
By: Amwayi, Oliver Shitanda

A Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Education.

Kenyatta University
Declaration

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

Amwayi Olive Shitanda (Mrs)

This thesis has been submitted for examination with our approval as University Supervisors.

Prof. Jack Green Okech,

Professor of Curriculum Development,
Department of Educational Administration, Planning and Curriculum Development.

Kenyatta University.

Dr. Joseph M. Malusu,

Senior Lecturer,
Department of Educational Administration, Planning and Curriculum Development.

Kenyatta University
Acknowledgement

I would like to thank my Supervisors Prof. Jack Green Okech and Dr. Joseph Masingule Malusu for their self-less effort as they guided and constructively advised me at various stages of this research. Thanks to Mr. John Akhamwa Shiundu who guided me in the initial stage of this study. Many thanks also to my colleagues Katiambo, Sakwa, Shililu, Mwandoe, Anakeya, Woka and Njoroge for their moral support.

Special tribute goes to the head-teachers, who allowed me to use their schools and the standard seven mathematic teachers and pupils who accepted to participate in the study. Thanks to the standard seven mathematics teachers who were observed teaching and the pupils who sat for the Test on Euclidean Plane Geometry. I received invaluable support from all the eight head-teachers of primary schools visited. They made it possible for me to work smoothly in their schools. Thank you so much.

Finally, I acknowledge the support provided by my family. My husband's support and counsel helped me through many difficult times when work seemed over-burdening. Invaluable support and assistance came from my children too. Special tribute goes to my parents who supported and encouraged me through my academic pursuits. Last but not least, I would like to thank Mrs. Mureithi and Miss Jeniffer, for typing this thesis. Their deligence and patience is highly appreciated.
Dedication

To my husband and children: Mr. Amwayi, Masters Job and Abel,
Misses Lilian and Edith
and to my parents
Kwatsima and my late mother Regina
Abstract

The dominance of Euclidean Plane geometry in Kenyan Primary school curriculum is quite prominent. Euclidean plane geometry makes up most of the subject matter taught in primary school geometry. Euclidean plane geometry is also given heavy weighting when setting Kenya Certificate of Primary Education (K.C.P.E) mathematics papers. However, K.C.P.E. candidates perform poorly in Euclidean plane geometry items. The purpose of the study was twofold:

- Investigate the mastery of Euclidean plane geometry by standard seven primary school pupils; and
- investigate whether there are any learning barriers that inhibit standard seven primary school pupils' mastery of Euclidean plane geometry.

A sample of 280 standard seven pupils consisting of 131 boys and 149 girls was selected using systematic random sampling from 20 public primary schools in Kakamega Municipality, in western Province of Kenya. Data was collected from the sample, using Test on Euclidean Plane Geometry (T.E.P.G.) and Checklist for Classroom Observation (CCO). These instruments were administered to the sample in their respective schools by the researcher assisted by classroom teachers.

The data collected was analysed using frequencies, means, percentage and standard deviations. Data from TEPG was further analysed using item difficulty and discrimination techniques. The t-test was used to test whether there was a significant difference between the mean scores of standard seven primary school boys and girls on the TEPG. On the other hand, chi-square test was used to determine whether there was a significant difference between the pupils' age group and scores obtained on the TEPG.

The investigation of mastery of Euclidean plane geometry among standard seven primary school pupils in Kakamega Municipality using the TEPG revealed that:-
There was poor mastery of Euclidean plane geometry by standard seven pupils. A significant difference existed between the mean scores of standard seven boys and girls on the TEPG in favour of boys. There was no significant difference between pupil's age-group and scores obtained on the TEPG. The study revealed that some of the learning barriers that could be inhibiting standard seven primary school pupil's mastery of Euclidean plane geometry were:

- Seventy five percent of the teachers only demonstrated one example before giving pupils an assignment;
- Scarcity of learning and teaching resources;
- Pupils not being given time to ask questions; and
- Pupils' exercise books not being marked regularly.

The conclusion reached in this study was that there was poor mastery of Euclidean plane geometry concept among standard seven pupils in Kakamega municipality.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Declaration</td>
<td>(ii)</td>
</tr>
<tr>
<td>Acknowledgement</td>
<td>(iii)</td>
</tr>
<tr>
<td>Dedication</td>
<td>(iv)</td>
</tr>
<tr>
<td>Abstract</td>
<td>(v)</td>
</tr>
<tr>
<td>Table of Contents</td>
<td>(vii)</td>
</tr>
<tr>
<td>List of Tables</td>
<td>(x)</td>
</tr>
<tr>
<td>List of Figures</td>
<td>(xi)</td>
</tr>
<tr>
<td>List of Acronyms</td>
<td>(xii)</td>
</tr>
</tbody>
</table>

## CHAPTER ONE: INTRODUCTION

1. Background to the Study ..................................................... 1
2. The Problem ............................................................................ 15
3. Research Questions .............................................................. 15
4. Hypotheses ............................................................................. 16
5. Purpose of the Study ............................................................ 16
6. Assumptions of the Study ....................................................... 17
7. Significance of the Study ...................................................... 17
8. Delimitation of the Study ...................................................... 18
9. Limitation of the Study ......................................................... 18
10. Theoretical Framework ......................................................... 18
11. Definition of Keys Term ....................................................... 20
12. Organization of the Study .................................................... 22
BIBLIOGRAPHY ............................................................79

APPENDICES

A. Test on Euclidean Plane Geometry................................................. 85
B. Marking Scheme of Test on Euclidean Plane Geometry .................. 98
C. Checklist for Classroom Observation ............................................. 105
D. Public Primary Schools in Kakamega Municipality ......................... 107
E. Pilot Study Item Analysis Indices for TEPG ................................. 108
F. Final Study Item Analysis Indices TEPG ......................................... 110
G. Samples of Construction Errors Made by Standard Seven Pupils ...... 111
H. Formulae used for Analysis .......................................................... 113
# List of Tables

4. Selected Schools, Population and Standard Seven Primary School Pupils Sampled for the Study.....................................................38
5. Specification of Item Distributions ..........................................................40
6. Distribution of Standard Seven Primary School Seven Primary School Pupils by Age and Gender .........................................................47
7. The Means and Standard Deviations of Standard Seven Primary School Pupils on the TEPG .................................................................48
8. A Grouped Frequency Distribution of Standard Seven Pupils' Scores on the TEPG ........................................................................49
10. A Grouped Distribution of Scores of Euclidean Plane Geometry Concepts .........................................................................................52
11. Frequency of Pupils with Mastery of Euclidean Plane Geometry Area by Gender .................................................................53
12. Frequency of Pupils with Mastery of Euclidean Plane Geometry Area by Age .............................................................................54
13. Analysis of the Differences Between the Mean Scores by Boys and Girls on the TEPG .................................................................55
14. Observed and Expected Frequencies of Scores by Various Age Groups of Standard Seven Pupils................................. 57
15. Distribution of Learning Resources Among Standard Seven Pupils .................................................................70
List of Figures

1.1 Illustration of Theory of Meaningful Learning ........................................ 19

K.C.P.E. (Kenya Certificate of Primary Education)

K.N.E.C. (Kenya National Examinations Council)

T.P.P.G. (Test on Euclidean Plane Geometry)

C.C.O. (Checklist for Classroom Observation)
List of Acronyms

**K.C.P.E.** (Kenya Certificate of Primary Education)

**K. I. E.** (Kenya Institute of Education)

**K. N. E.C.** (Kenya National Examinations Council)

**T. E. P. G.** (Test on Euclidean Plane Geometry).

**C. C. O.** (Checklist for Classroom Observation).

From Egypt the knowledge of geometry spread through interaction either through trade or sea travel. From their famous mathematician Euclid, the word geometry. McIlveny (1999) reports that Euclid (323-300BC) built on the work of his predecessors like Pythagoras, adding his own original propositions or theorems, into The Elements, which he wrote. The book covered not only plane and not of what is now known as algebraic geometry but also the first six volumes of the Elements, yet another important part of mathematics.
CHAPTER ONE
INTRODUCTION

Background to the Study

The historical development of Geometry is quite interesting. Corles (1964) reports that the first people to study geometry were the Egyptians, whose wealth depended very much on the River Nile. The Egyptian government had to measure the plots allotted to people so as to ascertain how much tax each had to pay. If part of an individual's land was washed away by the river, the portion that remained had to be measured again. This brought up the concept of area. Corles (1964) goes on to say that although the Egyptians used trial-and-error method none-the-less they were able to introduce geometry to the whole world. They were able to survey land and construct pyramids very well.

From Egypt the knowledge of geometry was passed to Greece by way of interaction either through trade or war (Corles, 1964). The Greeks through their famous mathematician Euclidean became the first to write books on geometry. McHenry (1993) reports that Euclid lived in Alexandria at the time of the first Ptolemy (323-285/283 B.C.). Euclid gathered the work of his predecessors like Pythagoras, added his own original work and arranged 465 propositions or theorems, into the 13 books called the 'Elements' which he wrote. The books covered not only plane and solid geometry, but also much of what is now known as algebra, trigonometry and advanced arithmetic. The first six volumes of the 'Elements' presented plane geometry; the next four
dealt with numbers and lengths while the last three focused on solid geometry. The focus of this study (Euclidean plane geometry) encompasses the content covered in the first six volumes of the Elements.

Saalfrank (1963) explains that Euclidean plane geometry is the branch of geometry which deals with the simpler and more apparent properties of geometric figures such as straight lines, circles, planes and spheres. It is taught in most schools at the present time under the names of plane and solid geometry. Oluoch (1984) says that the common Euclidean plane figures which primary school children should know include lines, angles, rectangles, squares, triangles, parallelograms and circles.

The dominance of Euclidean plane geometry in primary school geometry curriculum is quite prominent worldwide. Frame (1992) notes that Euclidean plane geometry makes up most of the geometry subject matter taught in primary schools. This is in line with the Cambridge Conference Report of 1969 which advocates for the study of geometry in elementary grades (Frame, 1992).

For the case of Kenya, the Primary School Syllabus has been designed in such a way that Euclidean plane geometry content is developed at each class level from standards one to eight. Solid geometry is only introduced towards the end of the primary school cycle. Recognition of Euclidean plane figures and making of patterns with the figures should be achieved in lower primary. Construction of the Euclidean plane geometry
figures, measurement and facts about the figures should be covered in upper primary (K.I.E 1992).

Although Euclidean plane geometry dominates the Kenyan primary school geometry curriculum, the KNEC (1998) KCPE Newsletter reports that candidates perform poorly in the geometry content of the KCPE mathematics paper. Table 1 contains information on areas of coverage and the number of questions set in each section of the mathematics paper and performance in the various areas for the period 1994-1997 in KCPE. The years 1994 to 1997 were selected for illustration in this study because at the time of the study the latest records available on KCPE mathematics were of this period (1994 - 1997).

Table 1

<table>
<thead>
<tr>
<th>Area of Coverage</th>
<th>Number of Questions and Percentage of Candidates Scoring Correctly</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>f</td>
</tr>
<tr>
<td>Arithmetic</td>
<td></td>
</tr>
<tr>
<td>Mechanical Arithmetic</td>
<td>6</td>
</tr>
<tr>
<td>Applied Number Problems</td>
<td>25</td>
</tr>
<tr>
<td>Using Data from Tables</td>
<td>3</td>
</tr>
<tr>
<td>Geometry</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>28.64</td>
</tr>
<tr>
<td>Algebra</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>42.69</td>
</tr>
<tr>
<td>Graphs</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>41.12</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
</tr>
</tbody>
</table>

The KNEC (1998) reports that the analysis in Table 1 is based on random samples. For example, in 1997, 41,698 candidates were selected from the total population of 436,928 who sat for the mathematics paper in the KCPE examination. It is evident from the table that at least 20 percent of the KCPE mathematics paper. These include arithmetic, algebra and graphs. The arithmetic items come from geometry. Table 1 also shows the number of items set in the other areas of the KCPE mathematics paper. The arithmetic items deal with addition, subtraction, multiplication and division of numbers, and could be categorized as mechanical arithmetic, applied number problems and using data from tables. On the other hand algebra has to do with solution of practical problems by using symbols, usually letters, for unknown quantities. Items on graphs deal with diagrams that show the relation between two quantities. Table 1 shows that the bulk of KCPE mathematics items come from arithmetic and followed by geometry.

Table 1 also provides information regarding candidates scoring correctly in all areas of the KCPE Mathematics paper. It is evident from Table 1 that candidates perform poorly in geometry items, since the percentage of those who score correctly is low. For example in 1997, eleven out fifty (22%) KCPE items were from geometry and only 37.61% of the sample candidates (41,696) got the items correct. If the 1997 percentages of candidates scoring correctly in the various sections of the mathematics paper are ranked, then geometry acquires the last position as shown in Table 2.
Table 2

*Performance Ranking of KCPE Mathematics Paper (1997)

<table>
<thead>
<tr>
<th>Questions</th>
<th>Total No. of Questions</th>
<th>Candidates Scoring Correctly</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arithmetic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Mechanical Arithmetic</td>
<td>4 8</td>
<td>24,339</td>
<td>58.37</td>
</tr>
<tr>
<td>• Applied Number Problems</td>
<td>25 50</td>
<td>19,031</td>
<td>45.64</td>
</tr>
<tr>
<td>• Using Data from Tables</td>
<td>4 8</td>
<td>19,219</td>
<td>46.09</td>
</tr>
<tr>
<td>Geometry</td>
<td>11 22</td>
<td>15,683</td>
<td>37.61</td>
</tr>
<tr>
<td>Algebra</td>
<td>2 4</td>
<td>16,162</td>
<td>38.76</td>
</tr>
<tr>
<td>Graphs</td>
<td>4 8</td>
<td>22,367</td>
<td>53.64</td>
</tr>
<tr>
<td>Total</td>
<td>50 100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source: Extracted from Table 1

Performance in geometry also held last positions in 1994 and 1995 except in 1996 when it was second last (position five out of six). Thus, there is persistent poor performance in the Euclidean geometry content.

An analysis of past KCPE mathematics papers reveals that Euclidean plane geometry is given heavy weighing when setting geometry items. This is illustrated in Table 3 which gives information regarding the number of Euclidean plane and solid geometry items set for the period 1994 – 1997.
Table 3


<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>f</td>
<td>%</td>
<td>f</td>
<td>%</td>
</tr>
<tr>
<td>Plane</td>
<td>8</td>
<td>80</td>
<td>10</td>
<td>76.92</td>
</tr>
<tr>
<td>Solid</td>
<td>2</td>
<td>20</td>
<td>3</td>
<td>23.08</td>
</tr>
<tr>
<td>Totals</td>
<td>10</td>
<td>100</td>
<td>13</td>
<td>100.00</td>
</tr>
</tbody>
</table>

*, Source: KNEC 1999

Table 3 shows that in 1994, 80 percent of the geometry items were from Euclidean plane geometry. As for the subsequent years (1995, 1996 and 1997), the percentage numbers of Euclidean plane geometry items, under geometry, were 76.92, 75 and 81.82 percent respectively. The fact that a larger percentage of items are set from Euclidean plane than solid geometry implies that Euclidean plane contributes considerably to the overall geometry scores of the candidates.

Euclidean plane geometry items form a large proportion of geometry items in KCPE and yet candidates perform poorly in them. For example, KNEC’s (1998) analysis of performance on selected items based on standard seven Euclidean plane geometry in the 1997 KCPE mathematics paper.
reveals that there is a problem as candidates do not perform well. The problem of poor performance in Euclidean plane geometry has been experienced in the past too (KNCE, 1990). The following questions have been used to illustrate the poor performances.

**Question 23 (KNEC, 1989)**

In the following figure the area of triangle PQR is equal to the area of triangle QRS. PQS is a straight line and RN is the common height of the two triangles.

![Diagram of triangles PQR and QRS with common height RN.]

Which of the following must be true?

A. PQ = RS  
B. QR = RS  
C. QR = QS  
D. PQ = QS

The response pattern for item 23 revealed that 12.3, 37.37, 27.36 and 22.16 percent of the sample candidates chose options A, B, C and D respectively. Some candidates (0.68%) had no answer for item 23. The correct option was D.
To answer this question correctly the candidates needed to have mastered their standard seven Euclidean plane geometry knowledge of how to find the area of a triangle. However, out of a random sample of 27,024 candidates, only 22.14% got the correct answer.

The following procedure should have been followed by the candidates in order to arrive at the correct option.

From the available information

Area of PQR = Area of QRS

Area of a triangle = \( \frac{1}{2} b \times h \)

In this case

\[ \frac{1}{2} P Q \times R N = \frac{1}{2} Q S \times R N \]

For the areas of the two triangles to be equal then

\[ P Q = Q S \]

**Question 30 (KNEC, 1998)**

To find the area of the shaded part, the area of the square enclosed in a circle of radius 7 cm must be subtracted from the area of the circle.

The figure below represents a square enclosed in a circle of radius 7 cm. The diagonals divide the square into four equal triangles. Considering each triangle, the shorter side is the shorter side of the shaded part

What is the area of the shaded part? (Take \( \pi = \frac{22}{7} \))
The response pattern for item 30 showed that 27.22, 25.40, 13.72 and 32.54 percent of the sample candidates chose options A, B, C and D respectively. The correct option was A. (KNEC, 1998).

The question required the candidate to have mastery of the standard seven Euclidean plane geometry knowledge of finding the side of the square using Pythagorean relationship. It also required the knowledge of finding the area of a circle and square. Nevertheless out of 41,698 sample candidates only 27.22% got the right answer.

The following is the procedure of how candidates could have worked out question 30.

**Step one**

To find out the magnitude of the sides of the square.

The diagonals divide the square into four equal right angled isosceles triangles.

Considering each triangle, the two shorter sides are 7 cm each.

![Diagram of a right-angled isosceles triangle with sides of 7 cm]
Using the Pythagoras theorem the largest side can be worked out as follows:

\[(7\text{cm})^2 + (7\text{cm})^2 = H^2\]

\[H^2 = 98\text{cm}^2\]

\[H = \sqrt{98\text{cm}^2}\]

*H* stands for the length and width of the square.

**Step Two**

To find the area of the square.

\[\text{Area} = \text{L} \times \text{W} = \sqrt{98\text{cm}^2} \times \sqrt{98\text{cm}^2} = 98\text{cm}^2\]

**Step Three**

To find the area of the circles

\[\text{Area} = \pi r^2 = \frac{22}{7} \times 7 \text{ cm} \times 7 \text{ cm} = 154\text{cm}^2\]

**Step Four**

To find the area of the shaded part.

\[\frac{\text{Area of circle} - \text{Area of Square}}{2} = \frac{154\text{cm}^2 - 98\text{cm}^2}{2} = \frac{56\text{cm}^2}{2} = 28\text{cm}^2\]
Options B, C and D appear in the process of working out item 30. It is only the candidates who have mastered their Euclidean plane geometry who would persist on working out the problem until the final step is reached.

**Question 38 (KNEC, 1997)**

In the figure below PQRS is a quadrilateral in which line PQ = line PR = line PS. Angle RPS = 68°. TOR is a straight line and line PQ is parallel to line SR.

What is the size of angle TQP?

A  62°  C  118°
B  68°  D  124°

The response pattern for item 38 showed that 17.28 percent of the sample candidates chose option A, while 26.80, 29.72 and 25.01 percent of the sample candidates chose option B, C and D respectively. The right option was C (KNEC 1998).
The candidates needed to have mastered standard seven Euclidean plane geometry content dealing with properties of angles, parallel lines and isosceles triangle and the facts that angles on straight line add up to $180^\circ$.

The following steps needed to be followed in order to eventually arrive at the correct response.

**Step One**

From the given information, it is clear that PRS is an isosceles triangle, and angle RPS $= 68^\circ$

Angles PRS and RSP are equal.

The sum of angles of a triangle is $180^\circ$.

Angles PRS = Angle RSP $= 180^\circ - 68^\circ$

$= 112^\circ$

Since angle PRS and angle RSP are equal

$$\angle PRS = \frac{112}{2} = 56^\circ$$

**Step Two**

It is also clear from the available information that line PQ is parallel to line SR, and line PR is a transversal. Angle PRS is alternate to angle QPR. One property of alternate angles is that they are equal.

From step 1 above angle PRS $= 56^\circ$

So angle QPR is also $56^\circ$
Step Three

Triangle QPR is another isosceles triangle. Given that angle QPR = 56° then
angle PQR + angle PRQ = 180° - 56°

= 124°

Since angle PQR and PRQ are equal, each of them will be:-

\[ \frac{124°}{2} = 62° \]

Step Four

It is clear that TQR is a straight line, and angles on a straight line add up to 180°. From step three, angle PQR = 62°. In this case,

Angle TQP + Angle PQR = 180°

Angle TQP + 62° = 180°

Angle TQR = 180° - 62°

= 118°

That is why the correct option in the alternatives given is C.

From the response pattern shown earlier, only 29.72% of the sample candidates (41,698) had mastery of the required Euclidean plane geometry content to work out question 38. The rest of the candidates either chose option A (62°) or D (124°).

The figures (62, 68, 124) appeared in steps one, two and three. It is possible that some candidates who chose wrong options did not have mastery of the required subject matter and shaded any option they came
across as they were calculating. The procedure of getting to the final answer was quite long. It is also probable that the candidates who chose options A and D were in a hurry to finish and ended with step three instead of proceeding to step four.

As shown earlier Euclidean plane geometry makes up most of the subject matter of primary school geometry in Kenya. Euclidean plane geometry is given heavy weighting when setting the KCPE mathematics paper. At least seventy five percent of the KCPE geometry items are set from Euclidean solid geometry (Table 3). This implies that performance on Euclidean plane geometry items greatly determines the grading of the geometry section of the KCPE mathematics paper.

Although Euclidean plane geometry makes up most of the subject matter of primary school geometry in Kenya and that it is given heavy weighting (at least 75%) when setting KCPE mathematics paper, there is persistent poor performance in geometry and even in specific Euclidean plane geometry items. So far, various studies been carried out to identify factors that influence performance in mathematics in Kenya (Bali, 1983; Munguti, 1984; Samumkut, 1986; Ogomas, 1987). These studies do not address the aspect of poor mastery of content which may be contributing to minimal performance in Euclidean plane geometry.

Kiswili (1995), in his study on how mathematics is applicable to all the subject in the school curriculum recommends urgent study of some topics in mathematics that are not easily mastered by learners. One of the topics
which Kiswili lists as needing investigation is geometry since learners perform poorly in it as compared to other topics of mathematics.

Based on these observations, there is justification for a study to be carried out on mastery of Euclidean plane geometry.

**The Problem**

Although Euclidean plane geometry makes up most of the subject matter of primary school geometry content (K.I.E. 1992) and it is given heavy weighting when setting the K.C.P.E. mathematics papers, candidates persistently perform poorly in KCPE Euclidean plane geometry items (K.N.E.C., 1990, 1998). The persistent poor performance in Euclidean plane geometry raises concern.

From the resources available to the researcher, very little research has been carried out in Kenya to find out pupils' status of mastery of Euclidean plane geometry and pupils' difficulties in mastery of the subject, which could be contributing to the poor performance. Thus this study aimed at investigating the mastery of Euclidean plane geometry concept among standard seven pupils.

**Research Questions**

The following questions were formulated from the problem of this study:-

- Have standard seven primary school pupils mastered Euclidean plane geometry concepts?
• Are there any areas of Euclidean plane geometry concepts in which standard seven primary school pupils have not mastered?

• Is there any significant difference between the mean scores of standard seven primary school boys and girls on the Test on Euclidean Plane Geometry?

• Is there any significant difference between pupils' age-group and scores obtained on the Test on Euclidean Plane Geometry?

• Are there any learning barriers experienced by standard seven primary school pupils that may inhibit their mastery of Euclidean plane geometry?

Hypotheses

The following hypotheses were generated from the third and fourth research questions in the previous section.

H₀₁ For mean scores of Test on Euclidean plane geometry, there is no significant difference between standard seven primary school boys and girls.

H₀₂ There is no significant difference between pupil's age-group and scores obtained from Test on Euclidean Plane Geometry concepts.

Purpose of the Study

The purpose of this study was to:
• Investigate the mastery of Euclidean plane geometry concepts by standard seven pupils.

• Investigate whether there are any learning barriers that inhibit standard seven primary school pupils mastery of Euclidean plane geometry concepts.

Assumptions of the Study

The study assumed that:

• Standard seven mathematics teachers are able to teach Euclidean plane geometry, and have no bias on topic areas in the teaching of primary school mathematics syllabus.

• All standard seven pupils involved in the study have learnt Euclidean plane geometry in their previous class levels.

• All standard seven primary school pupils have the ability to learn Euclidean plane geometry.

• Public schools in Kenya follow the same syllabus.

Significance of the Study

This study investigated the mastery of Euclidean plane geometry by standard seven pupils in Kakamega Municipality. The findings of this study will inform parents, teachers and pupils and education officials about pupils' mastery of Euclidean plane geometry. The study therefore helps the listed stakeholders to understand pupils' problems in the mastery of Euclidean
plane geometry that make them not to perform well. It sensitizes them on the need to come up with ways and means of helping pupils to master Euclidean plane geometry better. For example, teachers of geometry will use teaching strategies and materials that ensure mastery of content by pupils. The study forms a basis for further research about such aspects of geometry education as solid geometry. In addition to the above the findings of this study add to the world of knowledge as very little has been done in Euclidean geometry.

Delimitations of the Study

The study was delimited to standard seven pupils and their mathematics teachers. The study only focused on Euclidean plane geometry and did not consider other sections of mathematics or other subjects.

Limitations of the Study

Due to financial and time constraints, the study was only limited to eight selected primary schools out of the twenty four (24) primary schools in Kakamega Municipality.

Theoretical Framework

This study was guided by Ausubel's (1968) theory of meaningful learning. Ausubel is a psychologist and his theory of meaningful learning is general and not specific to the learning of geometry. Ausubel goes on to say that meaningful learning is a process through which new knowledge is
absorbed by connecting it to some existing relevant aspect of the individual's knowledge structure. This means that meaningful learning takes place when new knowledge is assimilated within the existing knowledge structure and if appropriate modification of prior knowledge takes place. Thus, existing relevant knowledge forms the foundation on which new ideas are anchored.

Orton (1992) records that when there is meaningful learning, mastery and recall are easy. Orton also suggests that good expository teaching could ensure that new knowledge is assimilated into existing relevant ideas. Figure 1. shows the researcher's illustration of the theory of meaningful learning.

**Figure 1**

Illustration of Theory of Meaningful Learning.

In this study the Euclidean plane geometry taught in standard seven is what Ausubel (1998) calls new knowledge. The Euclidean plane geometry learnt by standard seven pupils in their class levels is similar to what Ausubel called existing relevant knowledge. For meaningful learning to take place standard seven Euclidean plane geometry content has to be assimilated or absorbed into Euclidean plane geometry learnt in previous class levels.
The theory of meaningful learning was a guide in this study as it prompted the researcher to investigate standard seven pupil’s mastery of Euclidean plane geometry concepts learnt both in their previous class levels and standard seven in order to ascertain whether learning had been meaningful. The researcher also investigated how standard seven Euclidean plane geometry content is taught in an endeavour to link it to the existing relevant Euclidean plane geometry content.

Definition of Key Terms

- **Alternate angles**: Refers to angles on the opposite side of a transversal line.

- **Axiom**: Refers to a Euclidean plane geometry statement which is taken to be true and which is used as one of the starting points of sequences of proofs.

- **Elements**: Refers to the 13 volume books written by Euclid that consist of work from his predecessors, his own original work and 465 propositions.

- **Euclidean Plane geometry**: Refers to a type of geometry built upon Euclid's postulates and studies figures that are metric and lie on a flat surface or plane such as lines, angles, triangles, squares, rectangles, parallelograms, rhombi and circles.

- **Geometry**: Refers to a branch of mathematics concerned with the physical properties of space which include lines, curves, planes and surfaces in space and figures bounded by them.

- **High Item Difficulty Index**: Refers to item difficulty ratios above 0.75.
• **Item Difficulty**: Refers to the percentage of standard seven pupils who answered item correctly.

• **item Discrimination**: Refers to the degree to which an item distinguished between the high and the low achievers.

• **K.C.P.E. (Kenya Certificate of Primary Education)**: Refers to the examination taken at the end of the standard eight primary school education.

• **K.I.E. (Kenya Institute of Education)**: Refers to the curriculum centre where all school courses in Kenya are generated.

• **K.N.E.C. (Kenya National Examinations Council)**: Refers to the examining body for all school courses in Kenya.

• **Low Item Difficulty Index**: Refers to item difficulty values below 2 percent.

• **Mastery**: Refers to the understanding or acquisition of Euclidean plane geometry knowledge and skills.

• **Middle Item Difficulty Index**: Refers to item difficulty ratios between 0.25 and 0.75.

• **Postulates**: Refers to a Euclidean plane geometry proposition or a suggestion which forms a base for further reasoning.

• **Pythagorus Theorem**: Refers to the statement that the area of the square on the hypotenuse of a right angled triangle is equal to the sum of the area of the squares on the other two shorter sides.
• **Solid Geometry:** Refers to a type of geometry that studies three-dimensional figures such as cubes, cuboids, cylinders and spheres.

• **Transversal:** Refers to a line that intersects two or more other parallel lines.

**Organization of the Study**

The study is organized in five chapters. Chapter One titled: Introduction, deals with the background, theoretical framework and he statement of the problem. Other sections dealt with in Chapter One include purpose, research questions significance, assumptions, delimitation and limitations of the study. Meanings of key words and essential terms are also given in this chapter.

Chapter Two deals with a review of Related Literature. This Chapter is subdivided into two parts. The first part of the related literature is concerned with the mastery of Euclidean plane geometry. The second part is concerned with studies in Euclidean geometry.

Chapter Three is concerned with Design and Methodology of the study. It focuses on the location of the study, the sample and sampling procedures, the design and research instruments. Data collection procedure and methods of analyzing data are also addressed.

Chapter Four deals with results of the study. Chapter Five provides the Summary, Conclusions, Recommendations and Suggestions for Further Research.
CHAPTER TWO

REVIEW OF RELATED LITERATURE

This Chapter reviews related literature concerned with significant writings of authorities in the area of mastery of content and previous research studies on Euclidean geometry.

Review of Related Literature Concerned with Mastery

Bruner (1964) maintains that mastery within a given subject of content, such as Euclidean plane geometry involves not only the grasping of general principles but also the development of an attitude towards the subject.

Jensen (1973) asserts that mastery of complex mathematical concepts, which include Euclidean plane geometry often depends upon mastery of a hierarchy of simpler concepts and basic skills. Bell (1980) says that many learning difficulties, like those found in Euclidean plane geometry arise because children are moved onto new Euclidean plane geometry contents before they have completely mastered prerequisite skills and content. Hence, in order to master Euclidean plane geometry, pupils must be helped to build upon what they have already mastered. This is a situation where the already mastered content is useful in mastering new content ahead.

Copeland (1984) reports about the educational process as devised by behaviourists. The educational process looks at what is to taught (such as Euclidean plane geometry), isolating all the necessary components and then placing them in a chain or sequence for the learner to follow. In isolating all
CHAPTER TWO

REVIEW OF RELATED LITERATURE

This Chapter reviews related literature concerned with significant writings of authorities in the area of mastery of content and previous research studies on Euclidean geometry.

Review of Related Literature Concerned with Mastery

Bruner (1964) maintains that mastery within a given subject of content, such as Euclidean plane geometry involves not only the grasping of general principles but also the development of an attitude towards the subject.

Jensen (1973) asserts that mastery of complex mathematical concepts, which include Euclidean plane geometry often depends upon mastery of a hierarchy of simpler concepts and basic skills. Bell (1980) says that many learning difficulties, like those found in Euclidean plane geometry arise because children are moved onto new Euclidean plane geometry contents before they have completely mastered prerequisite skills and content. Hence, in order to master Euclidean plane geometry, pupils must be helped to build upon what they have already mastered. This is a situation where the already mastered content is useful in mastering new content ahead.

Copeland (1984) reports about the educational process as devised by behaviourists. The educational process looks at what is to taught (such as Euclidean plane geometry), isolating all the necessary components and then placing them in a chain or sequence for the learner to follow. In isolating all
the component elements, such as Euclidean plane geometry content, the premise is that there is no room for error. The child does not miss any necessary step and consequently masters the Euclidean plane geometry content taught. In fact, Orton (1992) says that careful sequencing of content to be learnt is likely to enhance mastery of the content. Copeland (1984) suggests that if a child misses any component, the child should repeat the sequence leading to that component. Thus, repetition is the correctional mode, in order for mastery of the component to occur. Copeland calls this procedure drill and practice.

Skemp (1971) discusses how content is mastered. He claims that the mastery of mathematical content which also includes Euclidean plane geometry should not be expected to be done through definitions, but by examples and counter examples. On the other hand, Orton (1992) says that knowledge has to be constructed by each individual if it is to become an integrated part of the structure of knowledge mastered by the individual.

Bloom (1976) features three variables that affect mastery of content which may include Euclidean plane geometry. The variables are:

- Cognitive entry behaviour;
- Affective entry characteristics; and
- Quality of instruction.

Bloom (1976) argues that the cognitive and affective outcomes of one unit of instruction such as that of Euclidean plane geometry, act as cognitive entry behaviour and affective entry characteristics for the next unit of
instruction of Euclidean plane geometry. Under conditions of high quality instruction of Euclidean plane geometry, where most learners are taken to high levels of mastery of the content on each unit before moving to the next, more learners will begin each subsequent unit of instruction of Euclidean plane geometry content with the necessary mastery prerequisites and will therefore be in a better position to master intended content. Learners' success as portrayed through mastery of Euclidean plane geometry will spawn more positive affective entry characteristics and learners will approach new Euclidean plane geometry content with more confidence and motivation.

Anderson and Faust (1974) say that if the goal of a lesson, say in Euclidean plane geometry, is to get the pupil to master a particular principal, an expository method usually will be superior to a discovery approach, since more content will be mastered through expository than discovery approach. For instance, Guthrie (1967) found out that when pupils were told of a principle, they needed an average of eleven examples to master that principle, whereas when pupils were expected to discover the principle, they needed an average of twenty three examples for mastery.

The foregoing literature review on mastery of content is important as it provides a deeper understanding of what mastery of content entails. This literature assisted the researcher to decide on what variables to look for when studying mastery of Euclidean plane geometry.

Dunkelberger and Heikkinen (1984) investigated the influence on learner
outcomes of the repeatable testing provision of Bloom's mastery learning model. They randomly selected 112 ninth grade students enrolled in the Introduction to Chemistry and Physics (ICP) course in three different schools with a population of 273 ICP students. The 112 selected were divided into two equal treatment groups.

The three instruments used in this study were a Cognitive Achievement Test (CAT), an attitude survey regarding science study and the Verbal Aptitude portion of the Delamere Educational Programme. The 45 item CAT developed by the researchers from an initial pool of 95 pilot items assessed student attainment of 33 of the 45 (73%) cognitive objectives. Content validity was verified by a panel of Judges. The CAT measuring end of year mastery had KR-20 reliability of 0.89.

The findings showed that neither student achievement nor their attitude towards learning science was favourably influenced by the presence of the repeated testing component. ANCOVA (Analysis of Covariance) techniques revealed no significant differences in student achievement when student verbal aptitudes were controlled.

Review of Related Literature Concerned with Previous Studies in Geometry

The following are summaries on a few studies in Euclidean geometry. One common factor about the studies is that they had gaps which the present study will fill.
Scholz (1996) investigated the relationships among pre-service teacher's conceptions of geometry, conceptions of teaching geometry and classroom practice. Ten pre-service teachers completed a card sort task with an interview. They also participated in a videotaped task, which consisted of viewing three experienced geometry teachers on videotape. Four of these pre-service teachers were observed eight times each during their professional internship experience. All interviews and observations were videotaped and transcribed for data analysis.

Results of this study indicated a complex relationship between the pre-service teachers' conception of geometry and conceptions of teaching geometry. The pre-service teachers' conceptions of geometry influenced their conceptions of teaching geometry and the teaching of subject matter influenced the pre-service teachers' conception of geometry as well. The relationship between the pre-service teachers' conception of geometry and their classrooms practices was directly influenced by textbooks used. Their beliefs about teaching geometry rarely emerged in their classroom practices. Finally these pre-service teachers had an overwhelming concern with class management which influenced their conception about teaching geometry.

Moody (1996), assessed student understanding of geometry based on Van Hiele Geometry Levels. He used a sample of 154 geometry students (76 females, 78 males) from three Arkansas high schools who were administered the Moody test in their high school's laboratory.
An IBM - compatible, computer administered software programme, the Moody Test for Van Hiele Geometry Levels, was constructed to investigate the discretion of each student level, as defined by the Van Hiele theory. The software test consisted of 20 questions in a multiple true/false format. One hundred and twenty (120) responses per study using 123 mathematics students enrolled at an Arkanses community college provided feedback for test item development. A test reliability index of 0.89172 was calculated for the Moody test.

A criteria score of 70% was set to determine understanding at each level. The study found that 88.3125 of the students fit the Van Hiele model and concluded that Van Hiele levels do exhibit discrete intervals of student understanding of geometry. Additional analysis found no significant difference in student scores due to age or gender. The study did note significant gender differences in favour of boys in the determination of student-fit with the Van Hiele model.

Hannibal (1996) analyzed young children's understanding of the geometric concept of shape, specifically of triangle and rectangle and defined patterns in the development of this understanding from ages three through six. Data was gathered through the researcher - conducted, videotaped, individual interviews with children (N=24) as they manipulated and categorized researcher designed forms as members or non-members of shape categories. These ten categorization tasks were arranged to study the effect
of task-design on children's acceptance of forms as members of shape category and to study the consistency of children's classification decisions across tasks. Task-design and stimuli-presented were both found to have an influence on children's acceptance of forms as shape category members. Four year old children were least consistent across shape categorization tasks with constancy increasing by age.

Petroskey (1995) evaluated the Bridgeport Public School's Geometry Midterm Examination for reliability, content validity and item analysis. A sample size of 111 was generated by selecting one out of every five geometry midterm examination answer sheets. Using Statistical Analysis Software (SAS), a computer programme was written to score the examinations. This was also used to determine the item difficulty, item discrimination, and biserial correlation. Using coefficient alpha the reliability of the Bridge Port Public School's midterm geometry examination was computed to be 0.88. The examination was reliable. A table of specifications was drawn up to check for validity. The examination was valid for its purpose.

Georgorio (1994) investigated the strategies, difficulties and errors of students solving processes of geometric activities whose underlying transformation is a spatial rotation. A sample of 645 students representative of males and females from three educational levels was used. The sample students were aged between 12 and 16 years.

Quantitative and qualitative analysis of data was done. The findings showed that the students' cognitive strategies were classified as decision
processing and focusing strategies. Students' difficulties and errors were also characterized.

Chemunyan (1992) made a survey of problems encountered in the teaching of geometry in upper primary classes (standards four to eight) in Kericho District, Kenya. His study sample consisted of six out of twenty four schools within Longisa education zone (Kericho District). Random sampling was used to select the six schools. The samples consisted of 28 upper primary school mathematics teachers.

Bar-charts, percentages and means were used to analyse data. The data, collected using questionnaire showed that teachers were not conversant with the geometry topics. The results further revealed that pupils covered the content in the syllabus without paying attention to the understanding of concepts.

Martell's (1982) study was designed to investigate what factual and conceptual knowledge is recalled by students who have completed a course in high school geometry. Questions stems served as stimuli to which students had to produce a response. Thirty-eight items were presented both verbally and by diagrams and included the areas of triangular items, items on similarity and parallelism, circles and their properties, and formulae. The items were taken from the Prerequisite Facts Test (PFT) that was developed and utilized by the staff of the Geometry Problem Solving Project (GPSP). The questions on this instruments represented the conceptual knowledge contained in a high school geometry course.
Data was obtained on 240 students from nine high schools in four different regions of the United States. The data was analyzed by SAS, SPSS and BIOMED programmes.

Statistical analysis revealed that students overall, recall the least information on circular items and that the diagrammatic presentation of the question stem elicits more correct responses than the verbal presentation. The subjects recalled the most information on triangular items.

Onnuam's (1981) study was about constructing and validating a hierarchy of sixth grade elementary school intuitive Euclidean geometry classification and relation concepts. The purposes of the study were two fold:

- To construct a hierarchy of sixth grade elementary school intuitive Euclidean geometry classification and relation concepts based on logical and psychological or pedagogical considerations, and
- To validate the hypothesized concept hierarchy by using expert judgment.

The study was based on Gagne's (1965) task analysis model. The procedure used was as follows: Geometry concepts currently taught in the elementary school were collected through the examination of mathematics textbooks series; a concept cluster hierarchy was developed based on geometry concepts found in the textbooks; a pilot study was done to improve the concept cluster hierarchy; experts were asked to give judgments on the concept on the concept cluster hierarchy through questionnaires; responses from experts were used to adjust the concept cluster hierarchy; a specific
concept hierarchy was developed by using as guideline the concept cluster hierarchy; experts were asked to give judgment of the specific concept hierarchy through questionnaire; and responses received from experts were used to adjust the specific concept hierarchy.

The textbook analyzed included five selected popular elementary school mathematics textbook series published during 1978 – 1979. Respondents used in the pilot study included six selected mathematics educators at Kansas State University. Experts were mathematics educators across the nation who regularly taught either methods or content courses for elementary school teachers. They were selected from the membership roster of the Research Council for Diagnostic and Prescriptive Mathematics. Responses were received from forty eight of the sixty-six in the first round and four of the five second round.

The descriptive analysis of the responses demonstrated that the structure of both proposed hierarchies were strongly supported. However, some aspects of both proposed hierarchies were strongly supported. However, some aspects of each hierarchy were adjusted according to the opinions of the experts.

The proposed hierarchy appeared to be useful as a guideline for the development of effective geometry curricula because its development took into consideration the discipline, psychology of the child and pedagogy of the classroom.
Gagné (1965), in one of his experiments completed a programmed lesson with six graders in non-metric geometry. The programmed lesson was arranged in such a way that the pupil progressed from simple prerequisite concepts to more complicated concepts and principles. The achievement test included a sub-test for each of the simple concepts upon which more complex concepts and principles were assumed to depend. The results showed that students almost never mastered the advanced concepts and principles unless they had also mastered the prerequisite concepts.

Piaget investigated the ability of children to represent basic Euclidean shapes by asking them to draw 21 shapes. In this study, Piaget pointed out three stages of geometrical and psychological development through which children go during the age range three to seven years.

Piaget did not consider the geometrical and psychological development of children after the age of seven years. However, the present study makes contributions towards children of ages 10 to 15 years as it focused on the mastery of Euclidean plane geometry by standard seven pupils who fell within the 10 to 15 age range. This study does not only look at the ability of standard seven pupils to draw Euclidean plane geometry shapes in the syllabus but also whether they have mastered facts about the shapes.
CHAPTER THREE
DESIGN AND METHODOLOGY

This chapter is concerned with the description of procedures used in the study. It focuses on the research design, population of the study, the sampling procedures, and research instruments. The chapter also addresses data collection procedures and methods of analyzing data. These procedures aimed at achieving the purpose of the study which was to:

- Investigate the mastery of Euclidean plane geometry concepts by standard seven pupils; and
- Investigate whether there are any learning barriers that inhibit standard seven primary school pupil's mastery of Euclidean plane geometry.

Research Design

The type of research design used in this study was the descriptive survey. Cohen and Manion (1994) report that descriptive surveys gather data at a particular point in time with the intention of describing the nature of existing conditions, or identifying standards against which existing conditions can be compared, or determining the relationships that exist between specific events. Cohen and Marion also say that descriptive survey involves the use of one or more of the following data gathering techniques: interviews, checklists, questionnaires, standardized tests of attainment and attitude scales.
The descriptive survey was suitable for this study because the purpose of the study was to gather data on mastery of Euclidean plane geometry among standard seven pupils, and learning barrier that inhibit the pupils' mastery of the subject, thus describing the nature of existing conditions. The nature of the study necitated the use of a test and checklist as data gathering instruments.

In addition to the above Kothari (1978) says that descriptive surveys proceed through well-defined stages which include:

- Formulating the purpose of the study,
- Designing the methods of data collection,
- Selecting the sample,
- Collecting the data,
- Processing and analyzing, and
- Reporting the findings.

This study proceeded through all these stages.

Description of the Population

According to the records at the Kakamega District Education office, there were twenty four (21) public primary schools in Kakamega Municipality in 1999. Twenty one of them had standard seven classes with a population of 1482 pupils, 710 boys and 772 girls, and three of them did not have class seven. There were 209 (33%) male and 432 (67%) female teachers in these schools.
The records at the District Education Office also revealed that there were nine private primary schools which had a total population of 1,471 pupils and 71 teachers.

**Selection of the Sample**

Public schools were used in this study because a greater percentage of pupils in Kenya go to public schools and these schools face similar problems such as over-enrolment and understaffing. Another reason for using public schools is that they mainly rely on Teachers’ Service Commission for staffing of teachers. Out of the 21 Kakamega Municipality public primary schools with standard seven class level, one was used for pilot study. A sample of eight schools was then selected from the remaining public primary schools with standard seven class level in Kakamega Municipality. Eight schools were selected because Borg and Gall (1983) recommend that a minimum sample of 35.71% is representative enough in a descriptive survey. Random sampling using lottery method was done where the names of the 20 schools were written on separate pieces of paper which were folded, rolled up and put in a box. The pieces of paper in the box were then mixed up in order to avoid bias. Then without looking eight pieces of paper were drawn from the box, one after the other without replacement. Drawing the pieces of paper without replacement ensured that in successive drawings each of the remaining elements (schools) had the same chance of being selected (Kothari, 1978).
A sample of 149 girls and 131 boys was selected respectively, through systematic random sampling, from populations of 363 girls and 321 boys in the sample schools who were part of the 772 girls and 710 boys of standard seven pupils in Kakamega Municipality. The numbers 149 girls and 131 boys formed 41 percent of their respective populations. Forty one percent falls within Borg's and Gall's (1983) recommended minimum representative sample of 35.71 percent in a descriptive survey design. The method of proportional allocation was used to find out the number of standard seven primary school pupils selected from each school.
<table>
<thead>
<tr>
<th>Schools</th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hirumbi</td>
<td>15</td>
<td>15</td>
<td>30</td>
<td>6</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>*Township</td>
<td>61</td>
<td>72</td>
<td>133</td>
<td>25</td>
<td>30</td>
<td>55</td>
</tr>
<tr>
<td>Kakamega</td>
<td>101</td>
<td>127</td>
<td>228</td>
<td>41</td>
<td>52</td>
<td>93</td>
</tr>
<tr>
<td>Shivakala</td>
<td>10</td>
<td>9</td>
<td>19</td>
<td>4</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Matende</td>
<td>35</td>
<td>39</td>
<td>74</td>
<td>14</td>
<td>16</td>
<td>30</td>
</tr>
<tr>
<td>Bukhulunya</td>
<td>49</td>
<td>46</td>
<td>95</td>
<td>20</td>
<td>19</td>
<td>39</td>
</tr>
<tr>
<td>Shitaho</td>
<td>16</td>
<td>22</td>
<td>38</td>
<td>7</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>Amalemba</td>
<td>34</td>
<td>33</td>
<td>67</td>
<td>14</td>
<td>13</td>
<td>27</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>321</td>
<td>363</td>
<td>674</td>
<td>131</td>
<td>149</td>
<td>280</td>
</tr>
</tbody>
</table>

* Kakamega
It was only the standard seven class level which was used in the this study. The rationale for selecting standard seven class level was guided by Jensen's (1973) report that mastery of complex mathematical concepts often depends upon mastery of a hierarchy of simpler concepts and basic skills. Standard seven was an appropriate class level to use for investigation of whether the hierarchy of simpler concepts and basic skills of Euclidean geometry taught in earlier class levels had been mastered.

Eight standard seven mathematics teachers, one from each selected school were observed teaching their standard seven pupils concepts and skills in Euclidean plane geometry. For schools with more than one streams there were more than one teachers teaching standard seven mathematics. In this case purposive sampling was used to select the teachers that were observed, whereby the head teacher made arrangements regarding which teacher could be observed teaching.

**Description of Research Instruments**

Two research instruments were used in this study, namely; Test on Euclidean Plane Geometry and Checklist for Classroom Observation.

1. **Test on Euclidean Plane Geometry (TEPG)**

The TEPG was developed by the researcher. The items constructed were based on the standard seven Euclidean plane geometry syllabus which constituted content of lines, angles, triangles, circles, quadrilaterals and compound figures. The TEPG consisted of 50 items in all. The items tested
pupils on knowledge, comprehension and application categories of the
cognitive levels as required by the Ministry of Education regulations (KIE,

To ensure that the instrument covered the syllabus as prescribed by
the Ministry of Education, a table of specification was prepared as shown in
Table 5.

Table 5

<table>
<thead>
<tr>
<th>Specification of Item Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area Of Geometry</strong></td>
</tr>
<tr>
<td>Lines</td>
</tr>
<tr>
<td>Angles</td>
</tr>
<tr>
<td>Triangle</td>
</tr>
<tr>
<td>Quadrilaterals</td>
</tr>
<tr>
<td>Circles</td>
</tr>
<tr>
<td>*Compound Figures</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

*Items that comprises two or more of standard seven topics.

The TEPG was of criterion-reference type. A criterion score of 66
percent was decided upon using the results of a pilot study that was carried
out in order to judge whether an examinee was a master of Euclidean plane
gometry concepts or not. To determine the criterion score of the TEPG, the
researcher was guided by the suggestion of Ebel (1972). Ebel suggests that
if less than 60 percent of the examinees exceed the 75 percent of the score the criterion score is the point midway between the 75 percent score and the score 60 percent of the examinees do exceed. The score 60 percent of the examinees exceeded was 57 percent, therefore the point midway between 75 and 57 percent was 66 percent. Authorities from KNEC who were consulted in order to confirm the criterion score agreed that a score of at least 66 percent was an appropriate measure of mastery Euclidean plane geometry. It was necessary to consult the authorities because Satterly (1986) recommends the involvement of experts in determining the criterion score.

As hinted earlier, the TEPG was piloted in one of the public primary schools in kakamega Municipality before the actual study was carried out. It was administrated to 57 standard seven primary school pupils in the pilot study. The purpose of the pilot study was to establish the reliability of the TEPG. The test was marked by the researcher and the performance analysed.

Item difficulty method was used to analyse the items in order to determine the quality of TEPG. The item difficulty indices for the TEPG were worked out and found to range between 0 and 0.96. Item difficulty indices for items 3, 4, 5 and 6 were over 0.9 while the index for item 33 was 0. Items 3, 4, 5, 6 and 33 were therefore adjusted accordingly since Ebel (1972) says that items that more than 90 percent or few than 10 percent of the pupils answer correctly cannot possibly contribute much to test reliability. After adjustment of items 3, 4, 5, 6 and 33, the TEPG was administered to the same pupils and the new difficulty indices for the entire TEPG ranged between 0.25 and 0.88 (See Appendix E). Another method used to analyse the TEPG items in order to determine the quality of the test was the item
discrimination index. The item discrimination indices of the TEPG ranged between 0.35 and 0.6. Ebel (1972) says that the closer the discrimination index is to 0.40 and above, the better the reliability of the item. The items in the TEPG had discrimination indices that were at least 0.4. Thus, they were reliable.

Kuder-Richardson Formula 20 was then used to establish the reliability of the entire TEPG. The reliability obtained was 0.9 (See Appendix E).

The content validity was determined by inspection of the items and by relating them to an outline of the materials, which are intended to be measured using experts in the teaching of geometry in primary schools. A table of specifications was drawn to show area of standard seven Euclidean plane geometry to be tested and the number of questions for each area according to the cognitive levels of knowledge, comprehension and application.

2. Checklist for Classroom Observation (CCO)

The Checklist for Classroom Observation (CCO) was prepared by the researcher. It was sub-divided into three sections, namely; quality of instruction, teaching-learning resources and evaluation. The section on quality of instruction derived information regarding the teaching-learning strategies used, how pupil’s attention was drawn and number of examples given to each concept. The teaching-learning resources section collected data concerned with the resources available to the teacher and the pupils and
whether the availability of the resources aided the pupils to learn better. The last section provided data on how pupils are evaluated in order to determine whether they have mastered Euclidean plane geometry.

The CCO was piloted in order to test for its reliability. Wiersma (1995) reports that observer agreement can be used to determine the reliability of a classroom observation inventory. The instrument will be reliable if two or more observers agree when recording the same performance. In the present study, the researcher and one of the teachers in the pilot study school used CCO to collect data. The two observers recorded their observations. Analysis of the recordings showed that the observers agreed or were consistent in their observations. The reliability coefficient obtained was 0.88.

Expert judgement was sought in order to rate the validity of the Checklist for Classroom Observation in terms of how effectively the instrument met its objectives.

Data Collection Procedure

The researcher first got a permit from Ministry of Education authorizing her to carry out the study. She then visited each of the eight selected schools to seek permission from the head teachers to use their schools for the study. The visits to the eight selected schools took three days. During the visits, the researcher made appointments with the head teachers and standard seven mathematics teachers regarding the use of their schools for the study. The first appointment was concerned with the date when the 280 selected
standard seven pupils in the eight sample schools would sit for TEPG. The next appointment was concerned with the date standard seven mathematics teachers in the eight schools would be observed while teaching a Euclidean plane geometry lesson.

The researcher administered the TEPG to standard seven pupils with the help of their mathematics teachers. For each of the schools, the pupils sat for the TEPG from 8.30 am to 10.30 am on different days of the week (excluding Saturday and Sunday). The pupils had been informed in advance that they would do the test so that they could have time to look for geometrical instruments if they did not have any.

The checklist was used by the researcher during classroom observation. For each of the eight schools, classroom observation took place between 11.00am and 11.35am on the day the sample pupils were taking the TEPG. The researcher sat at the back of the classroom where she saw and listened to the teacher and standard seven pupils during a Euclidean plane geometry lesson. The researcher recorded information as guided by the checklist. She entered a tally or a check (✓) to show presence of resources or frequency of pupil or teacher behaviours as they occurred.

Data Analysis Techniques

Data collected using the TEPG from pupils and the CCO from classroom teachers and pupils was recorded separately and then analysed manually by using descriptive statistics which included, frequencies,
percentages, means and standard deviations. A t-test for independent samples was used to test the first hypothesis. A chi-square was used to test hypothesis two. Specifically, the raw scores of the 280 standard seven pupils on the TEPG were changed into percentages. Frequency tables were constructed to show the mastery of Euclidean plane geometry. The mastery in various topic areas of Euclidean plane geometry was presented in another frequency table. Item difficulty and discrimination techniques were also used to analyse the mastery of content of the items of the test of Euclidean plane geometry. The t-test was used to show whether there was any significant difference between the mean scores of standard seven primary school boys and girls on the test on Euclidean plane geometry. On the other hand, chi-squared was used to determine whether there was a significant difference between pupils' age-group and scores obtained on the TEPG.

To answer the question of areas of Euclidean plane geometry in which standard seven pupils have not mastered, item difficulty and item discrimination techniques were used. Data collected through the CCO was used to answer the question of whether the teaching-learning strategies enhances mastery of Euclidean plane geometry and whether there were any learning barriers experienced by standard seven pupils that inhibit their mastery in the subject. Sums and percentages were used to compute the data.
CHAPTER FOUR

RESULTS OF THE STUDY

This chapter presents analyzed data findings of the study. The chapter is divided into two sections for the purpose of data analysis. The first part of the data analysis is concerned with data obtained from Test on Euclidean Plane Geometry (TEPG).

The research questions answered in the first part include finding out whether standard seven primary school pupils had mastered Euclidean plane geometry, identifying areas in which they had not mastered and testing whether there was any significant difference between the mean scores of standard seven boys and girls on the TEPG. In addition, the first section of this chapter also reports about results of the test of whether there was any significant difference between pupils' age-group and scores obtained on the TEPG.

The second section of chapter four is concerned with analysis of data collected from the Checklist for Classroom Observation which answered the question of whether there were any learning barriers that inhibited standard seven pupils' mastery of Euclidean plane geometry concepts.

Analysis of Data Concerned with the Mastery of Euclidean Plane Geometry.

The Test on Euclidean Plane Geometry (TEPG) was administered to 280 pupils, composed of 149 girls and 131 boys. Table 6 shows the age and
gender distributions of standard seven primary school pupils who sat for the TEPG.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Boys</th>
<th>%</th>
<th>Girls</th>
<th>%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-11</td>
<td>17</td>
<td>13</td>
<td>15</td>
<td>10</td>
<td>32</td>
</tr>
<tr>
<td>12-13</td>
<td>67</td>
<td>51</td>
<td>78</td>
<td>52</td>
<td>145</td>
</tr>
<tr>
<td>14-15</td>
<td>47</td>
<td>36</td>
<td>56</td>
<td>38</td>
<td>103</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>131</strong></td>
<td><strong>100</strong></td>
<td><strong>149</strong></td>
<td><strong>100</strong></td>
<td><strong>280</strong></td>
</tr>
</tbody>
</table>

Observations from Table 6 show that pupils in the age-group of 12 to 13 years were the majority as they formed 52 percent of the sample population. Out of the 145 standard seven pupils in the 12 to 13 age-group, 67 were boys while 78 were girls. Table 6 also shows that there were 47 boys and 56 girls making a total of 103 pupils in the 14 to 15 years age-group. One common fact about the last two age-groups analyzed is that the girls were more than the boys. The 10 to 11 years age-group had 17 boys and 15 girls.
The means and standard deviations of scores obtained from the TEPG between boys and girls are shown in Table 7.

**Table 7**
The Means and Standard Deviations of Standard Seven Primary School Pupils on the TEPG (N = 280)

<table>
<thead>
<tr>
<th>Sex</th>
<th>f</th>
<th>( \bar{x} )</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>131</td>
<td>38</td>
<td>4.4</td>
</tr>
<tr>
<td>Girls</td>
<td>149</td>
<td>31</td>
<td>4.9</td>
</tr>
<tr>
<td>Totals</td>
<td>280</td>
<td>34.5</td>
<td>4.7</td>
</tr>
</tbody>
</table>

From this table, the mean scores for boys and girls on the TEPG were 38 and 31 respectively. The mean scores show the general mastery of Euclidean plane geometry by standard seven boys and girls. Although the boys had a better mean on mastery compared to the girls, their general understanding does not measure up to the required criteria of 66% as will be shown later. Table 7 also shows that the standard deviations of the scores on TEPG for the standard seven girls and boys were 4.4 and 4.9 respectively. The difference between the girls’ and boys’ standard deviations was small. The small difference (0.5) in the standard deviations implied both girls and boys did not vary much in their general mastery of Euclidean plane geometry.

Scores of the TEPG were further tabulated and analysed using frequencies and percentages and presented as shown in Table 8.
Table 8
A Grouped Frequency Distribution of Standard Seven Pupils’ Scores on the TEPG (N=280)

<table>
<thead>
<tr>
<th>Score Range</th>
<th>Frequency</th>
<th>Cumulative Frequency (CF)</th>
<th>Percentage CF</th>
</tr>
</thead>
<tbody>
<tr>
<td>81-85</td>
<td>3</td>
<td>3</td>
<td>1.07</td>
</tr>
<tr>
<td>76-80</td>
<td>0</td>
<td>3</td>
<td>1.07</td>
</tr>
<tr>
<td>71-75</td>
<td>2</td>
<td>5</td>
<td>1.79</td>
</tr>
<tr>
<td>66-70</td>
<td>4</td>
<td>9</td>
<td>3.21</td>
</tr>
<tr>
<td>61-65</td>
<td>6</td>
<td>15</td>
<td>5.36</td>
</tr>
<tr>
<td>56-60</td>
<td>5</td>
<td>20</td>
<td>9.14</td>
</tr>
<tr>
<td>51-55</td>
<td>7</td>
<td>27</td>
<td>9.64</td>
</tr>
<tr>
<td>46-50</td>
<td>19</td>
<td>46</td>
<td>16.43</td>
</tr>
<tr>
<td>41-45</td>
<td>26</td>
<td>72</td>
<td>25.57</td>
</tr>
<tr>
<td>36-40</td>
<td>44</td>
<td>116</td>
<td>41.43</td>
</tr>
<tr>
<td>31-35</td>
<td>37</td>
<td>153</td>
<td>54.64</td>
</tr>
<tr>
<td>26-30</td>
<td>70</td>
<td>223</td>
<td>79.64</td>
</tr>
<tr>
<td>21-25</td>
<td>33</td>
<td>256</td>
<td>91.43</td>
</tr>
<tr>
<td>16-20</td>
<td>23</td>
<td>279</td>
<td>99.64</td>
</tr>
<tr>
<td>11-15</td>
<td>1</td>
<td>280</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Observation in Table 8 show that only nine out of 280 pupils in the sample obtained between 66 and 85 percent of the scores on TEPG. The nine pupils formed 3.21 percent of the sample population as shown in Table 8. It is also evident from the table that a majority (271) of the sample of standard seven pupils obtained scores between 11 and 65 percent on the TEPG. The modal class was 26-30.

Further analysis of the scores on TEPG based on gender showed the observations presented in Table 9.
Table 9
A Grouped Frequency Distribution of TEPG Scores by Gender (N₁=131, N₂=149, N=280)

<table>
<thead>
<tr>
<th>Score Range</th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>f</td>
<td>%</td>
<td>f</td>
</tr>
<tr>
<td></td>
<td>( \bar{x} )</td>
<td>SD</td>
<td>( \bar{x} )</td>
</tr>
<tr>
<td>81-85</td>
<td>2</td>
<td>1.5</td>
<td>1</td>
</tr>
<tr>
<td>76-80</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>71-75</td>
<td>2</td>
<td>1.5</td>
<td>0</td>
</tr>
<tr>
<td>66-70</td>
<td>3</td>
<td>2.3</td>
<td>1</td>
</tr>
<tr>
<td>61-65</td>
<td>4</td>
<td>3.1</td>
<td>2</td>
</tr>
<tr>
<td>56-60</td>
<td>3</td>
<td>2.3</td>
<td>2</td>
</tr>
<tr>
<td>51-55</td>
<td>4</td>
<td>3.1</td>
<td>3</td>
</tr>
<tr>
<td>46-50</td>
<td>10</td>
<td>7.6</td>
<td>9</td>
</tr>
<tr>
<td>41-45</td>
<td>11</td>
<td>8.6</td>
<td>15</td>
</tr>
<tr>
<td>36-40</td>
<td>24</td>
<td>18.3</td>
<td>20</td>
</tr>
<tr>
<td>31-35</td>
<td>14</td>
<td>10.6</td>
<td>23</td>
</tr>
<tr>
<td>26-30</td>
<td>30</td>
<td>22.9</td>
<td>40</td>
</tr>
<tr>
<td>21-25</td>
<td>15</td>
<td>11.5</td>
<td>18</td>
</tr>
<tr>
<td>16-20</td>
<td>9</td>
<td>6.9</td>
<td>14</td>
</tr>
<tr>
<td>11-15</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>131</td>
<td>100</td>
<td>149</td>
</tr>
</tbody>
</table>
Table 9 shows that seven boys and two girls scored the criterion mark of 66 percent. One hundred and twenty four boys (131 - 7 = 124) and one hundred and forty seven girls (149 - 2 = 147) scored less than 66 percent on the TEPG. The table also shows that two boys and one girl scored between 81 and 85 percent on the test. There was a big range between the best performing girl and the one who came after her. The mean score for the girls in the highest class interval (81-85) was higher than that for boys. So far, there was only one girl who scored between 11 and 15 percent. The lowest scores for the boys were within the 16 to 20 class interval. It is also clear from the table that the majority of boys and girls scored between 16 and 50 percent on the TEPG. The standard deviations of the boy’s scores on the TEPG in the various classes ranged between 0 and 2.3 while those for the girl’s scores ranged between 0 and 1.7.

Data on performance on the various topic areas or concepts of Euclidean plane geometry was analysis and presented as shown in Table 10.
Table 10
A Grouped Frequency Distribution of Scores on Euclidean Plane Geometry Concepts (N=280)

<table>
<thead>
<tr>
<th>Score Range</th>
<th>Frequency</th>
<th>Lines</th>
<th>Triangles</th>
<th>Quadrilaterals</th>
<th>Circles</th>
<th>Angles</th>
<th>Compound Figures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>f</td>
<td>f</td>
<td>f</td>
<td>f</td>
<td>f</td>
<td>f</td>
<td>f</td>
</tr>
<tr>
<td>77-87</td>
<td>28</td>
<td>8</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>66-76</td>
<td>33</td>
<td>9</td>
<td>7</td>
<td>19</td>
<td>23</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>55-65</td>
<td>50</td>
<td>21</td>
<td>15</td>
<td>0</td>
<td>15</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>44-54</td>
<td>8</td>
<td>48</td>
<td>26</td>
<td>57</td>
<td>24</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>33-43</td>
<td>73</td>
<td>48</td>
<td>75</td>
<td>116</td>
<td>66</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>22-32</td>
<td>53</td>
<td>61</td>
<td>115</td>
<td>0</td>
<td>77</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>11-21</td>
<td>35</td>
<td>85</td>
<td>36</td>
<td>79</td>
<td>65</td>
<td>135</td>
<td></td>
</tr>
</tbody>
</table>

Table 10 shows that 61 (28 + 33 = 61) out of 280 (22%) pupils scored at least 66 percent (minimum mastery score) and above on items on lines while 17 (6%), 13 (5%), 27 (10%), 33 (12%), and 5 (2%) of the 280 pupils achieved concept mastery scores on triangles, quadrilaterals, circles, angles and compound items respectively.

Content of items on lines was best mastered as compared to angles, triangles, quadrilaterals, circles and compound items since lines had the highest number of pupils 61 (22%) who acquired the mastery score. The least mastery of content was evident in the compound items as only 5 (2%) pupils achieved the criterion score.
An analysis of pupils with concept mastery of Euclidean plane geometry by gender was done and the findings summarized as shown in Table 11.

<table>
<thead>
<tr>
<th>Euclidean Plane Geometry</th>
<th>Boys</th>
<th>Girls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>f</td>
<td>%</td>
<td>f</td>
</tr>
<tr>
<td>Lines</td>
<td>36</td>
<td>13</td>
<td>25</td>
</tr>
<tr>
<td>Angles</td>
<td>27</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Circles</td>
<td>20</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Triangles</td>
<td>11</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Quadrilaterals</td>
<td>10</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Compound</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

From Table 11, it is evident that the percentage number of boys with mastery in the various Euclidean plane geometry areas was more than that for girls in all Euclidean plane geometry areas or topics.

The data collected from TEPG was also analyzed in terms of the frequency of pupils with concept mastery of Euclidean plane geometry areas by age as illustrated in Table 12.
Table 12
Frequency of Pupils with Mastery of Euclidean Plane Geometry Areas by Age (N=280)

<table>
<thead>
<tr>
<th>Euclidean Plane Geometry Areas</th>
<th>10-11</th>
<th>12-13</th>
<th>14-15</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
<td>1</td>
<td>29</td>
<td>31</td>
<td>61</td>
</tr>
<tr>
<td>Triangles</td>
<td>2</td>
<td>7</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td>Quadrilateral</td>
<td>1</td>
<td>7</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Circles</td>
<td>3</td>
<td>13</td>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td>Angles</td>
<td>5</td>
<td>17</td>
<td>11</td>
<td>33</td>
</tr>
<tr>
<td>Compounds</td>
<td>-</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

According to Piaget's stages of cognitive development, standard seven pupils fall in the stage of formal operations which ranges between eleven to fifteen years of age. Table 12 shows that the ages of the pupils in the study ranged between ten and fifteen years. The 14 to 15 age group had the highest percentage number of pupils who had mastered the concepts of lines, triangles and compound problems. On the other hand the 10 to 11 age group had the least percentage number of pupils who had mastered the various concepts. The 12 to 13 age-group had the highest percentage numbers of
pupils who had mastered the concepts quadrilaterals (2.5%), circles (4.6%) and angles (6.1%).

To test the hypothesis of whether there was a significant difference between the mean scores of standard seven primary school boys and girls on the Test on Euclidean Plane Geometry concepts a t-test was performed and the results tabulated as shown in Table 13.

Table 13

<table>
<thead>
<tr>
<th>Area</th>
<th>Boys (N=131)</th>
<th>Girls (N=149)</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>x</td>
<td>S.D</td>
<td>x</td>
</tr>
<tr>
<td>Lines</td>
<td>47.4</td>
<td>4.7</td>
<td>44.0</td>
</tr>
<tr>
<td>Angle</td>
<td>40.0</td>
<td>3.8</td>
<td>34.0</td>
</tr>
<tr>
<td>Triangles</td>
<td>45.0</td>
<td>4.4</td>
<td>24.4</td>
</tr>
<tr>
<td>Quadrilaterals</td>
<td>38.0</td>
<td>3.7</td>
<td>31.2</td>
</tr>
<tr>
<td>Circles</td>
<td>41.0</td>
<td>3.9</td>
<td>33.8</td>
</tr>
<tr>
<td>Compound figures</td>
<td>32.0</td>
<td>4.5</td>
<td>23.0</td>
</tr>
</tbody>
</table>

All t values were significant, df = 278 at p < 0.05.

Table 13 shows the computed values of t for standard seven primary school boys and girls in various Euclidean plane geometry concepts. By using the t-test for unequal populations, a comparison between the mean scores of boys and girls on the lines concept yielded a t = 6.18 (critical value:
t.05 = 1.645), with df = 278 in favour of boys. The computed t values for the rest of the Euclidean plane geometry concepts were 12 (angles), 36.79 (triangles), 14.46 (quadrilaterals), 14.49 (circles) and 16.07 (compound figures). The t values for all the listed concepts were greater than the critical or table t value (1.645) at 0.05 level of significance with 278 degrees of freedom. Thus, the null hypothesis was rejected. The conclusion made was that for mean scores of Test on Euclidean Plane Geometry concepts, there was a significant difference between standard seven primary school boys and girls. The difference favoured the boys. This revelation confirms the findings of Samumkut (1986) and Ogolla (1997) who found out that there was a significant difference between boys and girls in their performance in mathematics.

The second hypothesis of this study was concerned with whether a difference existed between the age-group of the pupil and scores obtained on the Test on Euclidean plane geometry. Table 14 shows a contingency table of the data that was used for computation. The table contains the observed and expected frequencies of scores on the TEPG by various age-groups of standard seven primary school pupils. The expected frequencies are in brackets. The chi-square test was used for analysis.
Table 14

Observed and Expected Frequencies of Scores by Various Age Groups of Standard Seven Pupils (N = 280).

<table>
<thead>
<tr>
<th>Age Groups</th>
<th>Scores 10 - 11</th>
<th>12 - 13</th>
<th>14 - 15</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>66% &amp; Above</td>
<td>1 (1.54)</td>
<td>6 (5.85)</td>
<td>2 (1.77)</td>
<td>9</td>
</tr>
<tr>
<td>Below 66%</td>
<td>31 (31.46)</td>
<td>139 (103.56)</td>
<td>101 (101.73)</td>
<td>271</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>145</td>
<td>103</td>
<td>280</td>
</tr>
</tbody>
</table>

Note: Expected frequencies are in brackets.

Difference insignificant at $\chi^2 = 0.246$, df = 3 at $p < 0.05$

The critical or table of chi-square for 2 degrees of freedom at 5% level of significance is 5.99. The computed chi-square was less than the table value. The result, thus, supported the hypothesis. It was therefore concluded that there was no significant difference between pupils' age group and scores obtained from TEPG. Generally, it is clear that standard seven primary school pupils' mastery of Euclidean plane geometry is quite poor. In trying to find out why most pupils were non-masters, it was evident from the scripts that pupils had not mastered simple concepts and basic skills that were learnt in their previous class levels. Generally it is clear that standard seven primary school pupils' mastery of Euclidean plane geometry is quite poor. In trying to find out why most pupils were non-masters. It appeared like pupils had
moved to their present class level before completely mastering prerequisite Euclidean plane geometry concepts and skills. For example, pupils had difficulties in finding the perimeter of a square (Appendix A, item 27). Only 20 percent of standard seven pupils answered the item correctly.

To find the answer to this item, the pupils needed to have mastered Euclidean plane geometry content on finding the perimeter of a square. The pupils were to apply the formula of finding the perimeter of a square. The pupils were to apply the formula of finding the perimeter of a square. The pupils were to apply the formula of finding the perimeter as shown in Appendix B, item 27. Some of the common wrong responses given by the pupils were:

\[ 2 \times 2 = 4 \text{ square units} \quad 4(2 \times 2) = 16 \text{ units} \]

In the first response it is apparent that the pupils could not differentiate between how to find the area and the perimeter of a square. The procedure followed was that used for finding the area of a square. In both the responses, pupils had misconceptions about how to find the perimeter of a square. Probably, they had not practiced enough in order to master the required concept.

The performance in various topic areas tells us something about the most mastered and least mastered topics. The least mastered area had to do with compound items, where only 2 per cent of standard seven pupils had concept mastery in Euclidean plane geometry. This raised a question as to whether the least popular Euclidean geometry area was not mastered either
because pupils had not understood it or teachers had omitted it during instruction or the pupils did not like it. The researcher tried to find out from the teachers why most pupils did not master the compound figures concept. Ninety percent of the teachers felt that most pupils had not understood it. The teachers said that pupils found that area of Euclidean plane geometry to be complex and hard.

Mastery of the lines concept was evident by most standard seven primary school pupils as compared to other topics. This could be because lines are straightforward and easier to understand than other topic areas. On the other hand compound figures involve two or more concepts and are thus more complex than say lines.

The percentage number of pupils who had mastered Euclidean plane geometry topics varied from one age-group to another as shown in Table 12. These variations have implications on the teaching methods used by standard seven mathematics teachers. There is need for flexibility in the teaching methods in order to meet the needs of the different age-groups.

The mastery of standard seven pupils in the content of the various items of TEPG was analyzed by determining their level of difficulty and discrimination (See Appendix F). Since the TEPG was of criterion-reference type, the item difficulty values were judged in relation to the specific content of the items (Ebel, 1971). The values were a guide in evaluating whether standard seven pupils had mastered the content required by each item. The values were classified as being of high, low and middle difficulty (Ebel, 1972).
From Appendix F, the item difficulty indices ranged between 0.1 and 0.89 percent. Items number 6, 13 and 20 had high item difficulty indices. Item 6 required pupils to identify the radius of a circle while in item 13 pupils were to find the area of a rectangle given the length and width. On the other hand pupils were to identify a right angle from a figure in item 20. Most of the pupils had mastered the content required by the three items, and that is why their indices were high.

The areas of Euclidean plane geometry in which most pupils had not mastered were those where the item difficulty indices were less than 0.25. There were cases where the percentage number of pupils who got the items correct was less than 0.25. At least one item from the low difficulty category was randomly sampled from each Euclidean plane geometry area for analysis. The item selected for evaluation of mastery of lines was item number 37 (See Appendix A). The item tested standard seven pupils skill and knowledge in construction of perpendicular lines. The pupils needed to have mastered how to use geometry instruments such as pair of compasses, ruler, set square or protractor when drawing the perpendicular line. It was found out that out of the 140 sample pupils (70 high achievers and 70 low achievers), it was only 24.3 percent of the pupils who had mastered the skill of constructing perpendicular lines. Out of the 70 pupils in the upper group of the sample, 35.7 percent of the pupils answered the item correctly. On the other hand 21.4 percent of 70 pupils in the lower group answered the item correctly. The item discrimination index for item 37 was 0.14 (See Appendix
The small decimal value of the item discrimination index implied that a high percentage of high and low achievers had not mastered the skill of constructing a perpendicular line.

Eight per cent of the 75.7 percent (100%-24.3%) pupils who did not get item 37 correct drew their perpendicular lines without using tools like pair of compass, set square or protractor. As a result their perpendicular lines did not form a right angle with the horizontal line QR (See Appendix G for sample). Twenty percent of the 75.7 percent of pupils who did not get a score for item 37 did not attempt the task. It is probable that these pupils had not mastered how to draw the perpendicular. From the above revelations, it is evident that the construction of the perpendicular line is one of the Euclidean plane geometry areas in which a majority of the pupils had not mastered.

Item 42 was selected for analysis in order to identify the weaknesses the pupils had in the Euclidean plane geometry content regarding vertically opposite angles corresponding angles and angle sum of a straight line and a triangle in order to answer items 42 correctly. However, only 15.7 percent of the sample pupils had the required mastery. The discrimination index was 0.2 The value implies that a large proportion of high and low achievers had not mastered the content. Thirty four point three percent of the low achievers had the required content.

Fourty seven percent of the sample pupils who had not mastered the content for items 42, gave their answer as 60°. The rest gave their answers
as $140^\circ - 60^\circ = 20^\circ$, $200^\circ - 80^\circ = 20^\circ$ and $180^\circ - 60^\circ = 120^\circ$. A few of the pupils did not attempt the item. Probably the pupils who gave the stated responses had no idea what they were writing because there was no logic as to why they responded the way they did. It is possible that they could not remember what they had been taught about vertically opposite and corresponding angles, and the angle sum of a straight line and a triangle. Thus teachers and pupils need to pay more attention in the area discussed so as to enhance mastery in Euclidean plane geometry.

An analysis of performance on item 15 of the TEPG was also done in order to evaluate mastery of construction of triangles. The pupils were to interpret the instructions given and draw the triangle accurately. The knowledge of using the ruler and pair of compasses to draw the triangle was vital. So far, only 15 percent of the sample (140) pupils drew the triangle correctly (See Appendix F). Both the high and low achievers had difficulties with items 15 since the discrimination index was 0.13. Fifteen percent of pupils form the upper group and 6 percent from the lower group had the mastery of the knowledge and skill of construction of the required triangle. The rest of the pupils neither followed the instructions nor did their measurement correctly. Thus accurate construction of triangles is another area of Euclidean plane geometry where non-mastery was portrayed extensively and needs special attention by teachers and pupils.

Item 35 of TEPG had to do with circles. It was found out that out of the 140 sample pupils, only 20 percent had mastered the content required by
the item. The discrimination index was 0.34. This value was better than for the cases discussed above. At least 37 percent of the high achievers had mastered the required content. The study showed that only 2.9 percent of the low achievers had the required concept mastery of Euclidean plane geometry.

For the standard seven pupils to get item 35 correct, they needed to have mastered Euclidean plane geometry content concerned with the circumference of a circle. They were to apply the formula of finding the circumference of a circle and compute correctly. (See Appendix B, item 35). However 80 percent of the sample pupils portrayed errors of two kinds. Twenty three percent of the pupils who did not get the item correct did wrong computations. For example one response read:

\[ C = \frac{\text{D}}{\text{D}} \]

\[ 50.24 = 3.14 \times \text{D} \]

\[ \text{D} = \frac{50.24}{3.14} \]

\[ = 8 \]

Probably the pupils who worked out item 35 in the illustrated manner were just careless. They did not bother to verify the answer they arrived at. Another reason for the wrong response could be that the pupils had a mix up in mathematical operations. So far the procedure was correct. A problem only arose when it came to the division operation in the final step.
Another response for item 35 was:

\[
\begin{align*}
\pi D &= C \\
3.14D &= 50.24 \\
D &= 50.24 - 3.14
\end{align*}
\]

The pupils who gave the above response must have confused the multiplication and addition operations.

The rest of the pupils who got item 35 wrong, had no mastery of the formula of finding the circumference of a circle and its application. So, another Euclidean plane geometry area in which a large proportion of non-mastery was portrayed had to do with the circumference of a circle.

Item 26, had a figure of a rectangle with length and width of four and one unit(s) respectively. Mastery and application of formula of finding the perimeter of a rectangle was necessary for one to respond to item 26 correctly. The study revealed that out of 140 sample pupils only 14.3 percent had the required mastery. The discrimination index was 0.23. This value was a pointer to the fact that a high percentage of both high and low achievers did not have mastery of content of item 26. It was clear from the scripts of the high and low achievers that most pupils did not interpret the measurements of the rectangle. As a result of the error they could not work out the perimeter. Thus, the study has shown that there is a large percentage of non-mastery in the quadrilaterals concept.

The percentage number of pupils who had mastered the content of item 34 was 10.7. The item required pupils to find the perimeter of a figure.
which consisted of a rectangle and semicircle. The pupils needed to have mastery of content of finding the circumference of a semicircle. They needed to comprehend how to find the perimeter of the rectangular part of the figure too. So far, 20 percent of the high achievers and one percent of the low achievers had the required mastery.

Generally about 90 percent of the sample pupils did not have the required mastery. The wrong response gave the impression that pupils had not practiced on such compound items. They treated the rectangle and the semicircular parts separately. Thirty percent of the pupils who did not get the item correct showed inability to work out the problems to the end. They gave their answer as 33, which is just part of the perimeter and denotes the perimeter of the semi-circle.

The analysis of data concerned with areas of Euclidean plane in which a majority of pupils had not mastered provided a wealth of information regarding pupils' mastery of Euclidean plane geometry concepts. The analysis was an effective way of gaining access to the difficulties that pupils experience with different Euclidean plane geometry concepts. Limited mastery of the presented Euclidean plane geometry areas was portrayed in the scripts. Investigation of such limitations was considered profitable in helping pupils and teachers to give them more attention and thus enhancing mastery of the subject.

Generally the proportion of difficulties experienced by difference achievement levels (See Appendix F, item Discrimination) suggest use of
different kinds of strategies of teaching from that used to instruct. An appropriate strategy would be to teach children on the basis of the difficulties they experienced.

It was clear from the scripts that most of the pupils did not have mastery in the areas discussed earlier either because they had not been taught or had not revised or were careless. This raises the question as to whether primary school teachers are aware of pupils' problems that make them to be non-masters in the areas listed above. There is need to find out whether teacher training pays attention to difficulties experienced by pupils that make them to lack mastery of Euclidean plane geometry.

Items in all topics that involved construction and measurement needed the use of geometrical instruments. However most pupils portrayed lack of skills in handling geometrical instruments; for example when measuring angles, bisecting angles, constructing triangles and circles (See Appendix G, item 10, 14 and 39). It is probable that such pupils had borrowed the instruments for the sake of doing the TEPG. The pupils did not have their own instruments which they could practice with and gain skill in using them. Teachers need to encourage pupils to buy their own geometrical instruments.

It may be argued that a pupil does not become a master of Euclidean plane geometry through exposure to the subject only. The pupil has to make an initiative. After instruction, the pupil has to study, attempt exercises and ask questions where necessary. It is possible that most standard seven
primary school pupils do not take this kind of initiative in Euclidean plane geometry.

Analysis of Data Concerned with Classroom Observation

One of the research questions of this study was to find out whether there were any learning barriers experienced by standard seven pupils that inhibit their mastery of Euclidean plane geometry concepts. A checklist for classroom observation (CCO) was used to gather relevant data. Thirty eight percent of the teachers observed teaching Euclidean plane geometry lessons were female while the rest (62%) were male. As regards the teaching-learning strategies used, all the teachers observed teaching Euclidean plane geometry lessons used expository teaching strategy where they gave clear explanations of the content of the topics they were teaching. They varied this with the question and answer method in order to encourage pupil participation in the learning of Euclidean plane geometry. The teachers could be commended for their teaching methods because Anderson and Faust (1974) say that if the goal of a lesson is to get the pupil to master a particular principle, an expository method will usually be superior to other teaching methods.

However, the teaching of Euclidean plane geometry involves giving exercises to pupils for drill and practice. Before such exercises are given, the teacher needs to work out examples for the pupils so that they can learn how to work out the exercises. The study revealed that 75 percent of the teachers
only demonstrated one example of Euclidean plane geometry problem before giving an exercise to the pupils. Guthrie (1967) found out that when pupils were taught a principle, they needed several examples in order for them to master that principle. So the one example the 75 percent of the teachers were giving was not sufficient to enable pupils to master in Euclidean plane geometry concepts.

Seventy five percent of the teachers used non-verbal cues such as gestures, eye contact, voice volume and tempo, and pause techniques in order to draw pupils' attention to learning Euclidean plane geometry. The pupils observed were alert and attentive in the classes where the above techniques of arousing pupil's attention were used. De Cecco (1970) says that pupils will perform better when they are simply alert. The researcher tried to find out whether this was true by comparing the mean scores of TEPG of the schools where the non-verbal cues were used and those that did not use the techniques. It was found out that the schools where teachers used non-verbal cues had a mean of 37.65% while those that did not apply the techniques had a mean score of 33.04%. So the schools that performed better are those where non-verbal cues were used to draw and maintain pupils' attention.

Bishop (1985) says that basic to the success of any attempt at curriculum improvement is the preparation and availability of suitable textbooks, teachers' guide and other teaching and learning materials. For Euclidean plane geometry, the teaching and learning materials would include
geometrical instruments such as pairs of compasses, protractors, rulers and others. In this case, if teachers and pupils have these teaching and learning resources, the teaching-learning process becomes more effective and better results are realized. The researcher found out that all the teachers observed had the basic textbooks and guide books. They also had chalk boards and chalk. Eighty eight percent had blackboard rulers, pairs of compasses and protractors; while twelve percent did not have any of the geometrical instruments. When the 12 percent of the teachers were asked how they managed to teach Euclidean plane geometry without geometrical instruments, they said that at times they borrowed the instruments from neighbouring schools. But in cases where the neighbouring schools were using their instruments, the school taught geometry theoretically without demonstrating the skills.

As for the pupils, the distribution of resources per school was as shown in Table 15.
Table 15

Distribution of Learning Resources Among Standard Seven Pupils

<table>
<thead>
<tr>
<th>Resources</th>
<th>No. of Pupils</th>
<th>Text Books</th>
<th>Exercise Books</th>
<th>Rulers</th>
<th>Pair of Compasses</th>
<th>Protractors</th>
<th>Pencils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shitaho</td>
<td>36</td>
<td>13</td>
<td>36</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>36</td>
</tr>
<tr>
<td>Matende</td>
<td>34</td>
<td>19</td>
<td>34</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>34</td>
</tr>
<tr>
<td>Amalemba</td>
<td>26</td>
<td>11</td>
<td>26</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>26</td>
</tr>
<tr>
<td>*Township</td>
<td>27</td>
<td>16</td>
<td>27</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>27</td>
</tr>
<tr>
<td>Kakamega</td>
<td>52</td>
<td>18</td>
<td>52</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>52</td>
</tr>
<tr>
<td>Shivakala</td>
<td>19</td>
<td>1</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Hirumbi</td>
<td>19</td>
<td>3</td>
<td>19</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>Bukhulunya</td>
<td>35</td>
<td>10</td>
<td>35</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>35</td>
</tr>
</tbody>
</table>

*Official name of the school is Kakamega Township

The schools where CCO was used were Shitaho, Matende, Amalemba, Kakamega Township, Kakamega, Shivakala, Hirumbi and Bukhulunya which had a pupil population in the streams observed of 36, 34, 26, 27, 52, 19, 19 and 35 respectively. At least all the pupils had an exercise book in which to write. However, there was a shortage of textbooks and geometrical instruments as is evident from Table 15. The situation was pathetic in schools like Shivakala and Hirumbi which had one and three textbooks respectively to be shared among 19 pupils each. On the other hand Shivakala had enough geometrical instruments for each pupil unlike the rest of the pupils. The reasearcher tried to find out why Shivakala had enough geometrical instruments and she was told that the Parents Teachers Association had bought those instruments as they are very important for learning.
Association had bought those instruments for the school. Generally, pupils who had the necessary resources were more involved in the activities of the lesson as they did the constructions of figures as instructed by the teachers. On the other hand, the pupils who did not have the geometrical set just sat and waited for the others to finish so that they could borrow their instruments. This was time wasting. There were times when teachers moved to the next step before these pupils completed their work.

It is evident from the observation above that there is a problem of allocation of sufficient learning resources to the pupils. The poor mastery as was shown earlier is a pointer that a problem exists probably in terms of provision of textbooks and geometrical instruments for the learners. Pupils would master Euclidean plane geometry concepts if they did a lot of practice of constructions and other problems. They would not be expected to do this practice if they did not have the necessary learning resources.

The teachers observed evaluated whether pupils had mastered what they had been taught in various ways. All the teachers asked questions on what they had taught. In case the responses given by the pupils were wrong, the teachers corrected the principles which had not been mastered. Seventy eight percent of the teachers went round their classes and marked pupils' books to evaluate pupils' performance on a given task. If the tasks had not been done to the teachers' expectation the teachers attended to individual pupils and corrected their errors. Sixty three percent of the teachers evaluated pupils' mastery of the content taught by requesting pupils to
demonstrate a given task on the chalkboard. If the pupils made errors they were corrected either by the teacher or the other pupils.

All the teachers encouraged pupils to participate by praising them when they gave a correct response of a question. Other teachers nodded when a correct answer was given. For all the schools observed the teachers never gave pupils time to ask questions. It is disturbing to note that pupils were not given time to ask question through which their needs and interests cold be detected. Learners are determinants of the curriculum too (Okech and Asiachi, 1992). So, they should be given time to ask questions.

An observation of pupils’ exercise books showed that only 12 percent of the teachers marked pupils’ books regularly. The rest of the teachers made pupils to mark their own books in most cases. When some teachers marked pupils' books, they used big crosses for wrong responses given, instead of appreciating any little effort made by the pupils. This is discouraging to the pupils. This could be a cause of pupils’ lack of interest in their work and thus poor mastery of Euclidean plane geometry.
CHAPTE R FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter summarises the findings of this study and makes conclusions which are drawn from the findings of the study. It also makes recommendations which could possibly improve pupils' mastery of Euclidean plane geometry if effected. The chapter also proposes further research.

Summary of the Findings

The investigation of mastery of Euclidean plane geometry among standard seven primary school pupils brought up revelations on:-

- The mastery of Euclidean plane geometry by standard seven pupils; and
- Learning barriers that inhibit pupils' mastery of Euclidean plane geometry.

The investigation of mastery of Euclidean plane geometry by standard Seven primary school pupils using TEPG revealed that:

- Only 3.21 percent of standard seven primary school pupils had mastery of Euclidean plane geometry;
- Mastery of Euclidean plane geometry in various topic areas varied. Out of the 280 pupils only 61 (21.7%) had mastery of lines. On the other hand 17 (6%), 13 (4.6%), 28 (10%), 33 (11.7%) and 5(1.7%) of the 280 pupils had mastery of triangles, quadrilaterals, circles, angles and compound items respectively.
- There was a significant difference between the mean scores of standard seven boys and girls on the TEPG in favour of boys.
• There was no significant difference between age-group of standard seven primary school pupils and scores obtained on the TEPG.

Areas of Euclidean plane geometry in which a large proportion of standard seven pupils had not mastered were determined through item analysis. Generally the entire subject of Euclidean plane geometry has a problem since only 3.21 per cent of the pupils had mastery in the subject. The areas where most pupils had not mastered were:-

• Construction of perpendicular lines;

• Problems related to vertically opposite and corresponding angles and angle sum of a straight line and a triangle;

• Construction of triangles;

• Circle problems;

• Interpretation of problems related to quadrilaterals and compound items.

For the case of learning barriers experienced by standard seven pupils that inhibited mastery of Euclidean plane geometry, the following revelations came up.

• Seventy five percent of the teachers only demonstrated one example before giving pupils an assignment.

• Twelve percent of the teachers did not have geometrical instruments. So, they could not demonstrate required skills for the pupils.

• Pupils in all the schools experienced scarcity of learning resources such as textbooks and geometrical instruments which are very basic for one to master in Euclidean plane geometry.
• Pupils were not given time to ask questions during the lessons.

• Pupils exercise books were not marked regularly.

**Conclusion**

The study revealed that there is poor mastery of Euclidean plane geometry concepts by standard seven primary school pupils. It is only 3.21 percent of the sample population of standard seven primary school pupils who attained the mastery level (66%). A majority of the pupils had not mastered various Euclidean plane geometry concepts.

It can also be concluded from the findings of the study that there is a significant difference between the mean scores of standard seven boys and girls in favour of boys, on the TEPG. The study also verified that no significant difference exists between age-group of the pupil and scores obtained on the TEPG.

Another conclusion drawn from the study is that pupils experienced learning barriers that may be inhibiting their mastery of Euclidean plane geometry. The barriers included:-

• Insufficient examples being demonstrated to the pupils by most of the teacher (75%);

• Scarcity of teaching-learning resources;

• Pupils not being given time to ask questions and

• Pupils’ exercise books not being marked regularly.
Recommendations

The following recommendations have been made in the hope that those concerned may consider them useful and helpful in seeking ways to improve mastery of Euclidean plane geometry.

Just as Ausubel (1968) suggests, one of the most important single factor influencing learning is what the learner knows, consequently teachers should recognize that it is useful to have some ideas of what their pupils already know before beginning a new topic. This is necessary because the TEPG results showed that most pupils had moved to their present class before mastering some Euclidean plane geometry content of previous class levels.

Teacher training curriculum should apart from other things focus on difficulties experienced by pupils in learning geometry and other areas of mathematics in order to equip future teachers on how to handle and address these problems.

Teachers and pupils need to give special attention to areas where most pupils portrayed non-mastery such as construction of perpendicular lines, construction of triangles, circle problems and the others.

Teachers should focus their teaching relevantly to mastery of Euclidean plane geometry. They should ensure that they demonstrate enough examples of Euclidean plane geometry problems to the pupils before giving them an assignment. Teachers should also guide pupils to practice more on items on the comprehension and application levels of the cognitive
domains. Another thing is that teachers should create time to mark pupils' exercise books.

Parents and other stakeholders should be sensitised on the importance of providing teaching-learning resources for schools as these could have serious implications on mastery of content by pupils. Then each school could come up with ways and means of raising funds to buy the resources.

Since the mastery of Euclidean plane geometry is generally poor, it is necessary for the needs and interests of the learner to be taken into account when teaching the subject. The basic concepts of the subject should be translated into how the learners view things and their interest drawn to the subject.

The Ministry of Education through the relevant departments should carry out regular inspections to schools and organize in-service courses for teachers in order to alleviate some of the probable causes of poor mastery of content.

The national examinations set by the Kenya National Examinations Council (KNEC) are normally norm-reference tests as they reflect a candidate's performance compared with the rest of the candidates. The KNEC should consider making its assessments to be of criterion reference so that teachers can work towards raising pupils to a specific level of achievement. This may reduce the public outcry of poor performance in mathematics.
Recommendations for Further Study.

The following are suggestions for further study:

- Follow up studies should be carried out in a wide region and involve other class levels. This study only covered a municipality and one class level.

- It is also necessary for a study to be done in three-dimensional geometry and other topics with mastery problems.

- Further research in this area should address the teaching strategy that would be effective in dealing with the problem of non-mastery of Euclidean plane geometry.


Technology (7th Ed.). §, 51-52.


Primary Schools. 'Unpublished M. Ed Thesis: Kenyatta University, Nairobi.


Test on Euclidean Plane Geometry

Time: 2 hours

Gender:  Boy( )
       Girl( )

Name of school ................................................................................................................

Pupil's Age: ......................................................................................................................

Answer all the questions in this section in the space provided

For items 1 and 2, name the following figures:

1) .................................................................................................................................

2) .................................................................................................................................

Use the following figure to answer items 3 and 4

3) What is the name given to lines 'A' and 'B'?
   ..........................................................................................................................

4) Line C is called a ......................................................................................................

.....................................................
What names are given to line ‘p’ and ‘r’ in the following figures?

5. \( P \) ……………………

6. \( r \) ……………………

Use the figures below to answer items 7 and 8.

7. Name from A, B or C one of the following shapes shown which can be drawn in the blank box above (iii) in order to continue with the pattern of the shape shown in the above diagram.
8) Draw the shape you have selected in the blank box (iii).

9) Find the angle marked $x$ in the figure below.

10. Construct a triangle $ABC$ where $AB = 5 \text{ cm}$, $BC = 6.5 \text{ cm}$ and angle $\angle ABC = 50^\circ$.

11. Measure the length $AC$ in item 10.

12. Ann and Job ran round the field as shown in the diagram. What distance did they cover in metres?

   \[
   \text{Take } \pi = \frac{22}{7}
   \]

13. Find the area of the diagram below.

14. Construct a circle of radius 3.5 cm with a given diameter.

15. Construct a circle of radius 1.5 cm. Using the protractor, measure the central angle of the circle you have drawn.

16. Chege drew a figure. The lines are the following.
   - Three equal sides
   - All angles are right angles
   - Opposite sides are parallel
   Which figure did he draw?

17. Bola drew a figure which had the following properties.
   - Three equal sides
   - All angles are equal
   - Opposite sides are parallel
   Which figure did he draw?
13. Find the area of the diagram below.

19 cm

| 4 cm |

14. Construct a circle of radius 3.5 cm with O as the center and AB as the diameter.

15. Construct a triangle ABC such that AC=3.5 cm and C is on the circumference of the circle you have drawn in item 14.

16. What is the size of angle COB from your construction in item 15?

17. The length of one side of a square plot of land in 26 m. A farmer fenced round the plot with three strands of wore. What was the total length of the wire used to fence the plot?

18. Chege drew a figure. The figure had the following properties:
   All side are equal
   All angles are right angles
   Opposite sides are parallel
   Which figure did he draw?

19. Sitalo drew a figure which had the following properties:
   Three equal sides
   All angles are equal
   Opposite sides are parallel
   Which figure did he draw?
Use the following figures to answer items 20-22. State whether the angle shown in the following figures is:-

i) Acute angle
ii) Obtuse angle
iii) Reflex angle
iv) Right angle

20. In the following triangle, \( \angle ABC = 90° \) is an angle in a right triangle.

21. [Diagram of parallel lines with a transversal]

22. [Diagram of intersecting lines]
23. A circle has a diameter of 14 cm. Find its area.

(Take $\pi = \frac{22}{7}$)

24. In the following triangle $ACB=50^\circ$. Find angle $ABC$.

25. State one property of parallel lines.

The four shapes P Q R and S have the same area. Find the perimeters of

26) P
27) Q
28) R
29) S

Study the pattern formed by the shapes drawn below and answer items 30 and 31

30. Draw the next shape

31. If 'i' has one triangle, 'ii' has four triangles and 'iii' has nine triangles, how many triangles are in the next shape?

..........................
32. Rono rings the bell five minutes to four o'clock every day. What type of angle is made by the hands of the clock when the bell rings?

a) Obtuse  
b) Acute  
c) Right  
d) None of the above

33. Find the circumference of the figure shown below:

(Take \( \pi = \frac{22}{7} \))

34. In the figure below, the diameter of the semicircle is 21 cm. What is the perimeter of the figure in centimeters?

(Take \( \pi = \frac{22}{7} \))
35. The circumference of a circle is 50.24 m. What is the radius of the circle? (Take \( \pi = 3.14 \))

Given triangle PQR as shown below, answer items 36-38.

36. Draw a bisector of angle PQR

37. Draw a perpendicular from P to line QR

38. If the perpendicular meets the bisector at S, What is the length of PS?

N is a point on line AB. Use the line to answer items 39-41

39. Draw a perpendicular to AB passing through N.

40. Mark point C on the perpendicular 9.2 cm above N.

41. Join AC and BC. What is the size of angle CAN?
42. In the figure below MYRZ, XQZ and RQS are straight lines. YX is parallel to RS. Angle MYX = 140° and XQS = 60°.

What is the size of angle RZQ?

43. Find the area of the shaded part in the figure below.
The diagram below represents a vegetable garden. One of its edges is a semi-circle.

44. Disclose what the dotted line stands for.

45. What is the perimeter of the garden?

54 cm
63 m
20 m
23 m

46. In the following figure, ABCD is a quadrilateral in which angle DAB=90° and angle ABD=36°. Line DA is parallel to CB and DB=DC.
What is the size of angle BDC?

47. The figure below represents a right-angled triangle ABC. The area of the triangle is 84 cm$^2$ and side BC=7 cm.

What is the length of side AB in cm?

48. In the figure shown below EFGH is a quadrilateral and EFH is an equivalent triangle. Angle EFG=90°

What is the size of angle FGH?
49. Complete the pattern above by drawing the relevant shapes in the open space on the left side of the figure.

50. Find the area of the shaded part.
Appendix B

Marking Scheme of Test on Euclidean Plane Geometry

<table>
<thead>
<tr>
<th>Answers</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Straight line</td>
<td>(1)</td>
</tr>
<tr>
<td>2. Winding line or wavy line</td>
<td>(1)</td>
</tr>
<tr>
<td>3. Parallel line</td>
<td>(1)</td>
</tr>
<tr>
<td>4. Transversal</td>
<td>(1)</td>
</tr>
<tr>
<td>5. Diagonal</td>
<td>(1)</td>
</tr>
<tr>
<td>6. Radius</td>
<td>(1)</td>
</tr>
<tr>
<td>7. (a) B</td>
<td>(1)</td>
</tr>
<tr>
<td>8.</td>
<td>(1)</td>
</tr>
<tr>
<td>9. Property of vertically opposite angles</td>
<td></td>
</tr>
<tr>
<td>$56^\circ + 62^\circ = 118^\circ$</td>
<td></td>
</tr>
<tr>
<td>$X = 180^\circ - 118^\circ$</td>
<td></td>
</tr>
<tr>
<td>$= 62^\circ$</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td></td>
</tr>
</tbody>
</table>
Construction of AB
Construction of BC
Measurement of angle ABC
Presentation of triangle

11. AC = 5

12. To find the circumference of the 2 semi-circles.
   Circumference = \( \pi d \)
   \( = \frac{22 \times 70}{7} \) m
   = 220 m

Total distance around the field = 220 m + 200 m

   = 620 m

13. Area = \( L \times W \)
    = 19 cm \times 4 cm
    = 76 sq cm

14. Construction of circle
15. Construction of triangle
16. Measure of angle COB = 120°
17. Perimeter = \(2(L + W)\)
   = \(2(26 + 26)\)
   = \(2 \times 52\)
   = \(104\) m

Length of wire for three strands of wire is
\(104\) m \(\times 3 = 312\)

18. Square
19. Equilateral triangle
20. Right angle
21. Reflex angle
22. Acute angle

23. Area = \(\pi r^2\), where \(r = \frac{1}{2}\) diameter
   = \(\frac{22}{7} \times 7 \text{ cm} \times 7 \text{ cm}\)
   = \(154\) sq cm

24. \(\angle BAC = \angle ACB = 50^\circ\) \(\rightarrow\) Isosceles triangle
   \(\angle BAC + \angle ACB = 100^\circ\)
   \(\angle ABC = \angle 180^\circ - 100^\circ\)
   = \(80^\circ\)

25. Parallel lines extend in the same direction and remain the same
distance apart.

26. \(P = 2(4 + 1)\)
   = \(10\) units

27. \(Q = 2(2 + 2)\)
   = \(8\) units

28. \(R = 2(3 + 1) + 2\)
   = \(10\) units
29. \[ S = 2(1+1)+8 = 12 \text{ units} \] (1)

30. \[ \text{(1)} \]

31. \[ 16 \] (1)

32. \[ \text{Obtuse} \] (1)

33. This is a quarter of a circle

Distance of curved part

\[ = \frac{1}{4} \pi D \]

\[ = \frac{1}{4}(22 \times 28 \text{ cm}) \]

\[ = 22 \text{ cm} \]

Total circumference of shape is

\[ 14 \text{ cm} + 14 \text{ cm} + 22 \text{ cm} = 50 \text{ cm} \] (1)

34. Circumference of semi circle

Circumference \[ = \frac{1}{2}(\pi D) \]
\[
\text{Perimeter } = 40 + 33 + 39 + 45 + 39 + 21 + 21 + 40 + 45 \\
= 302 \text{ cm}
\]

35. Circumference \(= \pi D\)

\[
\pi D = 50.24 \text{ m} \\
3.14 D = 50.24 \text{ m} \\
D = \frac{50.24}{3.14} = 16 \text{ m}
\]

But \(D = 2r\)

\[
2r = \frac{16 \text{ m}}{2} = 8
\]

36. Drawing bisector of angle PQR

37. Drawing perpendicular from P to line QR

38. Length of PS = 3 cm

[Diagram showing bisectors and perpendiculars]
39. Drawing perpendicular to AB through N

40. Marking point C on the perpendicular 9.2 cm above N

41. Size of angle CAN = 64

42. Knowledge of properties of:
   - Vertically opposite angles
   - Corresponding angles
   - RZQ = 180° - (60° + 40°)
     = 80°

43. Area = \( \frac{1}{2} \times 4 \text{cm} \times 6 \text{cm} \)
     = 12 sq. cm.

44. Diameter

45. Distance around semi-circle
   Circumference = \( \pi D \)
   But since it is semi-circle
   \( C = \frac{1}{2} \pi D \)
   = \( \frac{1}{2} \times 22 \times 63 \text{m} \)
   = 99 \text{m}
   Total distance around garden
   Perimeter = \( 2(20 + 54) + 63 + 23 + 23 + 99 \)
   = 356\text{m}

46. \( \angle ADB \) is
   180° - (36° + 90°) = 54°
   \( \angle ADB = \angle DBC \) (alternate angle)
   Since \( \angle DBC = \angle BCD \)
   Then \( \angle BDC = 180° - (54° + 54°) \)
   = 72°

47. Area = \( \frac{1}{2} \times b \times h \)
   84 = \( \frac{1}{2} \times b \times 7 \)
   7b/2 = 84 cm²
   b = \( \frac{84 \text{cm}^2 \times 2}{7 \text{cm}} \)
48.

\[ \angle FGH = 180^\circ - (30^\circ + 30^\circ) = 120^\circ \] 

(1)

49.

50. Area of rectangle is 25m x 20m = 500m^2

Area of circle is \( \frac{22 \times 7 \times 7}{7} \) m^2 = 154m^2

Area of shaded part is 500 m^2 - 154m^2 = 346m^2

(1)
Appendix C

CHECKLIST FOR CLASSROOM OBSERVATION

Name of School: .................................................................
Number of Pupils: ..............................................................

Quality of Instruction

1a. The teacher uses teaching-learning strategies that encourage pupil participation in the learning of Euclidean plane geometry.
   Yes ( ) (1 Mark)
   No ( ) (0 Mark)

b. The strategies being used are (tick):
   (i) Question-answer method (1 Mark)
   (ii) Individual instruction (1 Mark)
   (iii) Expository (1 Mark)
   (iv) Group work (1 Mark)
   (v) Others (Specify) (1 Mark)

c. Teacher draws pupils' attention to learning through (tick)
   (i) Gestures (1 Mark)
   (ii) Pause techniques (1 Mark)
   (iii) Eye contact (1 Mark)
   (iv) Voice pitch/tempo/volume (1 Mark)
   (v) Others (specify) (1 Mark)

d. How many examples does the teacher give before giving an exercise to pupils? (No example, 0 Mark; <2 examples, 1 Mark; and >2 examples, 2 Marks).

Teaching-learning Resources

2a. Which of the following teaching-learning resources does the teacher have and use in the classroom? (tick)
   (i) Blackboard and chalk (1 Mark)
   (ii) Textbook (1 Mark)
   (iii) Teacher's guide (1 Mark)
   (iv) Pair of compass (1 Mark)
   (v) Protractor (1 Mark)
   (vi) Blackboard ruler (1 Mark)
b. How many pupils have the necessary teaching-learning resources?

<table>
<thead>
<tr>
<th>Resources</th>
<th>Number of Pupils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbook</td>
<td></td>
</tr>
<tr>
<td>Exercise book</td>
<td></td>
</tr>
<tr>
<td>Ruler</td>
<td></td>
</tr>
<tr>
<td>Pair of compass</td>
<td></td>
</tr>
<tr>
<td>Protractor</td>
<td></td>
</tr>
<tr>
<td>Pencil</td>
<td></td>
</tr>
<tr>
<td>Rubber</td>
<td></td>
</tr>
</tbody>
</table>

(None, 0 Mark; ≤ Half the class, 1 Mark; > Half the class, 2 Marks; and All Pupils, 3 Marks)

c. How is the availability of the resources aiding pupils to learn better?
(1 Mark for appropriate explanation, 0 Mark for no explanation).

Evaluation

3a Teacher finds out if pupils have mastered what they have been taught

Yes ( ) (1 Mark)
No ( ) (0 Mark)

b. Teacher does this by:
(i) Asking questions (1 Mark)
(ii) Giving a quiz (1 Mark)
(iii) Giving an assignment (1 Mark)
(iv) Asking pupil to demonstrate on board (1 Mark)
(v) Any other, specify (1 Mark)

c. Teacher gives pupils time to ask questions

Yes ( ) (1 Mark)
No ( ) (0 Mark)

d. Teacher encourages pupils to participate by

(i) Praising pupil (1 Mark)
(ii) Nodding head when correct answer is given (1 Mark)
(iii) Accepting relevant ideas of pupils (1 Mark)

e. Does teacher mark and correct pupils' geometry exercise books?

Yes ( ) (1 Mark)
No ( ) (0 Mark)
Public Primary Schools in Kakamega Municipality

1. Amalemba
2. Bukhulunya
3. Hirumbi
4. Musaa
5. Matende
6. Rosterman
7. Shisasari
8. Approved
9. Shitaho
10. Kakamega Township
11. Bondeni
12. Ebwambwa
13. Kakamega
14. Shivakala
15. Kakamega Ndani
16. Lurambi
17. Mahiakalo
18. Maraba
19. Mwiyala
20. Nabongo
21. Nyayo Tea Zone
22. Chief Mutsembi (Young)
23. St. Lawrence (Young)
24. Daisy Special School
### Appendix E

#### Pilot Study Results of the TEPG

<table>
<thead>
<tr>
<th>Scores (x)</th>
<th>$(x - \bar{x})$</th>
<th>$(x - \bar{x})^2$</th>
<th>Scores (x)</th>
<th>$(x - \bar{x}) (x - \bar{x})^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 67</td>
<td>2707</td>
<td>767.29</td>
<td>30. 38</td>
<td>-1.3</td>
</tr>
<tr>
<td>2. 67</td>
<td>27.7</td>
<td>767.29</td>
<td>31. 36</td>
<td>-3.3</td>
</tr>
<tr>
<td>3. 63</td>
<td>23.7</td>
<td>561.69</td>
<td>32. 36</td>
<td>-3.3</td>
</tr>
<tr>
<td>4. 62</td>
<td>22.7</td>
<td>515.29</td>
<td>33. 36</td>
<td>-3.3</td>
</tr>
<tr>
<td>5. 58</td>
<td>18.7</td>
<td>349.69</td>
<td>34. 36</td>
<td>-3.3</td>
</tr>
<tr>
<td>6. 52</td>
<td>12.7</td>
<td>161.29</td>
<td>35. 35</td>
<td>-4.3</td>
</tr>
<tr>
<td>7. 52</td>
<td>12.7</td>
<td>161.29</td>
<td>36. 35</td>
<td>-4.3</td>
</tr>
<tr>
<td>8. 52</td>
<td>12.7</td>
<td>161.29</td>
<td>37. 34</td>
<td>-5.3</td>
</tr>
<tr>
<td>9. 52</td>
<td>12.7</td>
<td>161.29</td>
<td>38. 34</td>
<td>-5.3</td>
</tr>
<tr>
<td>10. 50</td>
<td>10.7</td>
<td>114.49</td>
<td>39. 33</td>
<td>-6.3</td>
</tr>
<tr>
<td>11. 50</td>
<td>10.7</td>
<td>114.49</td>
<td>40. 32</td>
<td>-7.3</td>
</tr>
<tr>
<td>12. 50</td>
<td>10.7</td>
<td>114.49</td>
<td>41. 32</td>
<td>-7.3</td>
</tr>
<tr>
<td>13. 48</td>
<td>8.7</td>
<td>75.69</td>
<td>42. 32</td>
<td>-7.3</td>
</tr>
<tr>
<td>14. 46</td>
<td>6.7</td>
<td>44.89</td>
<td>43. 30</td>
<td>-9.3</td>
</tr>
<tr>
<td>15. 46</td>
<td>6.7</td>
<td>44.89</td>
<td>44. 30</td>
<td>-9.3</td>
</tr>
<tr>
<td>16. 45</td>
<td>5.7</td>
<td>32.49</td>
<td>45. 28</td>
<td>-11.3</td>
</tr>
<tr>
<td>17. 44</td>
<td>4.7</td>
<td>22.09</td>
<td>46. 28</td>
<td>-11.3</td>
</tr>
<tr>
<td>18. 42</td>
<td>2.7</td>
<td>7.29</td>
<td>47. 28</td>
<td>-11.3</td>
</tr>
<tr>
<td>19. 42</td>
<td>2.7</td>
<td>7.29</td>
<td>48. 28</td>
<td>-11.3</td>
</tr>
<tr>
<td>20. 42</td>
<td>2.7</td>
<td>7.29</td>
<td>49. 28</td>
<td>-11.3</td>
</tr>
<tr>
<td>21. 42</td>
<td>2.7</td>
<td>7.29</td>
<td>50. 27</td>
<td>-11.3</td>
</tr>
<tr>
<td>22. 41</td>
<td>1.7</td>
<td>2.89</td>
<td>51. 27</td>
<td>-12.3</td>
</tr>
<tr>
<td>23. 41</td>
<td>1.7</td>
<td>2.89</td>
<td>52. 26</td>
<td>-12.3</td>
</tr>
<tr>
<td>24. 40</td>
<td>0.7</td>
<td>0.49</td>
<td>53. 26</td>
<td>-13.3</td>
</tr>
<tr>
<td>25. 39</td>
<td>-0.3</td>
<td>0.09</td>
<td>54. 26</td>
<td>-13.3</td>
</tr>
<tr>
<td>26. 38</td>
<td>-1.3</td>
<td>1.69</td>
<td>55. 24</td>
<td>-15.3</td>
</tr>
<tr>
<td>27. 38</td>
<td>-1.3</td>
<td>1.69</td>
<td>56. 22</td>
<td>-17.3</td>
</tr>
<tr>
<td>28. 38</td>
<td>-1.3</td>
<td>1.69</td>
<td>57. 24</td>
<td>-15.3</td>
</tr>
<tr>
<td>29. 38</td>
<td>-1.3</td>
<td>1.69</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$$\bar{X} = \frac{\Sigma X}{N} = 39.3$$

Computation of the reliability of TEPG using Kuder – Richardson Formula 20.

$$r = \frac{n}{n-1} \left( \frac{\sigma^2}{\Sigma pq} / \sigma^2 \right)$$

where:

- **r** = Reliability Index
- **n** = Number of Items on the Test
- **$\sigma^2$** = Variance of the Total Test Score
- **$\Sigma pq$** = Proportion of Examinees Giving the Correct Response to Item i.
- **$\Sigma X$** = Total of scores
- **$\sigma(X - \bar{X})^2$** = Total of squared scores

$$\sigma^2 = \frac{(X - \bar{X})^2}{N} = 6905.83/57 = 121.15$$

$$\Sigma pq = 11.3188$$

$$r = \frac{57/56}{(121.15 - 11.3188)/121.15} = 0.91$$

(Source: Aiken, 1997).
<table>
<thead>
<tr>
<th>Item</th>
<th>Difficulty Index</th>
<th>Discrimination Index</th>
<th>Item</th>
<th>Difficulty Index</th>
<th>Discrimination Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.72</td>
<td>0.53</td>
<td>26.</td>
<td>0.25</td>
<td>0.41</td>
</tr>
<tr>
<td>2.</td>
<td>0.70</td>
<td>0.49</td>
<td>27.</td>
<td>0.27</td>
<td>0.38</td>
</tr>
<tr>
<td>3.</td>
<td>0.68</td>
<td>0.5</td>
<td>28.</td>
<td>0.25</td>
<td>0.35</td>
</tr>
<tr>
<td>4.</td>
<td>0.66</td>
<td>0.52</td>
<td>29.</td>
<td>0.26</td>
<td>0.35</td>
</tr>
<tr>
<td>5.</td>
<td>0.71</td>
<td>0.57</td>
<td>30.</td>
<td>0.41</td>
<td>0.37</td>
</tr>
<tr>
<td>6.</td>
<td>0.75</td>
<td>0.42</td>
<td>31.</td>
<td>0.39</td>
<td>0.59</td>
</tr>
<tr>
<td>7.</td>
<td>0.35</td>
<td>0.45</td>
<td>32.</td>
<td>0.55</td>
<td>0.38</td>
</tr>
<tr>
<td>8.</td>
<td>0.39</td>
<td>0.39</td>
<td>33.</td>
<td>0.25</td>
<td>0.35</td>
</tr>
<tr>
<td>9.</td>
<td>0.69</td>
<td>0.51</td>
<td>34.</td>
<td>0.26</td>
<td>0.36</td>
</tr>
<tr>
<td>10.</td>
<td>0.36</td>
<td>0.41</td>
<td>35.</td>
<td>0.27</td>
<td>0.42</td>
</tr>
<tr>
<td>11.</td>
<td>0.31</td>
<td>0.45</td>
<td>36.</td>
<td>0.45</td>
<td>0.68</td>
</tr>
<tr>
<td>12.</td>
<td>0.30</td>
<td>0.62</td>
<td>37.</td>
<td>0.48</td>
<td>0.35</td>
</tr>
<tr>
<td>13.</td>
<td>0.80</td>
<td>0.38</td>
<td>38.</td>
<td>0.25</td>
<td>0.36</td>
</tr>
<tr>
<td>14.</td>
<td>0.43</td>
<td>0.52</td>
<td>39.</td>
<td>0.51</td>
<td>0.58</td>
</tr>
<tr>
<td>15.</td>
<td>0.26</td>
<td>0.35</td>
<td>40.</td>
<td>0.37</td>
<td>0.49</td>
</tr>
<tr>
<td>16.</td>
<td>0.26</td>
<td>0.36</td>
<td>41.</td>
<td>0.25</td>
<td>0.43</td>
</tr>
<tr>
<td>17.</td>
<td>0.25</td>
<td>0.45</td>
<td>42.</td>
<td>0.35</td>
<td>0.35</td>
</tr>
<tr>
<td>18.</td>
<td>0.45</td>
<td>0.39</td>
<td>43.</td>
<td>0.31</td>
<td>0.49</td>
</tr>
<tr>
<td>19.</td>
<td>0.41</td>
<td>0.38</td>
<td>44.</td>
<td>0.26</td>
<td>0.35</td>
</tr>
<tr>
<td>20.</td>
<td>0.88</td>
<td>0.35</td>
<td>45.</td>
<td>0.27</td>
<td>0.35</td>
</tr>
<tr>
<td>21.</td>
<td>0.54</td>
<td>0.37</td>
<td>46.</td>
<td>0.25</td>
<td>0.35</td>
</tr>
<tr>
<td>22.</td>
<td>0.46</td>
<td>0.43</td>
<td>47.</td>
<td>0.28</td>
<td>0.43</td>
</tr>
<tr>
<td>23.</td>
<td>0.48</td>
<td>0.6</td>
<td>48.</td>
<td>0.26</td>
<td>0.35</td>
</tr>
<tr>
<td>24.</td>
<td>0.45</td>
<td>0.55</td>
<td>49.</td>
<td>0.56</td>
<td>0.36</td>
</tr>
<tr>
<td>25.</td>
<td>0.63</td>
<td>0.46</td>
<td>50.</td>
<td>0.29</td>
<td>0.49</td>
</tr>
</tbody>
</table>
Appendix F

Final Study Item Analysis Indices for TEPG

<table>
<thead>
<tr>
<th>Item</th>
<th>Difficulty Index</th>
<th>Discrimination Index</th>
<th>Item</th>
<th>Difficulty Index</th>
<th>Discrimination Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.70</td>
<td>0.43</td>
<td>26.</td>
<td>0.14</td>
<td>0.23</td>
</tr>
<tr>
<td>2.</td>
<td>0.70</td>
<td>0.40</td>
<td>27.</td>
<td>0.20</td>
<td>0.29</td>
</tr>
<tr>
<td>3.</td>
<td>0.66</td>
<td>0.41</td>
<td>28.</td>
<td>0.14</td>
<td>0.21</td>
</tr>
<tr>
<td>4.</td>
<td>0.60</td>
<td>0.43</td>
<td>29.</td>
<td>0.11</td>
<td>0.10</td>
</tr>
<tr>
<td>5.</td>
<td>0.72</td>
<td>0.41</td>
<td>30.</td>
<td>0.34</td>
<td>0.33</td>
</tr>
<tr>
<td>6.</td>
<td>0.81</td>
<td>0.49</td>
<td>31.</td>
<td>0.32</td>
<td>0.54</td>
</tr>
<tr>
<td>7.</td>
<td>0.29</td>
<td>0.39</td>
<td>32.</td>
<td>0.51</td>
<td>0.29</td>
</tr>
<tr>
<td>8.</td>
<td>0.31</td>
<td>0.14</td>
<td>33.</td>
<td>0.11</td>
<td>0.14</td>
</tr>
<tr>
<td>9.</td>
<td>0.28</td>
<td>0.41</td>
<td>34.</td>
<td>0.11</td>
<td>0.19</td>
</tr>
<tr>
<td>10.</td>
<td>0.79</td>
<td>0.39</td>
<td>35.</td>
<td>0.20</td>
<td>0.34</td>
</tr>
<tr>
<td>11.</td>
<td>0.31</td>
<td>0.37</td>
<td>36.</td>
<td>0.40</td>
<td>0.60</td>
</tr>
<tr>
<td>12.</td>
<td>0.28</td>
<td>0.49</td>
<td>37.</td>
<td>0.24</td>
<td>0.14</td>
</tr>
<tr>
<td>13.</td>
<td>0.79</td>
<td>0.31</td>
<td>38.</td>
<td>0.21</td>
<td>0.30</td>
</tr>
<tr>
<td>14.</td>
<td>0.40</td>
<td>0.46</td>
<td>39.</td>
<td>0.46</td>
<td>0.54</td>
</tr>
<tr>
<td>15.</td>
<td>0.15</td>
<td>0.12</td>
<td>40.</td>
<td>0.21</td>
<td>0.43</td>
</tr>
<tr>
<td>16.</td>
<td>0.15</td>
<td>0.16</td>
<td>41.</td>
<td>0.16</td>
<td>0.33</td>
</tr>
<tr>
<td>17.</td>
<td>0.17</td>
<td>0.31</td>
<td>42.</td>
<td>0.16</td>
<td>0.20</td>
</tr>
<tr>
<td>18.</td>
<td>0.42</td>
<td>0.27</td>
<td>43.</td>
<td>0.32</td>
<td>0.44</td>
</tr>
<tr>
<td>19.</td>
<td>0.36</td>
<td>0.27</td>
<td>44.</td>
<td>0.16</td>
<td>0.13</td>
</tr>
<tr>
<td>20.</td>
<td>0.89</td>
<td>0.20</td>
<td>45.</td>
<td>0.12</td>
<td>0.13</td>
</tr>
<tr>
<td>21.</td>
<td>0.49</td>
<td>0.29</td>
<td>46.</td>
<td>0.10</td>
<td>0.11</td>
</tr>
<tr>
<td>22.</td>
<td>0.46</td>
<td>0.39</td>
<td>47.</td>
<td>0.14</td>
<td>0.39</td>
</tr>
<tr>
<td>23.</td>
<td>0.46</td>
<td>0.59</td>
<td>48.</td>
<td>0.14</td>
<td>0.15</td>
</tr>
<tr>
<td>24.</td>
<td>0.40</td>
<td>0.50</td>
<td>49.</td>
<td>0.54</td>
<td>0.24</td>
</tr>
<tr>
<td>25.</td>
<td>0.60</td>
<td>0.37</td>
<td>50.</td>
<td>0.25</td>
<td>0.44</td>
</tr>
</tbody>
</table>
Appendix G

Samples of Construction Errors Made by Standard Seven Pupils

<table>
<thead>
<tr>
<th>Items</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.</td>
<td><img src="image" alt="Diagram" /></td>
</tr>
</tbody>
</table>

14. Sample One

Sample Two
Sample One

Sample Two
Appendix H

Formulae Used for Analysis

1. **Item Difficulty Index**

\[
D = \frac{R}{T} \\
\text{where} \\
D = \text{Item Difficulty Index} \\
R = \text{Number of High Scoring and Low Scoring Pupils Who Got} \\
T = \text{Total Number of High Scoring and Low Scoring Pupils Who Attempted the Item (Source: Keeves, 1990)}
\]

2. **Items Discrimination Index**

\[
D = \frac{R_1 - R_2}{0.5 N} \\
\text{where} \\
D = \text{The Discrimination} \\
R_1 = \text{Number of High Scoring Pupils Who Answered Correctly} \\
R_2 = \text{Number of Low Scoring Pupils Who Answered Correctly} \\
0.5N = \text{One Half of the Number of Script in the Sample. (Source: Keeves, 1990.}
\]

3. **t-Test**

\[
t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{(S^2_1/N_1 + S^2_2/N_2)}} \\
\text{where} \\
t = \text{Computed Value of t} \\
\bar{X}_1 = \text{Mean Scores for Boys} \\
\bar{X}_2 = \text{Mean Scores for Girls} \\
S^2_1 = \text{Variance of Boys} \\
S^2_2 = \text{Variance of Girls} \\
N_1 = \text{Number of Boys' Scores} \\
N_2 = \text{Number of Girls Scores} \\
df = \text{Degree of Freedom (N_1 = N_2-2)} \\
at significance level of 0.05 (Source: Tuckman, 1972)
\]

4. **Chi-Square**

\[
\chi^2 = \sum \frac{(O-E)^2}{E} \\
\chi^2 = \text{Chi-square Value} \\
O = \text{Frequency of Occurrence of Observed Facts} \\
E = \text{Expected Frequency of Occurrence} \\
\text{(Source: Wiersma, 1995)}
\]