the relationship between the main pedagogical factors affecting the students learning of trigonometry in secondary schools and necessary recommendations were made on how to improve the performance. The instruments for the study are shown in appendices A-D. The study findings analysis, presentation and discussions were done in the next chapter after the data collection.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND DISCUSSION

4.1 Introduction

The study focus was to establish the pedagogical factors affecting the learning of trigonometry in secondary schools in Gatundu North Sub-County of Kiambu County, Kenya. The chapter present in details data analysis, presentation, results and discussion of the study from the descriptive statistics based on objectives of the study namely: To determine influence of instructional techniques and approaches on the level of students' participation in the learning of trigonometry, To establish the extent to which instructional resources were used in the teaching and learning of trigonometry, To determine the students' attitude towards the learning of trigonometry, To establish the challenges encountered by the students in the learning of trigonometry and finally the type of classroom interaction patterns that took place during trigonometry learning between teachers-students and students in Gatundu North Sub-county of Kiambu County.

trigonometry.

4.2 Influence of teaching methods on the level of students' participation in the learning of trigonometry. The data to verify the objective was collected, analyzed, presented , interpreted and discussed under the following subheading :

4.2.1 Teachers: Instructional techniques and approaches and the challenges faced when teaching trigonometry

The study sought to establish the influence of teaching methods on the level of students' participation in the learning of trigonometry. The fourteen teachers were asked to state the most frequently teaching methods that they applied in teaching of trigonometry. The table 4.1 below indicates the data analysis of their results:

Table 4.1: The most frequently applied Teaching methods in secondary schools

Teaching methods	Frequency	Percentage
Lecturing and demonstrations	7	50%
Pair, group or class discussion	2	14.3%
Question and answer	4	28.6%
Discovery method	1	7%
project work	0	0%
Field trips	0	0%
	14	100%

Table 4.1 Shows the teaching methods as applied by teachers where majority use lecturing and demonstrations at 50%, pair, group or class discussions at 14.3%, question and answer method at 28.6%, while Project work and Field trips were not used as indicated at 0%. Project work seems to be very unpopular with teachers although they are very important in teaching and learning of trigonometry. From the results of data analysis on the most frequently applied teaching methods by teachers, it was clearly indicated that the majority teachers were not using teaching methods that encouraged students' active participation. This was as result of 50% of the respondents indicating that they preferred using lecturing and demonstration methods but non used project work or field trips. This meant many students were passive during their lessons. This weakness on majority of teachers to apply the teaching methods that encouraged students' participation during the learning process might have resulted to many students being frustrated as result of misconception in trigonometry due to lack of enough opportunities to express themselves and hence the poor performance in topic. There is need for teachers to be

balancing between extreme expository strategies such as lecture and demonstration and heuristic methods such as discovery methods, project work and field trips. The study found that teachers tend to avoid them because for one they are time consuming and secondly many teachers may have little pedagogical content knowledge for teaching the topics. There is need for teacher educator to come up with program me that can help such teachers on how well they can integrate the two approaches in teaching trigonometry so that they can improve on students' participation in lesson and hence improve performance. In support of the same Miheso O'connor (2009) study concluded that an important step towards improving teaching should be an inclusion of specialized pedagogical content knowledge in the teacher preparation programmed

4.2.2: Learning activities as used by teachers in schools

The study sought to determine the learning activities which encourage students' active participation during the learning of trigonometry. The table 4.2 below indicates the analyzed results:

Table 4.2: Learning activities as used by teachers in schools

Learning activities	Frequency	Percentage
One on one discussion(teacher –student)	4	28.6%
Whole class discussion or Q/A	6	42.9%
Small groups discussions and presentation	1	7%
Individual discussion (pairing of students)	3	21.4%
	14	100%

Table 4.2 Shows the learning activities as used by teachers where 28.6% used one on one discussion, 42.9% question and answer method, 7% used small groups discussion and individual discussion groups. From the results of data analysis it was clearly indicated that many of the teachers did not apply learning activities that encouraged students' active participation during teaching and learning of trigonometry as indicated by the fact that only 7%

who used small group discussion and presentation. This was contrary to recommendation of ministry of education through secondary mathematics teachers' hand book guide January (2006) report. The report recommended heuristic methods of teaching as they encouraged active participation and involvement of the learners in planned class activities. Which are organized with the individual learners in mind and take into account their ability, aptitude and prevailing environmental conditions .The teaching methods that were applied by teachers seemed to have failed in meeting the ministerial recommendation and hence failed to capture the learners interest facilitating and encouraging reasoning through activity and problem solving. This had been the major cause of poor performance in trigonometry. The main reason given as to why these methods were unpopular with teachers was that they were time consuming and many teachers found it hard to plan for them in the same time frame of 40 minutes. Although many teachers were aware about their importance as they are student centered approach to teaching and learning process of trigonometry. This study finding indicated that the reasons as to why these student centered approaches were rarely used in schools was that many of the teachers were not competent with pedagogical contents knowledge of how to apply them during the teaching and learning process in topics such as trigonometry. There is need for teachers training to be coming up within-services courses for teachers where the issue of pedagogical content knowledge for teaching mathematics in secondary school is revisited.

This is in line with Miheso – O'Connor (2009) study which found that teacher's pedagogical content knowledge could be improved and its acquisition streamlined.

4.2.3 Observed Class discourse patterns in trigonometry classroom

The research sought to establish the kind of classroom interaction patterns that took place between teachers-students and students-students, which encouraged students' active participation in the learning process of trigonometry. The instrument used was Modified

Flanders Interaction Categories for coding teacher – students’ categories. The data was collected from the seven teachers ,each with two classroom observations making a total of 14 observations .The prevailing classroom interaction patterns in trigonometry in lessons were observed and audio recorded while the researcher noted down other non verbal interaction such as teaching methods applied, teachers and students activities and use of resources.

The collected data was coded using Flanders Interaction Category Analysis (FIAC) and the resulting frequencies for all the categories recorded from the selected schools across the two observed lessons. The mean use of each category per lesson was calculated by dividing the total frequency counts of each category coded by the total number of lessons observed in this case 14. This value provided an estimate of the category used per lesson by the individual teacher. The higher the mean the more the category was used. Relative frequency distribution and percentage of the total frequencies of the various categories of FIAC (Appendix D) for all the observation are in Table 4.3

Table 4.3: The means of class lesson observation discourses Coded Interaction patterns of the mathematics teachers and students during teaching and learning of the Trigonometry topic using the Flanders Interaction Analysis Category:

The Observed discourse patterns of form 3 mathematics teachers and students during trigonometry classroom lessons using FIAC were group into two categories such as the teachers and students discourse and the summary of each is as in table 4.3

Teacher discourse	Teacher/student discourse category code	Totals observed	Mean use of category	Percentage %
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Reaction	1. Accepts students feeling	83	5.90	0.85
	2. Teacher praises students	590	42.1	6.07
	3. Accept and use students ideas	545	38.9	5.60
Questioning	4a. Teacher ask convergent questions	1326	94.7	13.6
	4b. Teacher ask divergent questions	228	16.5	2.4
Lecturing	5a. Teacher centered	87	6.20	0.89
	5b. Demonstrates	1762	125.9	18
	5c. Teacher illustrates with aid	88	6.30	0.91
Directives	6. Teachers direct	978	69.9	10.1
	7. Teacher illustration	52	3.60	0.52
Student discourse	8. Student responses	925	73.2	10.5
	9a. Student initiates	795	56.8	8.20
	9b. Student – student initiation	350	25.0	3.60
	10a. Silence /confusion	460	32.9	47.0
	10b. Working in silence	1348	96.30	13.9
		9617	694.1	100

Teachers discourse (Reaction, Questioning, Lecturing, Directives) and student discourse (Responses, Initiating, Silence, Working in silence) during teaching and learning of trigonometry.

The Table 4.3 above revealed that teacher's discourses accounted for 59.2% of the total classroom discourses while students discourse for 40.8%. This results show that teacher's discourses dominated the classroom teaching and learning process of trigonometry lessons taking about two thirds of the total times of 40 minutes while students discourses took about a third. Teacher discourse dominance implies that there was relatively low use of student-centered teaching approach that led to autocratic teaching behavior that might have hindered the opportunities for student participation in this classroom teaching and learning process of trigonometry. Another serious problem noted was lack of the teachers making use of teaching aids to illustrate trigonometric concepts ideas as it accounted for 0.96%. This shows that many students especially the slow learners were having problems in trying to conceptualize and concretize trigonometry content knowledge and that why many students indicated that they had problems in drawing graphs especially when choosing suitable scale and plotting points. There is need for mathematics teachers to improve in their pedagogical content knowledge so that

they are able to use teaching methods that are student centered instead of teacher centered. Students' centered method such as small group discussion and peer teaching could be of great help in order to concretize trigonometry concept there is need for teachers to be making both visual and audio media in the teaching and learning process, especially to weak students. Teachers seemed to have avoided thought provocative questions as it is carried out 2.47%. The study finding indicated that many teachers were not able to note the misconceptions that students held at the end of the lessons due to their failure to ask divergent questions which could have acted as a feed back for their lessons.

These studies confirm the finding of other researchers done in similar study area. (Gathumbi (1995) Njuguna (2000) and Nyambura (2004) who found that most lessons were teacher dominated and teachers varied their teaching method. However they used more teacher centered techniques instead of the student – centered ones and thus limiting students' opportunities to participate.

During class observation through random sampling enquiry questions from students about availability of basic instructional resources such as the logarithms, calculators and Geometrical sets that the student were having the following statistics was obtained: extra county less than 75% of students had the three basic resources at that particular lessons. For County less than 50% were having the three basics resource and the worst was from Sub-County schools where less than 20% had the three resources such the logarithm, scientific calculators and geometrical sets. This means that the major challenge of learning trigonometry lies on teaching method that are applied by teacher's being teacher centered instead of learner centered and inadequate resources that student had. There is need for combined effort between the school administrators and teachers to making sure that students have the basic instructional resources at all the time from form I to form IV. The school administrators through the head of

mathematics department should make sure that the ratios of text book is reduced from the current 1:2 to 1:1 in all the categories of schools. Schools need to be doing auditing of their mathematics text books at the end of every year and at the same time repairing the worn-out books in order to maintain their ratios.

4.2.4 Challenges encountered by teachers while teaching trigonometry

The study sought to establish the challenges encountered by teachers while teaching trigonometry. The fourteen teachers were asked to state the major challenges encountered while teaching of trigonometry in secondary schools. Table 4.3.5 indicates the analyzed data results from the respondents.

Table 4.4: Challenges encountered while teaching trigonometry

Challenges encountered while teaching	Frequency	Percentage
Large number of students in classes	6	42.8%
Lack of Individual attention to slow learners	2	14.3%
Failure to complete assignments	2	14.3%
One on one interaction with students is difficult	4	28.6%
	14	100%

Table 4.4 shows the challenges encountered by teachers while teaching trigonometry in secondary schools where the participants indicated the challenges as large number of students in classes at 42.8%, lack of individual attention to slow learners at 14.3, failure to complete assignments by students at 14.3% and one on one interaction with students at 28.6%. From data analysis of table 4.3.5 it was clearly indicated that the major challenges facing teachers were that of overcrowded classrooms at 42.8%, followed by one on one interaction at 28.6% and the others two ;lack of individual attention to slow learners and failure to complete could not be ignored. This showed that although teachers were to be blamed for not using student centered methods at time circumstances dictated. In this table4.4, the issue of large number of

student in a class needs to be address because although many teachers are professionally qualified a class size of 45-50 could be rendering them to be ineffective. This is because with large number of students to handle, mathematics teachers are likely to be over burdened in their efforts to making students work and attending to individual differences. In this connection the school administrator should be strictly enforce the policy of on class size of 45 while at the same time teachers also to make use of small group discussion and peer - teaching during preps. The school administration should be designing construction of spacious classroom to avoid overcrowding. When it comes to provision of learning resources the ratio of text books should be 1:1 in order to be making sure all students have access to the text books at all time instead of current 1:2 or 3 which is in line with Kirembu (1991) study which revealed that in cases where teaching and learning resources such as text books are sufficient and other teaching/learning resources student participation is better in the teaching and learning process.

4.2.5 Students responses on mostly applied learning activities in secondary schools and challenges faced when learning trigonometry

The study sought to establish the mostly used learning activities that the students were involved in when learning trigonometry. The Figure 4.2.4 shows the analyzed data from the students' responses:

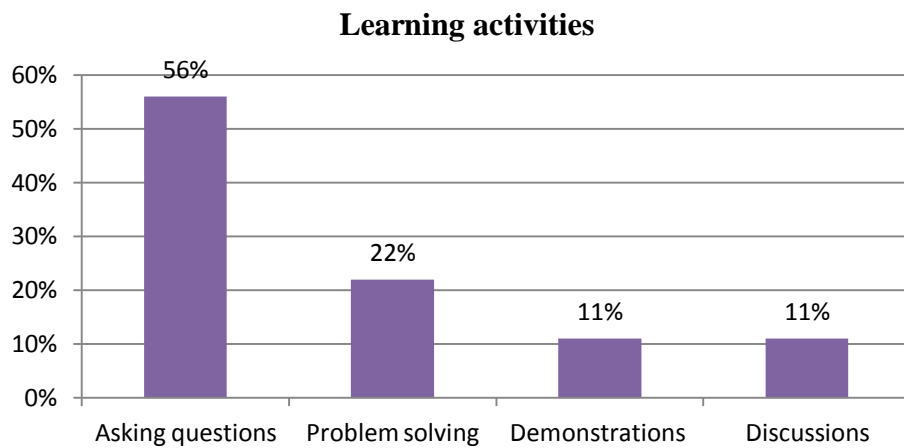


Figure 4.1: Learning activities as used in schools

Figure 4.1 shows the learning activities as used in classes, asking questions were the most used method at 56%, problem solving at 22%, demonstrations at 11%, discussions at 11%. The result from Figure 4.2.1 indicates that very little of collaborative learning by students was taking place during learning of trigonometry as indicated by the fact that only 11% of students were involved in discussions groups. This was contrary to Piaget theory of construction of knowledge which advocated for collaborative learning through discussion groups and peer teaching in which all students had equal opportunity to air their opinions in the learning process. There is need for teachers to embrace teaching methods that encourage students' active participation such as small group discussion which involve all students problem solving. This is in line with Cohen (1976) who stresses that collaborative effort by students to allow problem solving to continue when individual member might have encountered a difficult situation.

4.3 Type of teaching and learning resources required for the teaching and learning trigonometry.

The study sought to establish the resources needed for the teaching and learning of trigonometry in secondary schools. The fourteen teachers were asked to state whether they had

and used the following most needed resources for teaching and learning of the trigonometry topic In secondary schools: the KICD syllabus, textbooks, mathematics teachers' guide, KNEC reports, geometrical instruments and graph books. The Fig 4.2 indicates the result of their responses.

Fig 4.2: Teachers responses on use of trigonometry teaching resources available.

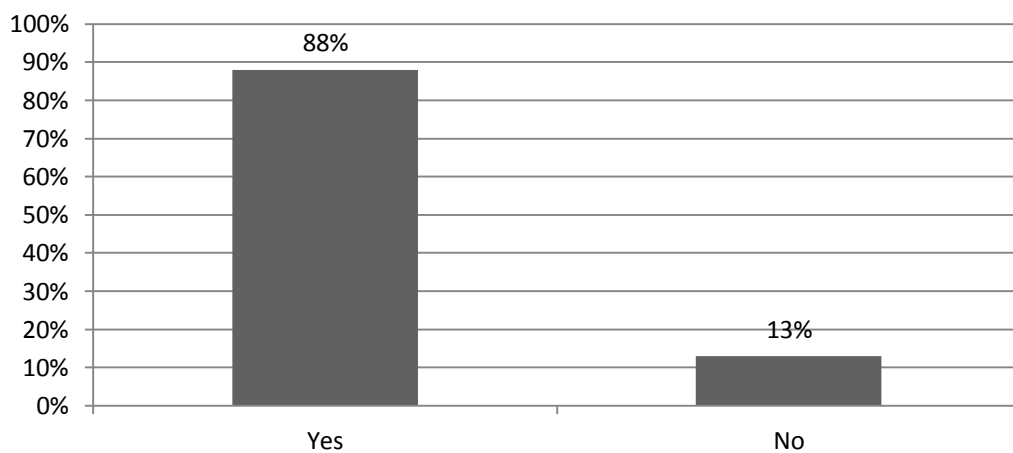


Figure 4.2: Use of trigonometry teaching resources available in schools such as graph books, all approved mathematics textbooks and teachers guide, recommended scientific calculators, KICD syllabus, KNCE reports and geometrical sets.

The above figure shows that 88% of the respondents used all the trigonometry teaching resources mentioned above while 13% indicated that they did not use them all. The result from Fig.4.2 indicated that the use of trigonometry teaching resources available by teachers was not a big challenge as indicated by 88% of the respondents who said they were using them compared to 13% who said not all of them were readily available for use. This shows that the majority of teachers had the necessary resources for teaching trigonometry and hence the challenge of teaching trigonometry could have been on the teaching methods applied by

teachers not being learner centered as it was observed during lesson observation. There is need for the teachers to be encouraging hand on activities by the students especially when carrying geometrical demonstration as that would increase student active classroom participation. In support to this Baker Gerstein and Lec (2002), on their comment about the synthesis of effective instructions strategies, recommend that segment of mathematics instructions should target teaching students to generate explanations of mathematics concept in their own words and to justify the methods they use to solve problems.

4.3.2 Resources available in schools for teaching and learning of trigonometry.

The research sought to establish the available resources for teaching and learning of trigonometry in schools. The teachers were asked state the mostly available resources for teaching and learning trigonometry used by teachers and students in secondary schools apart from class textbook. The Table 4.5 shows analyzed results of the respondents:

Table 4.5 Available resources for teaching and learning trigonometry

Most available resources in learning trigonometry	Frequency	Percentage
Mathematical logarithm tables	5	35.7%
Geometry instruments	3	21.4%
Scientific calculators	4	28.6%
Charts	2	14.3%
	14	100%

Table 4.5 shows the most available resources for teaching and learning of trigonometry used by students, mathematical logarithm tables were mostly used at 35.7%, geometrical instruments at 21.4%, scientific calculators at 28.6%, charts at 14.3%. From the results of Table 4.5 analyzed data ,it was clearly indicated the most utilized resources in teaching and learning of trigonometry were the mathematical logarithm tables with 35.7% followed by scientific

calculators with 28.6%, then geometrical instruments with 21.4% and least utilized was charts with 14.3%. This shows that for effective teaching and learning of trigonometry lesson the teacher must not only make sure the resources are readily available but also adequate in his preparation for the students. This is because the use of the instructional resources dictates the type of classroom activities that take place. This in line with studies done by Ngechu(1985) and Riungu(1988) which revealed that in cases where teaching and learning resources such as textbooks are sufficient and combined with other teaching aids students participation was better in the teaching and learning process and hence perform better in mathematics. in The schools should come up with way of motivating students to work hard through rewarding good performers by taking them to field trips related to the topics such visiting controls towers at Jomo Kenyatta International Air port and Kenya meteorological department. This is supported by Mutai (2010) research finding on attitude towards learning and performance in Mathematics among students in selected secondary schools in Bureti District where he noted that school must be aware that there are certain aspects of students learning mathematics that need to be improved in support.

4.4.3 How the resources such as mathematics textbooks were used

The study sought to establish how the students used the resources available such as mathematics textbooks in learning mathematics in secondary schools. The form three students were asked to state how they used the mathematics textbook by ticking a number of items as given in the table. The Table 4.6 indicates the analyzed result of the students' responses.

Table 4.6: Use of approved mathematics class textbooks such as KLB Form3 and longhorn Form3 by students

Students: Use of mathematics textbook	Frequency	Percentage
Class exercise practice	83	38%
Group discussions	18	8%
Revision	62	28%
Reading ahead of the lesson	58	26%

Table 4.6 shows the student's usage of mathematics textbook where the majority at 38% uses the textbooks for class exercise practice, 28% uses them for revision, 26% read ahead of the lesson and 8% use them for group discussions. From the results of Table 4.6 it was clearly indicated that the majority of students used the textbook for individual studies as indicated by 38% while a few for collaborative studies as shown by 8% engaged in group discussions. This was not in line with social constructivism theory developed by Jean Piaget (1960) which acknowledges the fact that students learn from each other as well as from the teachers. Teachers should encourage students to form discussion groups and make use of peer teaching. This will help weak student at the same time solve the problem of large class size.

4.4 Students' attitude towards learning on the concept of drawing trigonometry graphs

The study sought to establish the perception of Form Three students on the concept of drawing of trigonometry graphs in secondary schools. One student was selected using simple random technique from the seven schools that were used for class observation and was asked to briefly give his/her perception on the concept of trigonometry as guided. Table 4.7 shows analyzed results of the students' responses on their feeling about their perception on the concept of drawing trigonometry graphs.

Table 4.7 Students responses on their perception on the concept of drawing of trigonometry graphs.

Students responses on trigonometry	Frequency	Percentage
Very difficult	1	14.3%
Difficult	4	57.1%

Less difficult	2	28.6%
	7	100%

Table 4.7 shows the students responses on the trigonometry where the majority perceived it as difficult at 57.1%, less difficult at 28.6% and very difficult at 14.3%. The fact that 71.4% perceived the trigonometry concept to be difficult was clear indication of the attitude the students had. This meant many students had negative attitude towards the topic and hence affected their learning morale about the topic thus this was a major challenge. With proper guidance, motivation and provision of necessary resources the attitude of students can be changed. This is in line with Miheso K.M (2002) research finding on the investigation of the factors affecting mathematics performance among secondary school students in Nairobi province Kenya .She noted, “Attitude is a tool that can be manipulated by a given environment to enhance certain goals”.

4.5.2 The summary of students’ responses to various questions concerning their perception and attitude towards the trigonometry concept.

The study sought to establish the perception and attitude of students concerning trigonometry concept through the way they responded to various issues raised concerning trigonometry topics.

The respondents were asked to rate the factors on a scale of 1 to 5; (1: Strongly Disagree 2. Disagree, 3: Neutral, 4: Agree, 5: Strongly Agree) to determine the extent at which they agreed

or disagreed with statements relating to students attitudes towards trigonometry and the challenges encountered in learning and teaching trigonometry. Means for the factors were established in order to provide a generalized feeling of all the respondents. Means less than 1.5 implied that the respondents strongly disagreed with the statements on attitude or challenges encountered; means greater than 1.5 and less than 2.5 implied that the respondents disagreed with the statements. Means greater than 2.5 and less than 3.5 implied that the respondents were neutral with the statements. Means greater than 3.5 and less than 4.5 implied that the respondents agreed with the statements while means greater than 4.5 implied that the respondents strongly agreed with the statements. A standard deviation of 1 indicates that the responses are further spread out, greater than 0.5 and less than 1, indicates that the responses are moderately distributed, while less than 0.5 indicates that they are concentrated around the mean. A standard deviation of more than 1 indicates that there is no consensus on the responses obtained. The results are indicated in the Table 4.8 below:

Table 4.8: Mathematics student's responses

Mathematics students responses	N	Mean	Std. Deviation
Trigonometry is an important topic in mathematics	221	4.24	1.123
Trigonometry only requires memorization of formulae without understanding them	221	1.42	.622
Trigonometry is a dull topic	221	2.83	1.416
Languages used in trigonometry problems is not difficult to understand	221	3.79	1.373
Students like discussing trigonometry with others	221	3.38	1.449
Trigonometry questions are very difficult to do	221	3.21	1.236
Trigonometry makes me think hard and therefore helps me improve my understanding	221	4.14	1.187
When teachers' use appropriate teaching aids I have a better understanding	221	4.34	.721
Trigonometry questions should not be included in KCSE exams	221	4.17	1.002
Understand trigonometry irrespective of the gender of the teacher.	221	3.31	1.339
Look forward to trigonometry lessons	221	3.42	1.015

The research findings in table 4.8 revealed that the respondents agreed that trigonometry was an important topic in mathematics, languages used in trigonometry problems is not difficult to understand, trigonometry makes the think hard which improves the understanding of the respondents, when teachers use appropriate teaching aids the students understands better, trigonometry questions should not be included in KCSE exams at 4.24, 3.79, 4.14, 4.34 and 4.17 respectively, this therefore shows that when teachers use appropriate teaching aids the students understands better which needs to be encouraged.

However the respondents were neutral on whether students like discussing trigonometry with others, trigonometry was very difficult, students understood trigonometry irrespective of the gender of the teacher, and students looked forward to trigonometry lessons at 3.38, 3.21, and

3.31 respectively. The respondents disagreed that trigonometry is a dull topic at 2.83. The respondents also strongly disagreed that trigonometry only requires memorization of formulae without understanding them at 1.42. This shows that students know the importance of trigonometry concept and therefore their attitude can be change by provision of basic learning materials and appropriate teaching methods.

4.5 The challenges encountered by students in the learning of trigonometry were concerned.

The study sought to find out the challenges encountered by students in the learning of trigonometry topic was concerned. The teachers were given closed question as part of the questionnaire in which they were to answer by ticking either 'YES' or 'NO' depending on their opinions on statement . The table 4.9 shows the summary of the responses that the teachers gave concerning the challenges that the students were experiencing during the learning of trigonometry:

Table 4.9: The responses of teachers on challenges experienced by students in learning of trigonometry topic

Challenges experienced in trigonometry	Yes	Percentage	No	Percentage	
Terminologies used in trigonometry topics difficult for the students to understand	3	21%	11	79%	14
Students problems in using logarithms and calculators	10	71%	4	29%	14
Students encounter problems in scale drawing	9	64%	5	36%	14
Students have problems in relating the unit circle and trigonometry ratios	11	79%	3	21%	14
Students have problems in problem-solving involving sine rule and cosine rule	11	79%	3	21%	14

The table 4.9 shows the challenges experienced by students while learning trigonometry where 79% had difficulties in solving problems involving bearing ,angles of depression and elevation, another 79% had difficulties in relating the unit circle and trigonometry ratios, using logarithms and calculators was a challenge as perceived by 71% of the respondents, scale drawing was a problem as indicated by 64% of the respondents while the terminologies used in trigonometry topics was not seen to be difficult for the students as indicated by 79% of the respondents.

The problem of 71% of students being unable to use logarithms and calculators can be associated with acute shortage of the instructional resources especially in County schools and Sub-county school as indicated by the study finding. This shows the weakness on side of subject teachers who had failed to have made sure that the students had these instructional resources before starting to teach the topics. It also shows the weakness on the teaching method applied by teachers which did not encouraged active participation of learners such as small group discussion and presentation in which the students are fully responsible for their learning. Instead they were taught using traditional method such as demonstration and class discussion which were controlled and guided by the teachers. This means that many teachers need to be exposed to new Trends in mathematics education such as importance of use of collaborative methods in teaching and learning mathematics in secondary schools. Which can be achieved through intensification of SMASSE projects In-service courses where specialist in mathematics education can be used to train mathematics teachers. This is in-line with the study carried out by Miheso – O'Connor (2009) on proficiency on the teachers' pedagogical content knowledge in mathematics by assessing levels of teacher competency in the subject matter, knowledge of students and specialized knowledge of teaching mathematics. The study found the teachers to have displayed a sense of ill developed mathematical knowledge for teaching. This means

there is need for mathematics teachers to be exposed to in-service courses and seminars on specialized pedagogical content knowledge of mathematics in specific topics.

4.5.1 The main challenges encountered by students when drawing trigonometry graphs

The research aimed at establishing the main challenges encountered by the students' when drawing trigonometry graphs. The fourteen teachers were asked to state the main areas where they found students encountering problems when drawing trigonometry graphs. The Table 4.10 indicates the results of the analysis of the respondents:

Table 4.10: Areas of challenges encountered by the students when drawing trigonometry graphs

Areas of challenges	Frequency	Percentage
Plotting decimals places and significant fig.	4	30%
Identifying signs of ratios	4	26%
Not drawing smooth curves	3	19%
Not choosing the right scale	1	10%
identify turning points on graph	2	15%
	14	100%

When it come to challenges encountered by students when learning trigonometry involving drawing of graphs one thing became very clear that some teaching methods applied by teachers left students with knowledge gaps. The problem 30% of student being unable to plot points in graphs indicated that they were not properly guided of decimal and approximation and significant figures. The same case applies to 20% indicating that they had problem in sign of the trigonometric ratios which originated from algebraic expressions. Teachers should try to embracing the teaching methods that gives the students an opportunity to discover for themselves rather than rushing students with the aim of completing the syllabus. At the same time the subject teacher should be making sure that the necessary resources such as graph books, logarithms and geometrical sets are available before starting any topics in mathematics. This will help the student to develop the psychomotor skills for using the basics resources and in the process help themselves develop positive attitude toward the topics. Teachers should

also try to be asking thought provocative questions at the end of the topics in order to help them assess misconception early enough. This is in line with (Kirembu, 1991 Ngechu 1985 ND Riungu 1988) studies which revealed that in cases where teaching and learning, resources such as textbooks were sufficient and combined with other teaching aids student participation is better in the teaching and learning process and hence performed better.

4.5.2 The study sought to determine the challenges encountered by students when drawing trigonometry graphs.

Students were asked to state among the four challenges given the one which they encountered most of the time when drawing trigonometry graphs. The Table 4.11 indicates the analysis of the students' responses:

Table 4.11: Students responses on challenges faced in drawing trigonometry graphs

Challenges faced when drawing trigonometric graphs	Frequency	Percentage
Lack of concept understanding	140	62%
Poor scales	23	11%
Conversion of angles in degrees to radians	23	11%
Tables of values calculations	35	16%
	221	100%

Table 4.11 Shows the challenges faced when drawing trigonometric graphs, the majority of the respondents at 62% indicated that there was a problem understanding the concept which makes it hard for them to draw correct graphs, 16% indicated that tables of values calculations was also a problem, poor scales and conversion of angles in degrees to radians were at 11% respectively. These problems are attributed to the student's inability to understand the concept of trigonometry. This could have been as a result of inappropriate teaching methods applied as indicated by the results of Table 4.1 about the learning activities mostly used in secondary schools where Q/A or whole class discussion had 42.9% compared to small group discussion

with 7%. This shows the teaching method applied by teachers did not take care of individual differences of the learners hence left many of them with trigonometry knowledge gaps leading to misconception. This was in line with Sidhu (1991) whose study suggested that in order to increase teaching and learning process, there was need for the teachers to reduce dominance in controlling the classroom activities and give every student maximum opportunity to participate in the learning process.

4.6 The research sought to establish the main challenges that the students were encountering during the learning process of trigonometry in secondary schools.

The students were asked to state one among the five challenges given which was the most challenging to each one of them as an individual. The Table 4.12 indicates the analyzed results of the students' responses:

Table 4.12: Challenges encountered by students in learning process of trigonometry

Challenges encountered by students	Frequency	Percentage
Lack of basic resources (geometrical set, log table)	75	34%
Inadequate mathematics text books	24	11%
Languages used in trigonometry	56	26%
Lack of interest in trigonometry	61	27%
Lack of self confidence	5	2%
	221	100%

Table 4.12 shows the challenges encountered by students in learning trigonometry where lack of basic resources such as geometrical set, log table were at 34%, lack of interest in trigonometry was rated at 27%, languages used in trigonometry was 26%, inadequate mathematics text books at 11% and lack of self-confidence at 2%. From Table 4.6.4 results it

was clearly indicated that the main challenges were due to inadequate basic resources by students as revealed by 45%, followed by students negative attitude toward the topic with 29% and finally the language used in textbooks being difficult with 26%. The main challenge was lack of enough basic instructional resources. With proper planning on the part of teachers' the problem can be rectified and good performance achieved.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter entails the summary of the study, conclusion and recommendations based on the objective of the study. The study sought to find out the pedagogical factors affecting teaching and learning of trigonometry in secondary schools in Gatundu North Sub-County of Kiambu County, Kenya. In addition this chapter provides a direction for further studies.

5.2 Summary of the study findings

The purpose of this study was to establish the pedagogical factors affecting the teaching and learning of trigonometry in secondary schools. Data was collected using questionnaires which were administered to the targeted population of all the Form III mathematics teachers and students of various Extra-county, County and Sub-County schools in Gatundu North Sub-County. Class observation was done using modified Flanders Interaction Analysis Categories.

The study established that more teachers were degree holders of BED which means that they were professionally trained with the relevant skills. The study also noted that more teachers and head of mathematics departments had the teaching experience of more than 12 years which places them at a better position to understand the various students' dynamics in classes. The study revealed that most of the schools are faced with the challenge of overcrowded classes which makes it difficult for the teachers to have one-on-one interaction with the students. These strongly contribute to the low performance of students in trigonometry which relies on students understanding the concept instead of memorization.

The study also established that the most commonly used method of teaching in schools was lecturing and demonstration which is not the most efficient method. The group discussion

method was also used but the challenge of overcrowded classes limited the teachers from having a one-on-one interaction with the students. This did concurs with the study by (Ochola 1985) and K.I.E (1985) which established that demonstration, lecture, games example and discussion methods were commonly used for teaching mathematics in classroom, but this faced challenges when the classes were overcrowded.

The study finding revealed that most of the schools suffer from inadequate provision of learning resources such as lack of enough basic instructional resources for the students (geometrical set, log table), inadequate mathematics text books which forms the basic learning resources for trigonometry. This was not in line with the findings of (Kirembu, 1991; Ngechu, 1985; Riungu, 1988) who established that in cases where teaching and learning resources such as textbooks are sufficient and combined with other teaching aids student participation is better in the teaching and learning process and hence perform better in mathematics. Therefore this demonstrates the reasons as to why the student's performance has remained low in the region. The study also established that field trips and project work are rarely utilized in the region which hinders students exposure to the real life application of trigonometry in order to appreciate to the concept and hence importance of learning trigonometry.

The study established that student's attitude was negative since most of the students perceived the topic as difficult and very difficult, this concurs with the study by Sidhu (1991) which established that the majority of students hold trigonometry 'as a dry' and difficult topic full of abstract concepts which results to students taking little interest in it due to inadequate students participation in learning resulting to them being passive and inactive in classrooms. The study found that the students attitudes was also negative in that most of them were fairly interested in the topic or others were not interested at all. This again demonstrates the effects of teaching methods where the teachers applied lecture and demonstrations which was not adequate due

the large number of students in classes. The study confirms the findings by (Sidhu, 1991) who established that the topic can be 'softened' when appropriate teaching resources gives rise to certain activities that enhance student's participation in trigonometry teaching and learning process. Such activities may include illustrations using a diagram, analysis of trigonometry structure or reading text questions.

The study revealed that the respondents agreed that when teacher's use appropriate teaching aids they understand better which confirms the findings by Eshiwani (1983) who stated that the factors affecting the pupils performance in mathematics fall into two categories, social and environmental factors on one hand on the other class size, large classes contribute significantly to poor performance and low control of the class, the availability of adequate physical facilities as well as equipped libraries, essential equipment's and teaching materials are very important.

The study revealed that while the majority of the HODs were stating that the schools had enough learning materials, the majority of the teachers were neutral about the existence of the same. But the students confirmed that they had no enough learning textbooks and other teaching aids which are the basic instructional resources for trigonometry learning, which greatly affected the performance of the students. The findings concurs with the study by Njuguna (2000) who established that the use of teaching aids cannot be ignored in the teaching and learning of mathematics in secondary schools as we are aware that the use of teaching aids helps to facilitate the teaching and learning of concepts, increases efficiency on information processing, gives meaning to words, help focus on student interests and assists the teacher to relate abstractness to concreteness. For the success of a lesson depend on the methods used in teaching with appropriate teaching aids.

The study revealed that there was no one on one interaction with students which made the teachers individual attention to slow learners difficult; this was one of the reasons that the students indicated that they experienced the concept as being difficult to understand.

5.3 Conclusions

From the study it can be concluded:

1. Although trigonometry teaching and learning should be based on social construction theory ,many of the teachers did not apply teaching methods that encouraged collaborative learning such small groups discussion, project work and field trips .Instead they preferred teachers' centered approaches such as lecture, class demonstrations and whole class discussion methods which highly influenced students active participation during trigonometry. It is on this strength that the study feel there is need for teachers to use teaching methods that increase class participation by students such as discussion group methods which were lacking as this will help students improve their perception on trigonometry in learning which would help them develop the positive attitude towards its learning. This was as result of 50% of the respondents indicating that they preferred using lecturing and demonstration methods but non used project work or field trips as given by Table 4.1 This meant many students were passive during their lessons. This weakness on majority of teachers to apply the teaching methods that encouraged students' participation during the learning process might have resulted to many students being frustrated as result of misconception in trigonometry due to lack of enough opportunities to express themselves and hence the poor performance in topic. There is need for teachers to be balancing between extreme expository strategies such as lecture and demonstration and heuristic methods such as discovery methods, project work and field trips. The study finding revealed that teachers tend to avoid them because for one they are time consuming and secondly many teachers may have little pedagogical content knowledge for teaching the topics. There is need for teacher educator to come up with program me that can help such teachers on

how well they can integrate the two approaches in teaching trigonometry so that they can improve on students' participation in lesson and hence improve performance. In support of the same Miheso O'connor (2009) study concluded that an important step towards improving teaching should be an inclusion of specialized pedagogical content knowledge in the teacher preparation programmed

2. The learning resources were neither adequate nor readily available for students during teaching and learning process of trigonometry. Teaching and learning resources such as geometrical sets and calculators were inadequate especially in Sub-County schools which made it very hard for the students to apply psychomotor skills required in drawing of graphs. This may have led to many students indicating that they had problems in drawing trigonometry graphs. From the results of Table 4.5 analyzed data ,it was clearly indicated the most utilized resources in teaching and learning of trigonometry were the mathematical logarithm tables with 35.7% followed by scientific calculators with 28.6%, then geometrical instruments with 21.4% and least utilized was charts with 14.3%. This shows that for effective teaching and learning of trigonometry lesson the teacher must not only make sure the resources are readily available but also adequate in his preparation for the students. This is because the use of the instructional resources dictates the type of classroom activities that take place. This in line with studies done by Ngechu(1985) and Riungu(1988) which revealed that in cases where teaching and learning resources such as textbooks are sufficient and combined with other teaching aids students participation was better in the teaching and learning process and hence perform better in mathematics. in The schools should come up with way of motivating students to work hard through rewarding good performers by taking them to field trips related to the topics such visiting controls towers at Jomo Kenyatta International Air port and Kenya meteorological department. This is supported by Mutai (2010) research finding on attitude towards learning and performance in Mathematics among students in selected secondary schools in Bureti

District where he noted that school must be aware that there are certain aspects of students learning mathematics that need to be improved in support.

3. From Table 4.5: the fact that 71.4% of students perceived the trigonometry concept to be difficult were clear indication of the attitude the students had. This meant many students had negative attitude towards the topic and hence affected their learning morale about the topic thus this was a major challenge. With proper guidance, motivation and provision of necessary resources the attitude of students can be changed. This is in line with Miheso K.M (2002) research finding on the investigation of the factors affecting mathematics performance among secondary school students in Nairobi province Kenya .She noted, “Attitude is a tool that can be manipulated by a given environment to enhance certain goals”.

4. From Table 4.12 results it was clearly indicated that the main challenges were due to inadequate basic instructional resources such logarithm tables, geometrical sets and mathematics textbooks by students as revealed by 45%, followed by students negative attitude toward the topic with 29% and finally the language used in textbooks being difficult with 26%. With proper planning on the part of teachers’ the problem can be rectified and good performance achieved

5. From Table 4.3 results which revealed that teacher’s discourses accounted for 59.2% of the total classroom discourses while students discourse for 40.8%. This was an indication that teacher’s discourses dominated the classroom teaching and learning process of trigonometry lessons taking about two thirds of the total times of 40 minutes while students’ discourses took about a third. Teacher discourse dominance implies that there was relatively low use of student–centered teaching approach that led to autocratic teaching behavior that might have hindered the opportunities for student participation in this classroom teaching and learning process of trigonometry. Another serious problem noted was lack of the teachers making use of

teaching aids to illustrate trigonometric concepts ideas as it accounted for 0.96%. This shows that many students especially the slow learners were having problems in trying to conceptualize and concretize trigonometry content knowledge and that why many students indicated that they had problems in drawing graphs especially when choosing suitable scale and plotting points. There is need for mathematics teachers to improve in their pedagogical content knowledge so that they are able to use teaching methods that are student centered instead of teacher centered. Students' centered method such as small group discussion and peer teaching could be of great help in order to concretize trigonometry concept there is need for teachers to be making both visual and audio media in the teaching and learning process, especially to weak students. Teachers seemed to have avoided thought provocative questions as it is carried out 2.47%. The study finding indicated that many teachers were not able to note the misconceptions that students held at the end of the lessons due to their failure to ask divergent questions which could have acted as a feed back for their lessons.

These studies confirm the finding of other researchers done in similar study area. (Gathumbi (1995) Njuguna (2000) and Nyambura (2004) who found that most lessons were teacher dominated and teachers varied their teaching method. However they used more teacher centered techniques instead of the student – centered ones and thus limiting students' opportunities to participate. This has led to student's negative attitude towards the topic out of frustrations.

5.4 Recommendation for Policy and Practice

The study recommends that:

1. There is need for teachers to be ensuring that expository-oriented techniques are well integrated with heuristic approaches in order to make the teaching and learning of trigonometry stimulating to the level of encouraging or motivating students to participate in the lesson. The

classroom activities should be reduced from practice exercises emphasizing mechanical drill to inquiry activities requiring more time on problem solving. For instance, SMASSE activities encourage students to engage both on ‘minds’ and ‘hands’ on activities.

2. The teachers should try to make use of teaching aids such as drawing of charts, make sure that students have basic instructional resources such as geometrical sets, graph books and calculators in order to create interest during the learning process of trigonometry concepts such as drawing of graphs.

3. Efforts should be made to encourage mathematics teachers understand and appreciate the role of teaching media in teaching and learning process. They also need to be encouraged to devise and develop a variety of instructional media that best fit the learning needs of their students such a media will enhance students involvement in classroom interaction.

4. The curriculum developers and inspectorate should give room for professional development and in-service education and training in the use of interactive teaching styles, such as heuristic, which promotes students participation in trigonometry teaching and learning.

5. The ministry of education science and technology through free subsidized day secondary education programme should incorporate provision of three basic instructional resources such as logarithms, geometrical sets and scientific calculators Sub-County as they were found to have acute shortage of the items among the categories of schools considered. In order to maintain accessibility and availability of these resources it was found necessary that geometrical sets should be provided at Form one entry and Form three entry and for the other two logarithm and calculators should be provided once at form one and form three respectively. This will help to maintain the quality and quantity of the three basic instructional resources in our secondary schools.

5.5 Suggestions for Further Research

1. The data for this study was collected from varied groups of form three mathematics students, teachers and HODs in the same region of Gatundu North Sub-County , Kiambu County. Thus, the findings may not be generalized to other counties before further research is done on them to find out whether they might yield the same results. In this regard, replicating of this study can be done in the same settings in order to establish the validity and generalization of the present findings across different Counties across the country, Kenya.
2. The study was carried out in public schools. Replication can be done in private schools so that an informed generalization can be made.
3. With the improved technology there is need for a research done to investigate the relationship between teachers' use of information technology in teaching trigonometry and students' involvement in learning the topic.

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- a) Masters ()
 b) Trained Graduate (BED) ()
 c) PGDE ()
 d) Diploma trained (Dip ED) ()
 e) Others specify _____

3. For how long have you been teaching mathematics in secondary school _____ years/ months?

Part Two. Your Feeling About the teaching of Trigonometry.

Please indicate how you feel about trigonometry teaching by the extent of agreement using words.

Strongly agreed SA, Agreed A, Undecided U, Disagree D, Strongly Disagree SD.

Put a tick in one box for each statement. If you make a mistake put across through the marked box and then tick in the correct box.

	Teacher's feelings.	SA	A	U	D	SD
1	Trigonometry teaching is enhanced when using verbal explanations					
2	Student to student interaction improves student understanding of trigonometry concepts					
3	Appropriate teaching aids and their availability during trigonometry lesson improves the teaching and learning of it.					
4	Most students have problems in expressing themselves while asking or answering questions in trigonometry.					
5	Teaching trigonometry is enjoyable.					
6	Other than required text books I do not use other supplementary materials.					
7	Student's and teacher's verbal interaction improves trigonometry teaching.					
8	My teaching experience is that boys are better in trigonometry than girls.					
9	If you were to judge my students they appear dull and fear trigonometry					
10	Most of the students are shy to display their solutions on the board					

Part Three: Your feeling about trigonometry concepts

Please answer the questions below concerning trigonometry concepts.

I. As a teacher do you find terminologies used in trigonometry topics difficult for the level of the students to understand Yes No

If yes, which ones _____

II. As a teacher do you find students with the problem of using logarithms or calculators in verifying trigonometric ratio? Yes

If yes, what are the specific problems _____

III. Do students have problems in scale drawing involving bearing, angles of depression and elevation? Yes No.

IV. If the answer to the above question (iii) is yes what do you think should be done? _____

V. Do students have any problem in relating the unit circle and trigonometric ratios of angles greater than 90°? Yes No.

VI. What do you think should be done to help such students? _____

VII. Do your students have a problem in problem-solving involving bearing, angles of depression and elevation? Yes No.

VIII. Which is the most common mistake that students make when drawing trigonometric graphs for angles greater than 90°? _____

PART FOUR: TEACHING METHODS

Answer this part by ticking in the appropriate box or filling in the spaces provided.

1. Which of the following methods do you frequently use in teaching trigonometry?

- I. Lecturing and demonstration ()
 II. Pair, group or class discussion. _____
 III. Question and answer ()
 IV. Discovery method ()

- V. Project work ()
- VI. Field trips ()
- VII. Others specify. _____
2. Which teaching methods do you find most suitable in teaching trigonometry?

3. Which of the methods in (1) above actively engage students in active participation in learning process?

4. List the learning activities that your students enjoy most during the lesson?
(i) One on one discussion (ii) Whole class discussion
(iii) Small groups discussion and presentation. (iv) Individual discussion.
5. Are there times that you use more than one method in the same lesson? Yes () No () If yes in what way?

6. As a teacher, what are the main challenges do you encounter when teaching trigonometry in large classes which are not found in other topics.

7. Which type of classroom seating arrangement do you use in your class and how does it enhance student participation and learning process?
a) Pairing student b) Groups of 8 discussion and presentation
c) Question and answer method (whole class) d) Small groups (4) discussion and presentation
8. Do you think that teachers gender influence student's active participation in trigonometry teaching and learning process depending whether the school is boys or girls?
If yes, how _____
9. Comment on what should be done to improve the teaching and learning of trigonometry in secondary schools?

Thank you so much for your help
Daniel Kagenyi (Researcher.)

Appendix B

H.O.D INTERVIEW SCHEDULE

The instrument was aimed at determining the administrative challenges that were encountered by Head of Departments in secondary schools in Gatundu North District . The interviews were conducted by the researcher himself.

1. Age: _____
2. Sex: Male Female
3. Qualifications
 Masters in Education PGDE
 B.E.D B.S.C/ B.A
 DIPLOMA OTHERS
4. Teaching experience in mathematics
 Over 12 yrs 3-7 yrs
 8-11 yrs 2 and below yrs
5. What is your work load per week in mathematics?
 28 periods and above 15-22
 23-27 Below 15
6. Are you teaching other subjects apart from mathematics? Yes No.
7. Which other subjects are you teaching?
 Physics Biology
 Chemistry Geography
 Other (specify) _____
8. How many periods in other subjects?
 12 and above 5-7
 8- 11 Below 4
9. Do you use mathematics teaching resources in teaching trigonometry?
 Yes No
10. Which are some of the most available resources in teaching trigonometry?
 Mathematical logarithm tables Scientific calculators
 Geometry instrument Charts
 Others specify _____
11. In 10 above are they readily available? Yes No
12. Which of the following methods do you use in teaching trigonometry (Tick as many as you use)
 Inductive methods Deductive methods Lecture and Demonstratio
 Group discussion Project work Field trips
 Others specify: _____
13. Among the above mentioned methods of teaching trigonometry state two methods you rarely apply and give the reason for each.
 a) _____ b) _____
14. Do you associate trigonometry to real life experiences as you teach trigonometric graphs?
 Yes No
 If yes, how _____
15. How do you feel about teaching trigonometry?
 Very difficult Difficult very easy easy
16. Which among the following challenges do you face while teaching trigonometry?
 Lack of adequate resources Students negative attitude
 Limited time Large number of students in a class

Others specify _____

17. What is the general attitude of students you teach towards trigonometry?

Very interested

Interested

Fairly interested

Not interested

18. How do your students take the concept of trigonometry?

Very difficult

Difficult

Less difficult

I do not know

19. How much do you agree with the following statements: use only one of the following for each response:

Strongly Agree (SA) agree (A) Undecided (UD) Disagree (DA) or Strongly Disagree (SD)

	Statements	SA	A	UD	A	S
1.	Students are weak in learning trigonometry					
2.	Trigonometry is hard for students to comprehend					
3.	The school has enough mathematics text books and other resources for revision.					
4.	Teachers prefer teaching trigonometry in the morning					
5.	Head teacher gives adequate support of materials for teaching trigonometry					

Appendix C

MATHEMATICS STUDENT'S QUESTIONNAIRE (MSQ)

The purpose of this research is to identify the main challenges that both the teachers and students face during the teaching and learning process of trigonometry concept in secondary schools. The questionnaire has three parts. The first part requires you to give some personal and general information. The second part is concerned with your feeling about the trigonometric concept. The last part is concerned with your feeling about the teaching of trigonometric topic by your teachers.

Answer each section by ticking (\checkmark) inappropriate box or filling in the spaces provided. Answer the question as honestly as possible. The information you give will be confidential and used for research only. Please don't write your name.

Part one: personal and general information

1 (a) Name of the school -.....

(b) Type of the school

(a) Ex- county or county

(b) District boarding school

(c) District day school

2. Gender Boy () Girl ()

3. Which of the following challenges do you think influence your participation in mathematics especially when you are learning trigonometric topics.

- i. Lack of the basic necessity such as geometrical set, scientific calculator or logarithm table.()
- ii. Inadequate mathematics text books or having to share a mathematics text book with more than one student ()
- iii. The language used in trigonometry concepts being too difficult to understand()
- iv. Lack of interest in trigonometric topics()
- v. Lack of self confidence()
- vi. Any other specify.....

Give possible suggestions on what you think should be done in helping you to improve in trigonometry.....

Part two: Your feeling about trigonometry concept instruction

This part has statements and you are required to make decisions as to whether you strongly agree (SA), agree (A), undecided (UN), disagree (D), Strongly Disagree (SD) with each statement. Put a tick (\checkmark) in the box below if you agree with the statement or uncertain if you are not sure of the statement.

Please if you make a mistake put a cross in the mark box and then a tick in the appropriate box. The following stand for

SA- strongly Agree

A- Agree

UN- Undecided

D - Disagree

SD – Strongly Disagree

STUDENTS FEELING	SA	A	UN	D	SD
Trigonometry is an important topic in Mathematics					
Trigonometry only requires memorization of formulae without understanding them.					
Trigonometry is a dull topic.					
Language used in trigonometry problems is very difficult to understand					
I like discussing trigonometry with other students.					
Trigonometry questions are very difficult to do					
Trigonometry makes me think hard and therefore helps me improve my understanding					
I understand trigonometry when the teacher uses appropriate teaching aids.					
Trigonometry questions should not be included in K.C.S.E exam					
I understand trigonometry irrespective of the gender of my teacher.					
I always look forwards trigonometry lessons.					

PART THREE: YOUR FEELINGS ABOUT TRIGONOMETRY TEACHING.

1. The List below indicates some of the methods which your mathematics teacher uses in teaching trigonometry topics. Indicate by using a tick (✓) how frequent he uses them.

METHOD	VERY OFTEN	OFTEN	RARELY	NOT AT ALL
Lecture and demonstration				
Peer group discussion				
Field trips				
Question and answer				
Exploration/discovery				
Project work				

2. List three methods mentioned in (1) above in order of merits from the mostly used to the least _____ **3.** List the learning activities which are involved during trigonometry lessons (such as Note-taking, asking questions and explaining how to solve a problem, demonstration).

4. Which one of the learning activities in question 3 above do you participate most? Give reasons

5. What do you use mathematics textbook for? Tick as appropriate.

- i. For class exercise practices ()
- ii. For group discussions ()
- iii. To revise ()
- iv. To read ahead of the lesson ()
- v. Others specify () _____

6. List other materials that you use for learning trigonometry other than the class texts such as; models, charts and graphs etc

7 State three challenges you face when drawing a trigonometric graph.

8 State three things that you think could be done to improve the teaching and learning of trigonometric topics in your school

Thank you
Daniel Kagenyi.

Appendix D

Modified Flanders interaction categories. This instrument was used by the researcher for coding teacher-students categories. Modification include 4(4c, 4b) 5 (5a, 5b) 9(9a, 9b) 10 (10b)

Discourses	Teachers discourse categories								Students discourse categories						Total
Category	1	2	3	4a	4b	5a	5b	6	7	8	9a	9b	10a	10b	
1															
2															
3															
4a															
4b															
5a															
5b															
6															
7															
8															
9a															
9b															
10a															
10b															
Total															

Source: Nyambura Gladys(2004)

The key used is a follows:

1. Accept feelings this refers to teachers statements, which clarifies the feeling tone of the students in a non-threatening manner. Such feelings may be positive or negative. Predicting and recalling feeling are included.
2. Positive feedback: This refers to statements by the teacher, which praise or encourage students action or behavior such as nodding the head or saying “in huh” or say, “go on”
3. Accepts or uses students’ ideas: Refers to statement by the teachers which accept or use the idea of students. These include clarification, building ideas or suggestion by students.
4. Ask question
 - a) Refers to teachers convergent questions that serve to move conversation, to the next step to introduce a new topic, problem and to involve ideas that are important.
 - b) Open-ended questions that are probing and necessitates individual students thought and for which variation responses are accepted. Students play a major role in determining the pattern of verbal interaction.
5. Lecturing: This involves giving facts or opinions about content procedures. In this category the teacher expresses his ideas and asks questions. The category will be in three parts as follows:
 - (a) Lecturing involving only talk by the teacher without the use of teaching aids.
 - (b) Lecture with demonstrations where the teacher performs an experiment or demonstrates problem solving strategies to enhance part of the lesson. The teacher may demonstrate either before the whole class, small group or individual.
 - (c) Lecture with illustration or with teaching aids; the teacher combines lecture with the use of charts, chalkboard, books, real objects models etc.
 6. Giving directions: This refers to the statement by the teachers like, directions commands or orders with which students are expected to comply.
 7. Criticizes or Justifies authority: This includes any statement intended to change students’ behavior from non-acceptable pattern to acceptable. Statements stating why the teacher is doing what he is doing and those indicating extreme self reference are classified under this category.

8. Students' response: This refers to statement of students in response to teachers. The teacher initiates the contact or solicits student responses and sets limit to what the students says.

9. Students initiate: This category is in two parts

(a) Statement of own initiated type by the students are classified here. Students expression of own ideas, new topic, freedom to develop opinion and a line of thought like thoughtful asking questions to teacher are also coded in this category.

(b) Students - student talk or discussion. The teacher guides the inter-student discussion planning and presentation to stimulate and keep it thought provoking. The interaction is largely between the students while the teacher serves only as a moderator or consultant.

10. Silence or confusion:

(a) This refers to pauses, short periods of silence and confusion in which communication can not be understood by the observer or more than one student response to the teacher's questions is coded here.

(b) Students working on exercise silently, the students participate in solving a specific problem individually. Teacher's role is limited to monitoring and encouragement.

11. Teaching techniques

Key:

MT – More than one technique used

T1 - Teacher lecture

T2 - Pair group or class discussion

T3 - Question and answer

T4 - Demonstration

T5 – Peer teaching/ class present

T6 - Audio-visual aids

T7 - Explanation