INFLUENCE OF FORMATIVE EVALUATION ON LEARNER PERFORMANCE IN MATHEMATICS IN SECONDARY SCHOOLS IN EMBU COUNTY, KENYA

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DECLARATION

This research project is my original work and has not been submitted for any academic award at any other university.

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REG NO: E58/70566/2013

This research project has been submitted for examination with my approval as the university supervisor.

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DEDICATION

I dedicate this project to my beloved wife Joyce N. Kivuti, my son Elisha Kiama and my daughter Abigael Thayu for their great support, patience and understanding during my course.

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ABTSRACT

Assessment of students' academic achievement is a basic step in any educational project since it provides information about the success in the attainment of specific teaching objectives. Continuous quality improvement in formal learning depends upon well-conceived approaches to evaluation that have both formative and summative functions. Learning takes place in a context and within a system. Mathematics is perceived by society as the foundation for scientific and technological knowledge that is cherished by societies worldwide. A formative evaluation of students' performance is the best predictor of academic achievement in mathematics. The performance of Kenyan students in mathematics in the national examination has been very poor and more than 50% of the students fail mathematics in the national examination. Performance of students in Mathematics in Embu County in Kenya Certificate of Secondary Education for the last three years has been very poor. Thus, there is need for a research to be conducted to investigate the influence of formative evaluation on learners' performance in secondary school mathematics in Embu County, Kenya. The study employed a descriptive survey research design. The target population for the study was 173 Secondary schools while simple random sampling technique was used to sample 130 respondents composing of 70 students and 60 teachers from five school one from each Sub-County. Questionnaires and tests were used to collect primary data. The study generated both qualitative and quantitative data where quantitative data was coded and entered into Statistical Packages for Social Scientists (SPSS Version 17.0) and analyzed using descriptive statistics. The data was presented using tables and figures while explanation was done in prose. The study found that Mathematics teachers employ assignments test as a formative evaluation approach to way of measuring students' progress in mathematics performance which form an integral part of education system and that frequent assessment of students performance has demonstrated to improve student outcomes. The study also found that assessment is a crucial tool for simultaneously improving classroom practice and students' performance, and that it can enhance teaching and learning by providing a more focused application for learners. The study concludes that formative evaluation enables teachers to adjust their teaching to meet individual student needs, and to better help all students to reach high standards. The examinations have played a central role in the entire school programme influencing each activity that took place in the school. Examinations also made teachers to be selective in the content to be taught. Based on the findings of the study, the study recommended that teachers should carefully plan and administer mathematics quizzes, out of class assignments, supervised classroom mathematics assignments, end term and end year mathematics examinations. Incorporating various techniques, formative assessment can enhance teaching and learning by providing a more focused application for learners. To be truly effective, assessment should also be "formative" in other words, identifying and responding to the students' learning needs. Good feedback should be tied to explicit criteria regarding expectations for students' performance, thus making the learning process more transparent and modeling "learning to learn" skills for students.

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ACRONYMS AND ABBREVIATIONS

IDME Inspectorate Department of the Ministry of Education

KCSE Kenya Certificate of Secondary Education

KNEC Kenya National Examinations Council

NCTM National Council of Teachers of Mathematics

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Worldwide, Assessment of students' academic achievement is a basic step in any educational project since it provides information about the success in the attainment of specific teaching objectives (Wass, 2001). Evaluation is generally understood as testing which is a reliable procedure for collecting summative data, but it can also refer to the making of inferences based upon students' performances on "authentic" learning activities, whether the inferences are for summative or formative purposes (Erwin & Knight, 1995). Continuous quality improvement in formal learning depends upon well-conceived approaches to evaluation that have both formative and summative functions. Learning takes place in a context and within a system (Kaplan & Owings, 2001).

Evaluation can have a formative function that can help teachers to improve their teaching and learners to improve their learning. Formative evaluation is the process used by teachers and students to recognize and respond to student learning in order to enhance that learning, during the learning (Cowie and Bell, 1999). Formative evaluation is diagnostic, identifying what learners do not know, as well as that which they do well enough. Formative assessment has been shown to be highly effective in raising the level of students attainment, increasing equity of students outcomes, and improving students' ability to learn.

Utilization of formative testing in the teaching-learning process involve breaking up the subject matter content or course into smaller hierarchical units for instruction; specifying objectives for each units; designing and administration of validated formative tests; offering a group based remediation in areas where students are deficient before moving to other units and then administration of summative tests on completion of all units. The breaking up of subject or course into small units makes for adequate preparation for the tests by the students. Moreover, such frequent testing enables the students to get more involved and committed to the teaching-learning process thereby enhancing their performance. Formative assessment methods have been important to raising overall levels of student achievement.

Quantitative and qualitative research on formative assessment has shown that it is perhaps one of the most important interventions for promoting high-performance ever studied. Bloom, Hastings and Madaus (1971) pointed that formative evaluation is useful to both the students (as a way of diagnosing students' learning difficulties and the prescription of alternative remedial measures) and to the teacher (as means of locating the specific difficulties that the students are experiencing within subject matter content and forecast summative evaluation result). According to Gronlund and Linn (1990) formative evaluation serves three specific purposes, that is, to plan corrective action for overcoming learning deficiencies; to aid in motivating learners and to increase retention and transfer of learning. According to them, students' responses to a formative test could be analyzed to reveal group and individual errors needing correction.

Alonge (2004) had reported that the result of investigation into the extent to which cognitive entry characteristics and formative evaluation measured students' academic performance among University undergraduates show that formative evaluation has the highest predictive strength to academic achievement out of all variables, that is, certificate worth and Joint Admission and Matriculation Board (JAMB) results considered. In a similar study carried out among Polytechnic students, Ajogbeje (2012) reported that cognitive entry characteristics [West African School Certificate (WASC) and Polytechnics and Colleges Entrance Examination (PCEE)] are not significantly related to academic achievement of Polytechnic students in mathematics and that most of the students with good grades in WASC and PCEE examinations often times rely too much on these results which, in turn, affect their academic achievement. However, the study revealed that semester results (continuous assessment scores) are the best predictors of academic achievement in mathematics.

Mathematics is perceived by society as the foundation for scientific and technological knowledge that is cherished by societies worldwide. It is an instrument for political, socioeconomic, scientific and technological developments (Githua & Mwangi, 2003). Mathematics is a compulsory subject for all learners in Primary and Secondary schools in Kenya (KIE, 2002). It is also used by Universities to filter secondary school learners for entry into the prestigious science-based degree programmes (Kenya Universities Joint Admissions Board, 2006).

Greaney (2001) defines assessment as any procedure or activity that is designed to collect information about the knowledge, attitude, or skills of the learner or group of learners.

Assessment is therefore a process through which the quality of an individual's work or performance is judged. When carried out as an on-going process, assessment is known as Continuous Assessment (CA). CA is a formative evaluation procedure concerned with finding out, in a systematic manner, the over-all gains that a student has made in terms of knowledge, attitudes and skills after a given set of learning experience (Ogunniyi, 1984). According to Aggarwal (1999), CA is not simply continuous testing. Continuous assessment does not solely depend on formal tests. CA is more than giving a test, it involves every decision made by the teacher in class to improve students achievement. CA may take different forms such as formal questions given to students during class, take-home assignments/exercises and recapitulation exercises.

Assessment is either internal or external. Internal assessment refers to school-based assessment, which includes class assignments, teacher-made tests, recap exercises, projects, field studies and all these tools form part of the classroom continuous assessment strategies. A continuous assessment strategy refers to the different tools or procedures used in the classroom to understand the academic achievement levels of learners in terms of their knowledge, attitudes and values. Also a strategy in assessment is a purposefully conceived and determined plan of action. It is a pattern of assessment that seems to attain certain outcomes and to guard against others (Aggarwal, 1999). External assessment refers to tests that are produced by examining bodies away from school.

American public education seems unable to learn and improve. Classroom instruction has remained virtually unchanged for decades, despite endless cycles of reform and a growing body of educational research (Banilower and Heck, 2003). This lack of progress

is attributable to the current structure and culture of American education, which does not support rigorous practice. As each innovation gains widespread attention, a wave of superficial implementation efforts sweep across the educational community. Without the support required to do rigorous new work, the attempted innovation is stripped down to its simplest and most familiar elements; in the process, the most challenging elements, which are also necessary to the efficacy of the practice, are simply ignored (Fullan, 2007). Formative assessment is currently moving toward center stage on the national scene; and not surprisingly, it appears that most formative assessment efforts lack attention to the rigorous elements that are critical to potential effectiveness.

A growing number of researchers and educational leaders make a compelling case for the promise of formative assessment. Over the past twenty years educational research has pointed to the value of linking instruction to assessment (Marzano & Haystead, 2008; Reeves, 2007; Wiggins & McTighe, 1998), examining student work to inform instruction (Schmoker, 2006), and using formative assessment practices to drive learning (Marshall and William, 2004). Black and William's review of the research cites compelling data to indicate that formative assessment focused on student thinking can inform future instruction and learning; however, there is little evidence that the analysis of student thinking is used to drive instruction in the typical mathematics classroom in the United States (Weiss 2003). Textbooks, pacing guides, state tests, and courses of study govern the topics that are taught, the time spent on a topic and the depth of what is taught. These practices continue despite the results of international, national, state and college entrance tests which indicate that American high school students have not learned adequate

mathematics to support their own futures and career opportunities, or to support the future success of America in global competitive markets (Trends in International Mathematics and Science Study, 2007; Program for International Student Assessment, 2006; Friedman, 2005).

In Thailand Education for All (EFA) requires clear targets for quality improvement which specifies the need to assess students achievement (Kellagan, 2003). This is why the White Paper (1992) on the Education for National Integration and Development recommended that schools should maintain a cumulative record card on continuous internal assessment including class performance. Since then, teachers have continued to carry out continuous assessment in secondary schools for A Level classes as often as possible and without waiting until the end of each term or year.

In Somalia, the problem of secondary school students‘ poor performance in mathematics has persisted for a long time. Available records show that performance in mathematics among secondary school students in Somalia is as poor as in other countries. One secondary school mathematics teacher recalls that in the school year 1982-1983, out of 270 students (in one school) 19 of them passed in mathematics. This gives a failure rate of almost 93%. Similarly, the mean score was very low. According to statistics from the examination board of Imam Shafi‘i Foundation, an educational institution in Mogadishu, out of 232 students who sat for the secondary school leaving examination in the school year 2005-2006, 113 students failed. This accounts for 48.7%. In Somalia a student is considered to be a failure in a subject if he/she scores below 50% in that subject. Here the summative type of evaluation is used.

In Uganda, the Education Policy Review Commission (EPRC, 1989) was initiated to review the education system. The commission noted that, the two years of Advanced Level (A Level) secondary education be retained for the purpose of giving adequate time for preparation to students who wished to continue with higher education. The same commission emphasized the importance of both continuous assessment and final examinations (EPRC 1989).

A multiple of causes for the student's low achievement in mathematics has been attributed to difficulty in understanding the specialized mathematical language (Barton, 2002), ineffective, teacher-centered teaching methods and learners' negative attitudes towards the subject (Miheso, 2012), Learners lack of motivation to learn the subject (Githua and Mwangi, 2003) and lack of mathematics syllabus coverage (Shikuku, 2009). In this study students' perception of formative evaluation in mathematics referred to their opinions, feelings, emotions and judgments of the importance, usefulness and meaningfulness of teachers' actions, procedures, practices and social climate in which they assess and monitor students' mathematics learning.

Evaluation of students' mathematical work involves teachers' qualitative judgment of how well or how satisfactorily a student is performing or progressing in learning mathematics tasks (Hamachek, 1995). According to Dembo (1994) there are different types of instructional evaluation that a teacher can carry out. They include: placement evaluation which is aimed at finding out students' entry behavior before beginning instruction; formative evaluation which provides ongoing feedback to teachers and students regarding successes and failures during instruction; diagnostic evaluation which

attempts to find out specific learning difficulties that a student may have on specific mathematical facts, algorithms, concepts, principles or problem solving.

There is also summative evaluation, which comes at the end of instruction in a school term or year. It assesses the extent of attainment of instructional objectives, provides information to guide grading of students and evaluates teacher effectiveness (Dembo, 1994). This study focused on formative evaluation in which mathematics teachers give oral and written comments and grades as feedback, to indicate misconceptions, or correctness or incorrectness of mathematical performance (Dean, 1982). Formative evaluation requires that the teacher collects a lot of information on learners' performance through observations, classroom oral questioning, homework assignments, quizzes as well as informal inventories (Ebel & Frisbie, 1991).

Motivation to learn subject matter in this study referred to the internal drive or external force that initiate, maintain or causes to cease a learner's behaviour towards learning subject matter that is targeted and is the learner's goal (Husen and Postlethwaite, 1991). Extrinsic motivation is directed towards getting rewards that are external to the learner such as teachers' encouragement, positive feedback on learner's performance on skills or tasks.

For many years, the performance of Kenyan students in mathematics in the national examination has been very poor. The failure rate has consistently been more than 50% and has also been increasing. According to Eshiwani (1983) 62.3% of the candidates in 1979 obtained the failing grade nine which rose to 72.7% in 1980 and 75.1% in 1981 and

the trend is likely to continue in subsequent years. Nearly thirty six years later the situation has not changed. Performance of students in Mathematics in Embu County in Kenya Certificate of Secondary Education for the last three years has been very poor as shown in table 1.1 below.

Students' Performance in Mathematics in Embu County

Year	Candidates	Mean point	Mean grade	Schools
2012	7438	3.9356	D+	153
2013	7840	3.4702	D	169
2014	8120	3.3648	D	173

Source: Embu County Quality Assurance and Standards Office (2014)

1.2 Statement of the Problem

The importance of mathematics to an individual and society is acknowledged worldwide. Unfortunately, learners' performance in the subject at national examinations at the end of primary and secondary schools education is worrying all over the globe. Among the reasons given for the dismal mathematics achievement is lack of students' motivation to learn mathematics and hence their low achievement in it. Performance of mathematics subject in most students in secondary schools in national examination in Kenya has been very poor. In particular, Embu County has also been registering poor result on the mathematics subject. Poor performance of the mathematics in most secondary schools in the county motivates the researcher to conduct the study on the same. Thus there is need

for a study to investigate influence of formative evaluation on learner performance in mathematics in secondary schools in Embu County, Kenya.

1.3 Purpose of the Study

The purpose of this study was to explore influence of formative evaluation on learners' performance in secondary school mathematics in Embu County, Kenya.

1.4 Research Objectives

The study was guided by the following research objectives:-

i. To investigate the influence of assignments on learners performance in mathematics
ii. To determine the influence of continuous assessment tests on learners performance in mathematics
iii. To find out the influence of frequency of formative evaluation on learners performance in mathematics
iv. To investigate the influence of feedback on formative evaluation on learners performance in mathematics

1.5 Research Questions

i. How do assignments influence learners' performance in mathematics?
ii. To what extent do continuous assessment tests influence learners' performance in mathematics?
iii. How does frequency of formative evaluation influence learners' performance in mathematics?

iv. How does feedback on formative evaluation influence learners' performance in mathematics?

1.6 Significance of the Study

The findings of this study are of great important in a number of ways. First, the findings are of great important to the teachers at public and private schools in indentifying how classroom assessment influences students' performance. The findings of the study are of important to the school administrations in identifying the importance of formative evaluation and hence provide adequate facilities and approaches in enhancing students' performance which eventually improve overall school performance. The findings are also important to the curriculum developers in evaluating the curriculum and put emphasis on formative evaluation practices. The findings are important to the teacher training institutes in training teachers on the importance of formative evaluation and the best approaches on the same. Teachers may also benefit from this study as the findings may necessitate in service course to train them on different types of formative evaluation that promote students' performance. They may be educated on the importance of formative evaluation in promoting students' performance.

1.7 Limitations of the Study

The study involved secondary schools drawn from one county in Kenya; the sample may therefore not be representative of all the secondary schools in Kenya. The main findings of this study may as a result not apply to other secondary schools in Kenya. It was also difficult to cover a large population due to the limited time allocated for the research.

Some students' might also not be able to understand the questions due to problems in the language of instruction. The researcher was available to clarify and interpret questions for such students.

1.8 Delimitations of the Study

The study investigated the influence of formative evaluation in improving students' performance with focus to secondary schools in Embu County. Owing to the large number of schools in Embu County, the study was conducted only in selected secondary schools. This involved collecting information from principals, deputy principals, teachers using questionnaires and from students using tests. The study focused on the available literature on formative evaluation.

1.9 Basic Assumptions of the Study

It is assumed that all teachers are well trained and have good mastery of the subject content. In addition, it is the assumption of this study that all the various textbooks that are used in the mathematics classroom are of acceptable quality and that the time allocated to the topics of study was equal in all cases. It is also assumed that students in all cases are of similar learning backgrounds and that any differences in learning is a direct result of the classroom experiences with which students interact. Although the study was based in a rural setting, the learning environments are assumed to be least influenced by external factors such as socio-economic status of the community. It is also assumed that the respondents provided accurate responses to the questionnaire and

produce all records deemed necessary by the researcher and that the end of term examinations in mathematics are valid and reliable.

1.10 Definition of Significant Terms

Assignments a task given to students by their teachers to be completed out of the class time

Continuous assessment test is a process that attempts to provide evidence concerning students' performance, which when interpreted helps the assessors to take measures for further improvements

Direct Instruction- Academic instruction led by the teacher in a face -to- face formal' manner, where the teacher tells, shows, models, demonstrates and teaches the skill to be learned. The key word here is the teacher, for it is the teacher who is in command of the learning situation and leads the lesson. The contrary to this definition is referred to as the indirect instruction.

Educational administrators - refers to all those persons involved with monitoring learning programmes in schools such as principals of secondary schools and the Inspectorate Department of the Ministry of Education.

Evaluation- The ability to process information in order to make judgment, draw conclusions, and arrive at decisions.

Feedback is information about reactions to a product, a person's performance of a task, etc., used as a basis for improvement.

Formative evaluation is the process used by teachers and students to recognize and respond to student learning in order to enhance that learning, during the learning.

Frequency the rate at which something occurs or is repeated over a particular period of time or in a given sample

Learner is someone who is learning about a particular subject or how to do something.

Learning Resource is any person, material or event that establishes a condition, which enables the learner to acquire knowledge, attitude and skills.

Pedagogical Practices - These are generic-teaching practices associated with classroom organization and differentiation of instructional opportunities.

Performance - means the student's ability to think, reason and solve problems and that is indicated by the score attained in the mathematics assessments.

Teacher assessment - refers to the process of gathering and providing information to the learner about his or her performance on learning tasks made and used by the learners' teacher.

1.11 Organization of the Study

The report has five chapters. Chapter one outlines the context of the study including the background, statement of the problem, study objectives, research questions, significance of the study, limitations and delimitations and definition of significant terms.

Chapter two reviews literature with regard to the study. It considers views of those who have researched on assessment including performance trends, types and techniques of assessment in schools as well as the usefulness of formative evaluation in teaching of mathematics. It includes the summary of related literature, theoretical framework and the conceptual framework.

Chapter three provides the research methodology. It includes; the research design, target population, Sample and sampling procedures, research instruments, validity of the instruments, reliability of the instruments, data analysis techniques, time frame, financial budget, and data collection procedures and the rationale of choosing them.

Chapter four presents' analyses of the data collected and discusses the results. The discussions are based on the research questions touching on all assessment variables mentioned in the study.

Finally chapter five summarizes the findings and gives conclusion of the study. Also suggestions for additional research are given. A bibliography and appendices are presented at the end of the project.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

The chapter provides an extensive literature and research on influence of formative evaluation on learner performance in mathematics. The chapter covers the following sections, that is, influence of assignments, continuous assessment tests, frequency of formative evaluation and feedback on learners' performance in mathematics, summary of literature review, theoretical framework and conceptual framework.

2.1.1 Assignments

Assignments are a classic way of measuring student progress and are integral to accountability of schools and the education system. Ajogbeje (2012) found that the utilization of diagnostic assignments with remediation in appraising learning weaknesses enhances the acquisition and retention learning tasks among students. To meet a range of student needs, teachers vary instruction methods. They ensure that lessons include different approaches to explaining new concepts, provide options for independent classroom work, and encourage students who have grasped a new concept to help their peers. Teachers use a mix of approaches to assess student understanding of what has been taught. They may use diagnostic assessment to determine a student's level when he or she first enters a new school or at specified times during the school term to help shape teaching strategies. During classroom interactions, they most often use questioning techniques. Questions regarding causality, or open-ended questions, for example, often reveal student misconceptions.

Ughamadu (1990) in his study on the interactive effect of formative assignments and cognitive style on students' learning outcomes in secondary school chemistry found that analytical students exposed to formative testing with remediation performed significantly higher in composite concept attainment at classification and formal level than global students. However, in a study carried out on continuous assessment as predictors of students' grades SSCE Chemistry, Oluwatayo (2007) reported that formative assignments are weak predictors of excellent grades in SSCE Chemistry.

Teachers also make the learning process more transparent by establishing and communicating learning goals, tracking student progress and, in some cases, adjusting goals to better meet student needs. Teachers are able to compare their assignments with other teachers to ensure that they are treating students equitably (Mindes, 2003). They often find that comments are more effective than marks for improving student performance and helping all students to reach high standards. It is not always easy to drop or decrease the frequency of marks; however, sometimes students and their parents prefer to know how they are doing relative to other students.

Formative assignments are meant to provide feedback that can be used to improve teaching and learning. Students who are struggling are typically assessed more frequently because progress monitoring has been demonstrated to improve student outcomes. It follows, therefore, that such assessments must be used routinely throughout the school year so that instruction can be modified to improve learning outcomes. Most major assessments serve audiences other than the learner. Feedback reaches all levels of the system, except the one that counts most the student. Assignments should help students

understand the teacher's learning intentions and what constitutes success, provide students with opportunities to revise and improve their thinking, and help students monitor their own progress over time. Most of the teachers want reflective learners who take ownership in their own learning, then students need to be involved in decision-making at an early age, such as viewing exemplary work to construct their own rubrics (Stiggins & Chappuis, 2006).

2.1.2 Continuous Assessment Tests

William and Black (2003) defined continuous assessment tests as a process that attempts to provide evidence concerning students' performance (achievements), which when interpreted helps the assessors to take measures for further improvements. One of the alternative ways of assessing and teaching is the notion of implementing formative assessment in different contexts. Incorporating various techniques, continuous assessment tests can enhance teaching and learning by providing a more focused application for learners. Continuous assessment test is a process of gathering evidence within the stream of instruction in order to inform teaching and learning. To be considered formative, the evidence must be elicited, interpreted, and used by both teachers and learners (Wiliam, 2011). In contrast, summative assessment is used to evaluate progress and achievement, assign grades, and appraise programs. Continuous assessment tests involves getting the best possible evidence about what students have learned and then using this information to decide what to do next.

In a classroom that uses continuous assessment tests to support learning, the divide between instruction and assessment blurs. Everything students do such as conversing in

groups, completing seatwork, answering and asking questions, working on projects, handing in homework assignments, even sitting silently and looking confused is a potential source of information about how much they understand (Leahy, 2005). When classroom practice is based on continuous assessment tests, teachers and students together develop a framework for what can be expected in students' learning, for what it means to move toward intended mathematics learning goals and for a common goal of continuous and progressive learning. Continuous assessment test is a crucial tool for simultaneously improving classroom practice and students' performance (Petit & Zawojewski, 2010).

There is a growing body of research emphasizing the use of continuous assessment tests in classroom instruction as a means to improve student achievement. Black and Wiliam (2002) noted that greater student achievement in classrooms where teachers use such techniques. Similar findings are replicated in a meta-analysis (Ehrenberg, 2001). In particular, they report the impact of continuous assessment tests on student achievement being four to five times greater than the effect of reducing class size. Studies by Clements, Sarama et al. (2011) have found that professional development focused on and the instructional use of learning progressions results in improved student achievement. The findings also suggest that knowledge of learning progressions in the use of continuous assessment tests has the potential to strengthen the interpretation of evidence of student work to inform instruction and learning.

A requirement for implementing continuous assessment tests successfully for all students is maintaining the right classroom atmosphere. The classroom culture must breed success

instead of competition. The foundation for this culture is a belief by the teacher that all students are capable of achieving. In such a classroom, the information gleaned from quizzes, homework, class discussions and any type of assessment used for formative purposes can make a difference to individual students if it is conveyed appropriately to them. Chappuis and Chappuis (2008) recommended using continuous assessment test on a daily basis, and asserted that formative assessment in its purest form involves “no final mark on the paper and no summative grade in the grade book.

2.1.3 Frequency of Formative Evaluation

Students perform in any subject depending on the type of assessment used and consequently assessment must closely match the learning objectives. The choice of the most suitable type of assessment is a crucial question. To be truly effective, assessment should also be “formative” in other words, identifying and responding to the students’ learning needs (Clements et al. 2011). In classrooms featuring formative assessment, teachers make frequent, interactive assessments of student understanding. This enables them to adjust their teaching to meet individual student needs, and to better help all students to reach high standards. Teachers also actively involve students in the process, helping them to develop skills that enable them to learn better.

Fuchs and Fuchs (1986) examined 21 controlled studies about the effects of frequent formative evaluation on the achievement of students in preschool through Grade 12. In these studies, teachers conducted formative assessments between two and five times per week. The average effect size was 0.70 standard deviations for classrooms that used student data to draw progress reports on each student and to adjust instruction, and the

average effect size was 0.26 for classrooms that used formative assessments but did not systematically organize the resulting data.

Studies of curriculum-based measurement Fuchs, Fuchs and Hamlett (1989) examined the effects of administering weekly or biweekly assessments in reading, mathematics and spelling and receiving computer-generated graphs of student progress together with instructional recommendations. Taken together, these studies demonstrate that students in classrooms receiving graphical progress reports and instructional recommendations improved more quickly and achieved higher outcomes, compared to both students in classrooms without instructional recommendations and students in a control group. Teachers using the assessment, reports, and instructional recommendations recounted addressing more skills, providing more one-on-one instruction, and facilitating more peer-to-peer instruction.

Bergan, et al. (1991) evaluated an 8-week implementation of an assessment and instructional planning system for 838 high-poverty kindergarten students. The assessments required students to demonstrate mastery of increasingly difficult tasks in mathematics, reading, and science. Teachers administered the assessments every two weeks and consulted with a researcher to interpret the results and plan instruction. Even in this short time period, use of the assessment dramatically lowered special education referral and placement. One of every 17 students in the experimental group was referred to special education, and one of 71 was placed. In the control group, one of every 3.7 students was referred, and one of 5 was placed.

A study examining the impact of progress monitoring to assess K-3 students' literacy skills found, across a sample of 200,000 students, that the frequency of progress monitoring has a positive impact on student outcomes (Hupert, Heinze, Gunn & Stewart, 2009). Where fewer progress monitoring administrations took place, smaller effect sizes were observed. Where larger numbers of progress monitoring administrations took place, greater effect sizes were seen. In the infrequent progress monitoring condition (averaging 3 assessments per year), small to moderate effect sizes were observed, with the strongest effect sizes observed in kindergarten (ranging from 0.26 to 0.71). In the frequent conditions (averaging 11 assessments per year), moderate to large effect sizes were observed, with the strongest effects being observed in kindergarten and first grade (ranging from 0.40 to 1.25). The higher the frequency of formative evaluation the greater the performance of the students in mathematics.

2.1.4 Feedback on Formative Evaluation

Feedback is vital to formative assessment, but not all feedback is effective. Feedback will inform students how well they are progressing. Feedback needs to be timely and specific, and should include suggestions for ways to improve future performance. Good feedback should be tied to explicit criteria regarding expectations for students' performance, thus making the learning process more transparent, and modeling "learning to learn" skills for students (CERI, 2008). The purpose of formative assessment is not accreditation; it should provide direct feedback about the learning and teaching processes and may have beneficial effects for both students and teachers (Rushton 2005).

Black and William (1998) identified a number of studies conducted under ecologically valid circumstances to support the fact that not all feedback is effective. For instance, "ego-involving" feedback rather than feedback on the task at hand appeared to have a negative impact on performance. Students also obtained better results when they were working toward process goals rather than product goals, and when tracking progress toward overall goals of learning. Grades may actually undermine the positive help of specific feedback on tasks (Butler & Winne, 1995). Teachers may provide verbal or written feedback on student's work. Teachers and researchers have found that the most effective feedback is timely, specific and tied to explicit criteria. Teachers also adjust their strategies to meet needs identified in assessment.

Verbal and written communication should concentrate specifically on what is wrong with the student's work and what can be done to make it better. Teachers have to keep in mind that the message should be more about improvement and less about evaluation. As Black and Wiliam (1998) put it, "feedback to any pupil should be about the particular qualities of his or her work, with advice on what he or she can do to improve, and should avoid comparisons with other pupils.

While writing constructive comments on student s' work will require more time and effort on the part of teachers, the return in terms of improved student achievement is worth the investment. To avoid being overwhelmed, teachers should spend more time on selected assignments and not grade every single piece of student work. In one study, teachers became more skilled at writing helpful comments to students as they gained experience in writing comments and shared examples of effective feedback with each

other (Black, Harrison, Lee, Marshall, & Wiliam, 2004). The last word on commentary to students is this: to be effective, feedback should cause thinking to take place. Interestingly, many teachers found that the process of composing comments caused them to think as well; they began reassessing assignments and modified activities to eliminate tasks that did not involve higher-order thinking.

As Garrison and Ehringhaus (2007) claim assessment is a very large topic that integrates everything from 'statewide accountability tests to district benchmark or interim tests to everyday classroom tests. Well designed assessment establishes apparent assumptions, sets a sensible workload (one that does not drive students into 'rote reproductive methods' to study), and gives students opportunities to self monitor, review, practice and get feedback (James, McInnis, & Devlin, 2002).

2.2. Formative Assessment

Formative assessment is not a new term and can be defined in many ways. Black and William (1998) defined formative assessment as it is all those activities undertaken by teachers and by their students in assessing themselves that provide information to be used as feedback to modify teaching and learning activities". This definition does not limit itself to formal tests, quizzes, or homework. Assessment is a collection of evidence about student learning through a variety of ways such as portfolios, journals, dialogue, questioning, interviewing, work samples, formal testing, and projects. They defined formative assessment as such assessment where the evidence is actually used to adapt the teaching to meet student needs. The key difference between summative and formative assessment is what is done with the information. Summative uses the information to

show how the student performed against others or how many learning goals he or she has mastered at the end of learning. Formative assessment uses the information collected to determine where the gap of learning is for the student and then is used to determine how to close the gap.

Stiggins and Chappius (2006) explained assessment for learning as a formative assessment philosophy that involves the student in their assessments by giving the students clear classroom-level targets based on state or local standards. Those targets are then transformed into dependable and accurate assessments. The vision of the successful outcome is shared and understood by the students through models of success and quality work and or the use of descriptive rubrics. The teacher generates feedback, either written or verbal, that describes where the student is on the learning continuum of that target and provides specific communication to the student on how to narrow that gap. This study used the definition provided by the Council of Chief State School Officers (CCSSO) in which formative assessment was defined as a process used by teachers and students during instruction that provides feedback to adjust ongoing teaching and learning to improve students' achievement of intended instructional outcomes (McManus, 2008). The CCSSO also included the five critical attributes of formative assessment: learning progressions, learning goals, descriptive feedback, self- and peer assessment, and collaboration (McManus, 2008). The first wave of research on formative assessment focused on the collection of information by the teacher, school, or district to make systemic changes in curriculum or instruction for the previous year. The focus was on the teacher as user of the information collected. The first major research findings on this

level of formative assessment were presented from the meta-analysis by Terry Crooks' (1988) which articulated the effect that formative assessment can have on instruction and thus academic achievement.

Since Crooks (1988), the study of formative assessment and the student-centered version often referred to as "assessment for learning" was brought to the education community again 10 years later in a second wave of interest. This second wave of interest and research on formative assessment not only examined the teacher as a user of formative assessment but also focused on the student as the primary and more important user of the collected information. The paramount findings from this second wave on formative assessment were attributed to Black and William (1998), who published the results of an extensive meta-analysis on assessment and classroom learning. They presented evidence, from numerous studies, that supported the use of frequent feedback to students about their learning and that such feedback can aid in large learning gains for the individual student and class. They also examined the role of student self-assessment and peer assessment alongside formative assessment strategies used by teachers. Their meta-analysis comprised a collection of 681 publications, and 250 of the original collection were selected. The results of this selection were published in summary in a later article, "Inside the Black Box: Raising Standards through Classroom Assessment" (Black & William, 1998).

Although the terms "formative" and "summative" assessments or evaluation have been around since the 1950s with Benjamin Bloom and the 1960s with Michael Scriven, these two studies reignited attention to the impact that formative assessment strategies can have

on teacher instruction and student learning. Although Crooks (1988) and Black and William (1998) have presented compelling arguments for the use of formative assessment in public education, it is an area that has not been studied extensively since the publishing of Black and William's findings. Subsequently, the use of formative assessment and student inclusion as a decision maker and a user of assessment information, are rare in America's public educational systems and the research of its use is likewise as rare (Herman et al., 2008). However, in the cases and studies that have since been reported, the impact of formative assessment attributes has mirrored the effects originally published by both Crooks (1988) and Black and Wiliam (1998). Although the majority of these studies have focused on the impact on test scores or student achievement, little has been studied on the effects such a shift in assessment would have on students' eagerness to learn and academic efficacy.

2.2.1. Attributes of formative assessment

Terry Crooks (1988) in a meta-analysis of studies on classroom evaluation practices has summarized results from 14 specific fields of research to clarify the impact between classroom evaluation practices and student outcomes. Crooks' review synthesized research as related to the impact of classroom evaluation on students. Crooks defined classroom evaluation as "…evaluation based on activities that students undertake as an integral part of the educational programs in which they are enrolled. These activities may involve time spent both inside and outside the classroom. This definition includes tasks such as formal teacher-made tests, curriculum-embedded tests (including adjunct questions and other exercises intended to be an integral part of learning materials), oral

questions asked to students, and a wide variety of other performance activities (cognitive and psychomotor)" (p. 467).

Crooks (1988) has summarized his findings about the importance of classroom evaluation as it affects students. Based on his evaluation of research, he found that classroom evaluation guides students' judgment of what is important to learn, affects their motivation to learn, forms their self-perception of competence, helps them make decisions about what and how much to study, consolidates learning, and impacts the development of their learning strategies and skills. Crooks posited that classroom evaluation "…appears to be one of the most potent forces influencing education". Crooks' (1988) evaluation of research uncovered that the practice of classroom evaluation relies heavily on recall of isolated bits of information, but research has repeatedly shown that such fragments or details are readily forgotten without a context or broader framework. More concerning is the focus of such evaluation on knowledge base information when, according to Crooks' examination, accumulation of knowledge is less important than learning skills and habits. The research that Crooks examined displays a disparity between the importance placed on higher-order thinking and transference of learning and the evaluation of such thinking.

Based on their extensive meta-analysis, Black and William (1998) have supported that innovations that strengthen the use and practice of formative assessment produce learning gains. They have cited such substantial and profound learning gains in studies in which the participants range from 5-year-olds to undergraduates and range over several school subjects and countries. The results of such studies reported a typical effect size between

.04 and .07. Black and William pointed out that such effect sizes are larger than most effect sizes reported for educational interventions. They continued by clarifying the impact such an effect size would have on the United States. An effect size of .07 would change the status of the United States from the middle of 41 countries in mathematics to one of the top five. The most dramatic of the findings reported by Black and Wiliam (1998) was the impact that these strategies had on struggling students those with learning disabilities and low-achieving students. The results showed that frequent and specific feedback yielded substantial gains in both groups of students, with the greatest gains for low achieving and learning-disabled students. Although formative assessment has been shown to have a large positive impact on all students it yields substantial impact on low achievers by concentrating on specific problems they are having difficulty with, providing them a clear understanding of where they are in their learning and providing a clear understanding of what needs correcting and how to correct it (Black & William, 1998).

Black and William (1998) articulated the nature and extent that formative assessment should be used in the field of education. Their studies showed that the primary user of assessment information to promote and improve learning is the student; however, the student has responded to the current educational system by focusing on "rewards," also known as "grades" or "class ranking." The student is encouraged by the collection of more grades or points. Students are avoiding authentic learning for fear of poor grades or less point and pursue finding answers instead of generating answers (Black & William, 1998b). It is necessary to refocus students on learning and away from point-collecting or

reward-seeking behavior. Black et al. (2004) followed this examination of research with a research study of 19 secondary school teachers and their students in the United Kingdom. The study conducted used the suggestions from Black and Wiliam's (1998) meta-analysis, applied them to a school setting, and measured the results on student achievement. The main interventions of this study were questioning, feedback through grading, peer and self-assessment, and the formative use of summative tests. The result of this experiment was an average effect size around 0.3 standard deviations in a variety of externally administered standardized achievement tests (Black et al., 2004).

William, Lee, Harrison, and Black (2004) have conducted research examining the impact that formative assessment practices of 24 teachers had on student achievement in schools in the United Kingdom. The intervention was several full-day and half-day workshops provided to the teachers about formative assessment practices. The teachers were then observed throughout the course of the year, and their curriculum and lesson plans were also examined to determine the extent that formative assessment strategies were used in instructional planning. The quantitative results of achievement scores for students taking the local standardized assessment used by the school and the graduation exit exam known as the "national school-leaving examination" (GCSE) from previous or tandem classes showed a statistically significant increase in the average score of students in the various courses. The results showed an impact on achievement scores on external assessments or assessments created by an outside agency such as national standardized tests (Wiliam, Lee, Harrison, & Black, 2004).

The authors concluded by explaining the impact such an increase would have on a large-scale inclusion: If used in a full school setting these results would raise a school in the 25th percentile to the upper half (Wiliam et al., 2004). The results from the August 2008 CRESST (Center for Research on Evaluation, Standards, and Student Testing) Report 740 supported the use of formative assessment and the effects that its use has on student achievement. The study employed a model of formative assessment that used the components of specified goals for student learning (targets of learning), frequent formative assessments aligned with goals or targets, and instructional decisions made from formative data. The study focused on one area of the model: the quality of teachers' interpretation of assessment results and how the accuracy of teachers' judgment would affect student performance. Teachers in this study were asked to establish learning goals or targets, assess students on goals or targets, give goal or target-based instruction, and use assessment data to make changes in instruction. The study examined the accuracy of teachers' prediction of student achievement and the relationship to middle school learning. Analysis of results showed a consistent, positive relationship between teacher accuracy and middle school student learning (Herman, et al., 2008).

This study involved seven experienced middle school science teachers from districts across California in the implementation of a unit on buoyancy from the Foundational Approaches in Science Teaching (FAST) curriculum. The unit used formative assessments embedded in daily instruction. The teachers received intensive sustained training and support to use formative assessment strategies. The study examined teaching logs, pretest and post-test data, and teacher judgment data compared with

formative assessment data. The data showed a strong correlation between the accuracy of a teachers' perception of what percentage of her class was on target with the expected level of understanding and the overall increase in student achievement. This study suggested that teachers who collect formative data and use such data to inform their instructional decisions have a larger impact on student achievement (Herman et al., 2008).

A study of the impact that formative assessment had on some Scottish primary and middle schools provided evidence that the use of formative assessments has a positive impact on increase in student responsibility for their learning and improved motivation, confidence, and classroom achievement. Kirton et al. (2007) studied the impact of Project One of the Assessment for Learning Development Programme in 16 Scottish primary schools and two middle schools where teachers were given strong professional development in formative assessment practices through workshops, learning communities, and support from Scottish national learning and education agencies. Teachers were given the opportunity to choose which formative assessment practices they would use and monitor. The study sought to discover the extent that this project was perceived to have on classroom practice; improved student learning, motivation and behavior; change in teachers' beliefs, attitudes, and understandings of assessment; school climate; and parental interest and involvement in their child's education. The study collected data through self-evaluation, examining action plans, teacher journals, case study reports, field visits to ensure validity of documented evidence, interviews of staff and students, and classroom observations. The collected generated results indicated that

the project was perceived by the participants to have had a positive impact on students, teachers, and pedagogy, but little impact on involving parents. Final evaluations declared that all 33 schools perceived the project to be successful. All of the collected data suggested that 14 schools appeared to have embraced the strategies, 14 seemed to have made adequate progress, and 5 seemed to have gained less (Kirton et al., 2007).

Research conducted by Smith (2008) reported that frequent formative assessments can predict achievement on measures of Adequate Yearly Progress indicators in mathematics as measured by standardized criterion-referenced competency tests in the Gainesville School District in Georgia. Smith conducted research in one school district of 2,900 middle school student scores over three years. In examining the data, the scores of post-test formative assessments given on a quarterly basis were shown to accurately predict increases in the state's AYP measurement test. For every one unit increase in quarterly score on the post-formative assessment, a positive gain in student achievement could be predicted. The research model correctly predicted participant 84.87 percent of the outcomes (Smith, 2008).

Although the majority of research has been conducted on the most stressed areas of needed improvement in mathematics and science according to a study by Christian Colby Kelly and Carolyn E. Turner (2007), research has also shown the impact that including formative assessment attributes has had on the second language classroom for preuniversity students. Colby-Kelly and Turner reported on the results they collected from nine teacher and 42 student participants. The 42 students all reported a variety of original languages other than English and were enrolled in pre-university classes in

England. The research questions were summarized in this way: What are the teacher and student perception, the nature, and the evidence that formative evidence benefits learning in a second language classroom setting. Colby-Kelly and Turner's research findings suggested that teacher-student feedback with a motivational component appeared to be effective in motivating some English language learners to focus on learning. According to interviews and questionnaires, teachers demonstrated that they were in strong favor of using formative assessment practices in their classrooms. The surveyed teachers also agreed that student involvement in assessment was positive and that self-evaluation and feedback fostered learning; however the teachers were not in agreement on whether students believed that assessments contributed to learning. All but one teacher agreed that assessments and teacher comments did impact student learning (Colby-Kelly & Turner, 2007).

2.2.2. Formative evaluation on learner performance

The evaluation of students' progress and the ultimate level of achievement in schools is a very important part of any educational system. The utilization of formative testing in the teaching learning process involve breaking up the subject matter content or course into smaller hierarchical units for instruction; specifying objectives for each units; designing and administration of validated formative test; offering a group based remediation in areas where students are deficient before moving to another units and then administration of summative test on completion of all units. Ajogbeje (2010) opined that the breaking up of subject or course into small units enable students to adequately prepare for periodic tests. And these periodic tests also provide a means of getting the students to be more

involved and committed to the teaching-learning process thereby enhancing their performance. Hence the regular testing of students' ability as demanded by the "6-3-3-4" system of education assists greatly in discovering the performance of students and could also be used to improve learning.

The essence of using tests and other evaluation instruments during the instructional process is to guide, direct and monitor students' learning and progress towards attainment of course objectives (Alonge, 2004; Kolawole, 2010). Teachers and learners cannot perform optimally or effectively without the availability of adequate information on student's standing at any given time and the extent of his progress towards the achievement of instructional objectives. Hence, the tests given periodically, as continuous assessment tests, are supposed to remove the threatening effects of a single test (summative test) generally given at the end of a course of study. Some of the aspects of continuous assessment that are very relevant to the teaching-learning outcomes include the frequency of the period of reporting on teacher-learner achievements, effecting immediate feedback of results into the teaching-learning situation and the emphasis that the results of these in-course assessments be combined with those of terminal assessments in deciding the final output of the individual learner.

Bardwell (1981) submitted that feedback is the information, which a teacher provides a student about his/her performance on a particular task or test. He further argued that when such information is provided, the student concern begins to have a better understanding of his/her capabilities and he/she might begin also to have a different perception of himself/herself. Studies have shown that feedback provides (1)

reinforcement effect (Gronlund & Linn, 1990) and (2) correctional information (Bardwell, 1981; Gronlund & Linn, 1990). Ajogbeje (2012a) opined that formative evaluation process includes the provision of feedback to students on their scores or performance in a given test. Kulharvy (1977) reported that there are two conditions under which feedback does not perform its facilitative role. One, if the feedback has high availability for the learner before he responds and two, if the material studied is very difficult for the learner. He further stated that in the absence of these conditions, one would conclude that studies which are based on both theories agreed that feedback on performance helps to confirm correct responses as well as to identify and correct errors. This correctional function is probably the most important aspect of feedback, and if one was given the choice, feedback following wrong responses probably has the greatest positive effect. Hence in this study, feedback was used as means of effecting correction and reinforcing students learning.

Kirkland (1971) stated that test scores feedback may affect the motivational, self-confidence and anxiety level of a student while Bridgeman (1974) opined that feedback from tests motivates the students intrinsically. Erinosho (1988) also opined that a person who is informed of his successful performance on a test would begin to develop interest in that subject and may continue to explore means of doing well in subsequent tasks. On the other hand, a negative feedback on performance may produce one of two effects. One, the students may use it for correction purposes and try to do well on later tests. That is, it influences him positively. Two, he/she may choose to be defeated and could begin to develop a feeling of inadequacy in the subject. The consequence is that he/she would

continue to perform poorly as well as lose interest in the area of study. The findings of these studies have implication for teaching and learning in secondary schools. They point to the need for effective mounting of formative testing with feedback strategy in the school system.

Kirkland (1971) also argued that the way a person perceives a test influences his test-taking behaviors. He stated that if the person sees the test score as accurate, he will be willing to accept the result and act on them. But if he sees the test score as a poor reflection of his capabilities, he will dismiss them or rationalize them away. Hence, test results which are not indicative of what the students expect or conceive of themselves, produce negative effect on their academic performance. Scannel and Tracy (1975) associated the lack of knowledge of performance on an earlier task with lower and incomplete subsequent learning and poorer retention of what has been learnt. Erinosho (1988) also claimed that lack of knowledge of performance on a task might raise anxiety in the student. This is because he/she would not be able to assess his/her ability and competence on the task. The implication of all these reported findings is that feedback from tests is effective to the extent that the student perceives the scores as representing his goals. Feedback from tests, only promote learning when the student attempt to do well and such student tends to assume responsibility for his successes or failures rather than blame it on environmental factors. If a student has no predetermined goals, information on his score alone may not be effective in producing increased performance. Means and Means (1971) and Ajogbeje (2012) observed that most of the research studies reviewed utilizes tasks which involved simple computations that are not comparable to the complex

demands of an academic subject. The type of feedback received by the students on their performance in most of these studies were skillfully guided while the methodology employed includes assigning of students in the sample to treatment groups using criteria such as ability, pretest score or previous performance. Students were subsequently given the task on which they were to work after which random feedback rather than true score were given to students on their performance. In some of the studies, random scores were given to participants depending on the treatment group (Bridgeman, 1974); others randomly used expressions such as “Excellent”, “Good”, “you have tried”, etc (Bridgeman, 1974; Means & Means, 1971) after which post-test was administered and comparison of achievement were made between the experimental and control groups. Hence, it is possible that some of the students were given scores, which they felt were not true representation of their ability thereby eroding their confidence and performance in subsequent tests.

Finally, findings on the effect of feedback on subsequent performance on a task have been inconclusive. It is possible that the perspective from which the studies were conducted need to be widened. It may well be that there are other aspects of the learning environment which influence feedback effect. It is a common features in most of our school systems for students’ scripts to be stockpiled in the teachers’ offices only to be dashed out to market hawkers or to be destroyed after a period of time. In some cases students are provided the feedback of their performances after they might have written the final examinations on the subject. Such a feedback hardly serves any useful purpose for improving the learner’s performance in mathematics. The current trend of formative

testing without the adequate provision of feedback to students in our school system is a contributory factor to the consistent mass failures of students in most secondary schools mathematics.

2.3. Assessment in Mathematics

Formative assessments are understood as assessment for learning (Stiggins & Chappuis, 2005). While there are varying definitions of formative assessment offered by experts in the field, they share some common elements. Formative assessment is a systematic and continuous process used by educators during instruction in order to evaluate student learning while it is still evolving (Black & William, 1998). Formative assessment is linked to instructional objectives and integrated within each aspect of teaching and learning at the classroom level. Both the teacher and students are dynamically involved in formative assessment (Stiggins & DuFour, 2009). One of the driving purposes of formative assessment is the opportunity to provide teachers with a continuous feedback loop to adjust ongoing instruction and close gaps in learning. Kaminski and Cummings (2007) define formative assessment as the process by which data are used to adjust teaching to meet students' needs.

The Principles and Standards for School Mathematics (National Council of Teachers of Mathematics, 2000) recommends that teachers “build new mathematical knowledge through problem solving” and that all students be given opportunities to solve quality problems that motivate and build mathematical confidence. In order to facilitate such learning, teachers must understand the problem-solving process and provide students with guided instruction and a variety of problem-solving activities (Kroll & Miller,

1993). In problem solving, SWD often have the additional challenge of decoding text due to the co-morbidity of reading and mathematics difficulties (Knopik, Alarcon, & Defries, 1997).

One educational strategy aimed at offering students authentic real world problems to improve their problem-solving ability is called Problem-Based Learning (PBL). PBL has historical roots back to Dewey (1944) who believed that teachers should appeal to the students' natural instincts of creativity and exploration. It was this belief that learning should be linked to "ordinary life" and that in doing so, students would naturally build their capacity to learn and think (Dewey, 1944). Although Medical Schools adopted this principle for teaching adult learners, it has only recently gained educational momentum in public schools. Barrows and Tamblyn (1980) define PBL as the learning that results from the process of working toward the understanding or resolution of a problem. According to Delisle (1997) PBL prepares today's 21st century learners for success in a fast-changing world by developing skills in thinking, researching, problem solving, and technology.

2.4 Research Gap

Mathematics is perceived by society as the foundation for scientific and technological knowledge that is cherished by societies worldwide. Mathematics is a compulsory subject for all learners in Primary and Secondary schools in Kenya (KIE, 2002). It is also used by Universities to filter secondary school learners for entry into the prestigious science-based degree programmes (Kenya Universities Joint Admissions Board, 2006). Despite the importance attached to mathematics by society there has been low achievement in the

subject in Kenya (Kenya National Examinations Council-KNEC, 2004) and in other parts of the world as indicated by the Third Trends in Mathematics. Though the fact that research findings strongly emphasize the importance of mathematics teachers in the society, its performance in national examination depicts poor results in most secondary schools. Thus the current study is aimed to investigate the influence of formative evaluation on learners' performance in secondary school mathematics in Embu County, Kenya.

2.5 Summary of Related Literature

Formative assessment builds students' learning to learn skills by emphasizing the process of teaching and learning, and involving students as partners in that process. It also builds students' skills at peer-assessment and self-assessment, and helps them develop a range of effective learning strategies. Students who are actively building their understanding of new concepts (rather than merely absorbing information) and who are learning to judge the quality of their own and their peers' work against well-defined criteria are developing invaluable skills for lifelong learning.

Several studies show that formative assessment methods have an even stronger impact for underachieving students. Selected studies focus on teaching which stresses the importance of effort over ability, or of task-centered feedback (as opposed to ego-involving feedback). These studies show relatively stronger improvements for previously underachieving students. Further research in this area may have significant implications for teachers working with larger groups of underachieving students or in "failing" schools. In evaluating students' academic performance, in any subject curriculum, rather

than envisaged the assessment of the 'received' curriculum, educators might speak of the understood curriculum based on the cognitive theory using humans as information processors. The essence of using tests and other evaluation instruments during the instructional process is to guide, direct and monitor students' learning and progress towards attainment of course objectives (Kolawole, 2010).

Many teachers incorporate aspects of formative assessment into their teaching, but it is less common to find it practiced systematically. If formative assessment is used as a framework for teaching, teachers change the way they interact with students, how they set up learning situations and guide students toward learning goals, even how they define student success (Stein & Brandsford, 1979). Teachers using formative assessment have changed the culture of their classrooms, putting the emphasis on helping students feel safe to take risks and make mistakes and to develop self-confidence in the classroom. Teachers working with students from backgrounds other than their own also make efforts to understand cultural preconceptions. They interact frequently with individual or small groups of students and involve students in the assessment process, providing them with tools to judge the quality of their own work.

The effect of using formative assessments in the classroom has a powerful effect on student achievement (effect sizes ranging from 0.04 to 0.07). The effect is attributed to teacher ability to monitor what students know and how they understand it; to the specific types of feedback that teachers provide to students based on their performance and to the specific actions that teachers take to respond to student results and the supports that they have in place to do so. Black and Wiliam (1998) in their analysis of 250 formative

assessment studies found that there is a positive effect on both the quality of teaching and the achievement of students, with gains frequently more substantial for low-performing students.

Different researchers have identified different factors adduced as being responsible for the consistent poor performance of students in mathematics. These include among others lack of proper digestion and utilization of research findings by mathematics teachers, sex -stereotyping, transfer of poor attitudes of older students to the younger ones, and poor self-concept towards mathematics, instructional/classroom characteristics, societal factors and school factors (Nwoji, 1999); teachers' characteristics (Onocha and Okpala, 1985); anxiety, motivation, reasoning ability, problem solving skills and instructional strategy (Udousoro, 2000). In his review of the research, Crooks (1988) reports that effects sizes for summative evaluations are consistently lower than effect sizes for formative assessments. In short, it is formative assessment that has a strong research base supporting its impact on learning (Marzano, 2006).

2.6 Theoretical Framework

The Classical Conditioning Theory by Ivan Pavlov (1929-1936) guided this study. Pavlov performed an experiment on dogs and discovered that dogs learnt to salivate in response to a bell. Many trials had been given in each of which the bell was sounded and food was simultaneously (slightly later) presented. It was thought therefore that students in secondary school classes would get good grades whenever the teacher taught and students were exposed to many trials of continuous assessment activities. According to Pavlov, Conditioned Response (CR) was the response developed during training and Conditioned

Stimulus (CS) was the stimulus, which included training/teaching activities intended to evoke the CR (i.e. good grades in the final examination). Unconditioned Response (UR) was the same or almost the same response as the CR but it existed prior to training, normally being given whenever a certain stimulus; the Unconditioned Stimulus (US) was presented.

Chauhan (1975) since it is the teacher who teaches mathematics that cause fear in the students, students comes to fear the teachers even when it is not mathematics lesson. Responses in classical conditioning tend to be emotional and involuntarily in the sense that they are out of the conscious control of the learner. For learning to occur, the conditioned and unconditioned stimulus must be associated. The major contribution of the classical conditioning to learning is that the external environment is important in school for efficient learning. Secondly, the theory also shows that practice and exercise are essential in learning since these strengthen the Stimulus-Response (S-R) bond. Classical conditioning can be used for breaking bad habits and for developing positive attitudes.

In this study, the Conditioned Response (CR) was the attainment of good grades, which was evoked by the Conditioned Stimulus (CS), which was continuous assessment, and Unconditioned Stimulus was the teaching. To Pavlov, pairing food and the sound of the bell made the dog salivate and in this study, pairing of teaching and continuous assessment activities could make students perform better in terms of good grades in the final examinations. The theory of Pavlov that suggested conditioned stimulus and conditioned response was an important aspect to this study in helping us to understand

the relationship between continuous assessment strategies being used (i.e. assignments, cats, frequency and feedback) as the stimuli and academic performance of students as respondents.

2.7 Conceptual Framework

A conceptual framework is a model presentation where a researcher conceptualizes or represents the relationship between variables in the study by showing the relationship diagrammatically (Young, 2009). The influences of classroom assessment on learner performance are diagrammatically illustrated in figure 2.1 below.

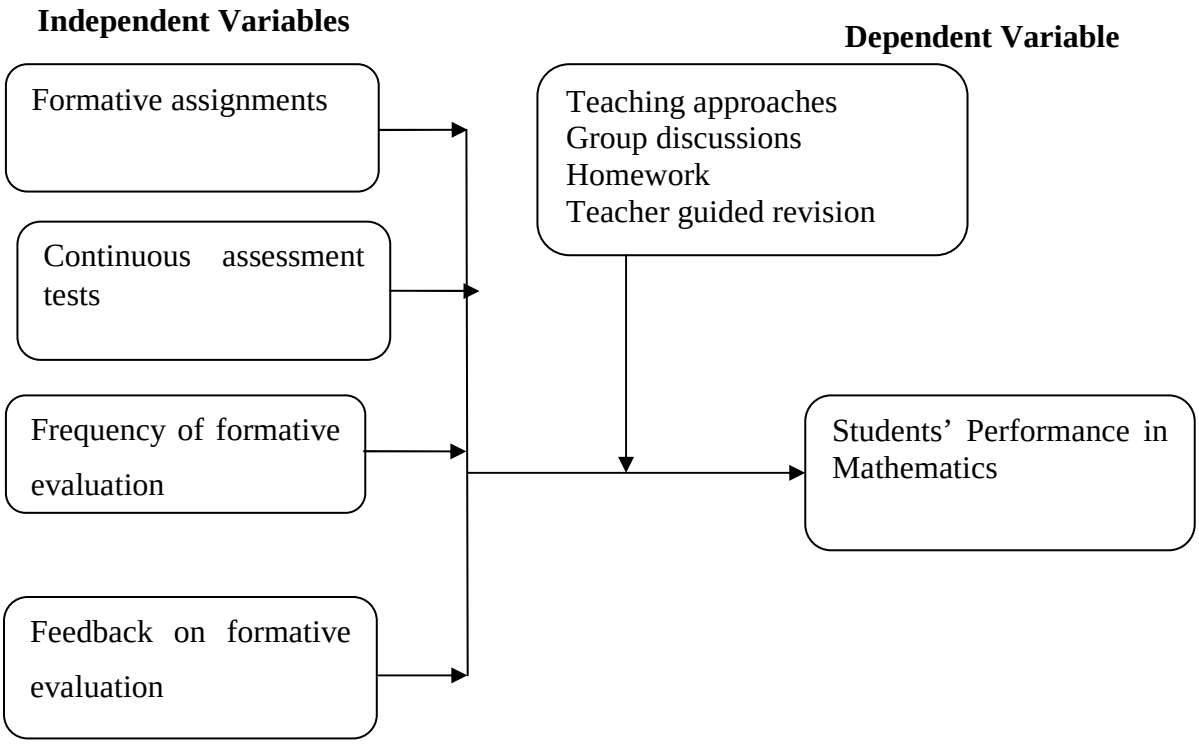

Figure 2.1 Conceptual framework

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter present research methodology under the following subheadings; research design, target population, sample size and sampling techniques, research instruments, instrument validity, instrument reliability, data collection procedure and data analysis techniques.

3.2 Research Design

A research design is a plan or blueprint of how the researcher intends to conduct the research. The study employed a descriptive survey research design. Descriptive survey research design is a type of research used to obtain data that can help determine specific characteristics of a group. A descriptive survey involves asking questions (often in the form of a questionnaire) of a large group of individuals either by mail, by telephone or in person. The main advantage of survey research is that it has the potential to provide us with a lot of information obtained from quite a large sample of individuals. By employing this study design, this study will focus on obtaining quantitative data from a cross-section of members.

3.2 Target population

A population refers to the specific cases that the researcher wants to study. It can also refer to the collection of all individuals, families, groups that the researcher is interested in finding out about. The target population for the study was Secondary schools in Embu

County while study populations were principals, deputy principals, mathematics teachers and students. According to the MoE (2014) there are 173 secondary Schools in Embu County with each school having an average of 18 teachers (principals, deputy principals and teachers) contributing to 3114 teachers and all schools having a total of 36000 students.

3.3 Sample and Sampling Procedures

Sampling design is that part of statistical practice concerned with the selection of a subset of individual observations within a population of individuals intended to yield some knowledge about the population of concern, especially for the purposes of making predictions based on statistical inference. The study adopted simple random sampling technique to select 70 respondents from a total of 350 students from 5 secondary schools within Embu County, this represents 20% of the total population; 60 teachers were selected randomly from the 5 sub counties where 12 teachers were targeted in each Sub-County, these were composed of principals, deputy principals and mathematics teachers.

3.4 Research Instruments

The study used questionnaire and continuous assessment tests in collecting primary data. The questionnaires were used to collect data from the principals, deputy principals, mathematics teachers while tests were given to the students. The data instrument addressed the four research objectives while it was sub-divided into two sections. The first section of the questionnaire enquired general information about the respondents, while the next sections answered the four research objectives, that is, formative

assignments, CATs, frequency of formative evaluation and feedback on formative evaluation. The structured questions were used in an effort to conserve time and money as well as to facilitate in easier analysis as they are in immediate usable form. The questionnaire comprised of both open and close-ended questions. The researcher involved three research assistances to help in distribution of questionnaires to the targeted respondents. The questionnaires were administered through drop and pick later method. The quantitative section of the instrument to be employed will use both a nominal and a Likert type scale format to determine each of the variables. A 5 point Likert scale ranging from 1 to 5 was used as answers to statement like questions. The Likert - type format is selected as the format yields equal - interval data, a fact that allows for the use of more powerful statistical to be used to test hypotheses (Kiess & Bloomquist, 2008).

3.5 Validity of the Instruments

The research instrument was piloted in five schools which will not be part of the schools selected for the study. This ensured by going through the questionnaire with the respondents to ascertain that each of the items is framed in the least ambiguous way. Pilot study aims at establishing construct validity of the instruments. The pilot study assisted in identifying the problems which the respondents may encounter in the process of answering the questions put across to them. The piloted questionnaires were revised and ambiguous items modified. One of the main reasons for conducting the pilot study is to ascertain the validity of the questionnaire. The study used both face and content validity to ascertain the validity of the questionnaires. Content validity draws an

inference from test scores to a large domain of items similar to those on the test. Content validity is concerned with sample-population representativeness.

3.6 Reliability of the Instruments

Reliability is a measure of the degree to which a research instrument yields consistent results or data after repeated trial. Reliability is concerned with the question of whether the results of a study are repeatable. A construct composite reliability co-efficient (Cronbach alpha) of 0.6 or above, for all the constructs, will be considered to be adequate for this study. The acceptable reliability coefficient is 0.6 and above. Cronbach Alpha was used to test the reliability of the research instrument.

3.7 Ethical Consideration

The researcher considerate enough and followed the regularities of the sample populations. The researcher seeks permission from the school administration to allow the researcher to conduct the study. The researcher assured the respondents of proprietary measures that the findings were accorded and used only for academic purpose. The researcher maintained confidentiality at all time.

3.8 Data Collection Procedure

The researcher seeks permission to carry out the study from the National Commissions for Science, Technology and Innovation. The researcher then proceeds to the schools where audiences were sought with head teachers. A request to the principal to invite the teachers for introduction and a briefing on the confidentiality of the data to be filled in the

questionnaire was done. Drop and pick later method were used to administer the questionnaires. Filled questionnaires were collected after two weeks.

3.9 Data Analysis Techniques

Data were cleaned, coded, entered and analyzed using Statistical Package for Social Science (SPSS, Version 21.0). SPSS was used because it is fast and flexible and provides more accurate analysis resulting in dependable conclusions. Data processing implies editing, classification, coding, and tabulation of collected data so that they are amenable to analysis. Data analysis involves computation of certain measures along with searching for patterns of relationships that exist between the dependent variables and independent variables. The data were analyzed according to variables and objectives of the study. Descriptive statistics was used to analyze, present and interpret data. Descriptive analysis involved use of frequency distribution tables and cross tabulation which were used to generate values between dependent and independent variables used in the study. Content analysis was used for the qualitative data from the open ended questions in the questionnaire.

CHAPTER FOUR

DATA ANALYSIS AND INTERPRETATION OF FINDINGS

4.1 Introduction

This chapter discusses the interpretation and presentation of the findings. The purpose of the study was to analyze influence of formative evaluation on learner performance in high school Mathematics in Embu County, Kenya. The finding was intended on answering the study's research questions. Data composed was collated and reports were produced in form of tables and figures and qualitative analysis done in prose.

4.2 Response Rate

Table 4.1 Response Rate

Response	Frequency	Percentage (%)
Filled in questionnaires	117	90
Un returned questionnaires	13	10
Total	**130**	**100**

Source: Researcher (2015)

The study targeted a sample of 130 respondnets from secondary Schools in Embu County, Kenya. However, out of 60 questionnaires distributed 47 respondents completely filled in and returned the questionnaires while 70 students participated in CATs, this represented a 90% response rate. This is a reliable response rate for data analysis as Mugenda and Mugenda (2003) pointed that for generalization a response rate of 50% is adequate for analysis and reporting, 60% is good and a response rate of 70% and over is excellent. The response rate was arrived at through the data collection procedure of using the questionnaires adopted by the researcher; he personally participated in data collection

process with assistance of several research assistants from the various schools he visited and waited for respondents to complete filling the required information. He kept on reminding the respondents to fill the questionnaires through frequent phone calls to the assistants and received the filled in questionnaires from the assistants once fully filled.

4.3 Demographic Characteristics of the Respondents

As part of the general information, the research requested the respondents to indicate their educational level and their qualifications, duration of working, position held in the school, age and the gender balance among the members of staff.

4.3.1 Position of Respondents

Table 4.2 Position of Respondents

	Frequency	**Percent**
Teacher	28	24
Deputy Principal	14	12
Principal	7	6
Students	70	60
Total	**117**	**100**

The study requested respondents to indicate the position they hold in the schools. Majorities (60%) of the respondents were students, 24% were teachers, 12% were deputy principals, while 6% were principals. This implies most of the respondents were students. This illustrates that the respondents had worked as principals/deputy principals or teachers for a long period and they can give credible information on influence of formative evaluation on learner performance in secondary school Mathematics in Embu County, Kenya. They may give information concerning the frequency at which the

formative evaluation is conducted on learners. This will greatly assist to determine whether the performance is related to the frequency or not. When the frequency is high students tends to study always which improves their mastery of the content which improves performance and vice versa.

4.3.2 Educational Qualifications of Teachers

The study requested respondents to indicate their academic qualifications. This was of great importance for the study since it had a correlation to the capability of teachers to deal with the issues of students' performance.

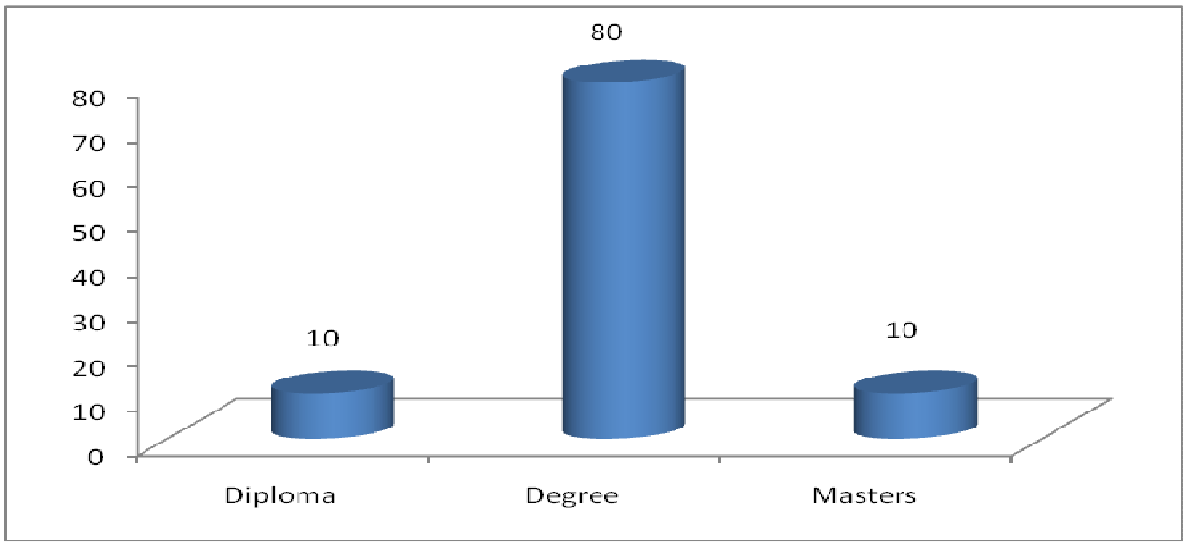

Figure 4.1 Educational Qualifications of Teachers

Figure 4.1 summarizes the findings of the results. Most (80%) of the respondents were degree holders, 10% held masters as their highest level of education while the rest 10% had attained diploma as their highest academic qualification. This depicts that most of the teachers being degree holders are capable of role modeling the students to be the right persons in the society. Further it was depicted that teachers who are masters holders and

degree holders are mainly assigned to teach the upper classes, that is, form three and four classes since they have the required capacity of tackling the concepts of mathematics at this level and they have the knowledge on when to administer the formative evaluation to measure the students understanding which depicts their performance. For those who have diploma level of education they are mainly assigned to teach lower forms that is form one and two which are less demanding in terms of content to be delivered. This will enable them to teach mathematics concepts well which improves learner performance.

4.3.3 Duration of Working

The research sought to establish respondents' working experience based on the number of years they have worked. The study found it important to establish the duration that the teachers have been working in the region; this forms the basis to which the study can rely on the response given by the respondents.

Table 4.3 Duration of Working

	Frequency	**Percent**
1 to 5 years	12	24
6 to 10year	10	20
11 to 15 years	9	18
16 years and above	18	37
Total	**49**	**100**

Table 4.2 shows the findings of the result, most (37%) of the respondents had worked for duration of over 16years, 24% for duration of 1-5 years, 20% for 6-10 years while worked 18% had for a period of 11-15years. This illustrates that the respondents had

worked as principals/deputy principals or mathematics teachers for a long period and they can give credible information on the student's performance. This also depicted that the length of working is directly proportional to the learner's performance in mathematics. This is because teachers who had worked for a longer duration of time had ample information on when to administer the CATs, the rate at which they should be administered and also the key areas that need to be tested in the formative evaluation. This would assist the teachers to be able to measure the learners' performance from different perspectives and how to improve it. Classes taught who have taught for many years indicated good performance in mathematics.

4.3 Influence of assignments on learners performance in mathematics

In order to determine the influence of assignments on learner's performance in mathematics, the respondents were requested to indicate the extent to which they agreed with various statements on the influence of assignments on learner's performance in mathematics. The responses were rated on a five point likert scale where: - strongly disagree, 2- disagree, 3- neutral, 4- agree, 5- strongly agree Table 4.2 below illustrates the study findings.

Table 4.4: Influence of assignments on learners performance in mathematics

	Mean	STDev
I employ assignments test as a formative evaluation approach to way of measuring student progress in mathematic performance which form an integral part of education system	4.90	0.305
Through utilization of diagnostic assignments with remediation enhances the acquisition and retention learning tasks among students	4.33	0.758
I apply different approaches to explaining new concepts to provide options for independent classroom work and encourage students who have grasped a new concept to help their peers	4.80	0.407
Frequent assessment of students performance has demonstrated to improve student outcomes	4.87	0.346
We use assessments frequently which are modified to improve learning outcomes of the students	4.53	0.629
Assessments have proved to help students understand the teacher's learning intentions and what constitutes success in mathematic subject	4.83	0.379
Assessments provide students with opportunities to revise and improve their thinking, and help students monitor their own progress over time	4.87	0.346

From the study findings, the majority of the respondents strongly agreed that; they employ assignments test as a formative evaluation approach to way of measuring student progress in mathematics performance which form an integral part of education system (mean=4.9), assignment given to students performance have demonstrated to improve students outcomes and that assignments provides students with opportunities to revise and improve their thinking, and help students monitor their own progress over time (mean=4.866667) respectively. In addition respondents strongly agreed that; assignments have proved to help students understand the teacher's learning intentions and what

constitutes success in mathematics subject (mean=4.83), they apply different approaches to explaining new concepts to provide options for independent classroom work and encourage students who have grasped a new concept to help their peers (mean=4.80), and that they use assignments frequently which are modified to improve learning outcomes of the students (mean=4.53). Respondents also agreed that through utilization of diagnostic assignments with remediation enhances the acquisition and retention learning tasks among students (mean=4.33). This indicates that mathematics teachers employ assignments test as a formative evaluation approach to way of measuring student progress in mathematic performance which form an integral part of education system and that frequent assignments given to students have demonstrated to improve students outcomes. This also depicts that teachers should provide as many assignments as possible and also that they should give the feedback frequently to enable the learners to correct themselves on where they might have gotten wrong. This sharpens their skills and thus improves their general performance. This study has clearly demonstrated that formative students' perceptions evaluation in mathematics in secondary schools is related to students' motivation to learn mathematics which would lead to higher levels of mathematics achievement (Hemke, 1990). Frequent assignments given to students have demonstrated to improve students' performance in mathematics.

4.4 Influence of CAT on Learners Performance in Mathematics

Respondents were kindly requested to indicate the extent to which they agreed with various statements on continuous assessment tests on learner's performance in mathematics. The responses were rated on a five point likert scale where: - strongly

disagree, 2- disagree, 3- neutral, 4- agree, 5- strongly agree Table 4.3 below illustrates the study findings.

Table 4.5: Influence of Continuous Assessment Tests on Learners Performance in Mathematics

	Mean	**STDev**
Continuous assessment tests provide evidence concerning students' achievements, which when interpreted helps the assessors to take measures for further improvements	4.87	0.346
Formative continuous assessment tests can enhance teaching and learning by providing a more focused application for learners	4.83	0.379
Summative assessment is used to evaluate progress and achievement, assign grades, and appraise programs	4.21	0.805
Formative assessment involves getting the best possible evidence about what students have learned and then using this information to decide what to do next	4.77	0.430
Formative assessment is a crucial tool for simultaneously improving classroom practice and students' performance	4.90	0.305

The study revealed that most of respondents strongly agreed that continuous assessment tests are crucial tools for simultaneously improving classroom practice and students' performance (mean=4.9), continuous assessment tests can enhance teaching and learning by providing a more focused application for learners (mean=4.83), and that continuous assessment tests involves getting the best possible evidence about what students have learned and then using this information to decide what to do next (mean=4.77). In addition respondents agreed that summative assessment is used to evaluate progress and achievement, assign grades, and appraise programs (mean=4.21). Further the study depicts that teachers should administer CATs regularly so that learners can understand

concepts and revise appropriately. Also the teachers should implement CATs in different contexts. Incorporating various techniques, continuous assessment tests can enhance teaching and learning by providing a more focused application for learners. The findings of this study concur with the arguments of Chinn and Ashcroft (1993) that evaluation in mathematics is an essential and important component of learning mathematics. The time that teachers spend on monitoring and evaluating students' performance was found to be related to student's mathematics achievement in upper primary schools in Swaziland (Lockhead & Verspoor, 1991). The students that are given CAT regularly tends to register better scores in the summative evaluation.

4.5 Influence of Frequency of Formative Evaluation on Learners Performance in Mathematics

In order to determine the influence of frequency of formative evaluation on learner's performance in mathematics, the respondents were requested to indicate the extent to which they agreed with various statements on the influence of frequency of formative evaluation on learner's performance in mathematics. The responses were rated on a five point likert scale where: - strongly disagree, 2- disagree, 3- neutral, 4- agree, 5- strongly agree Table 4.4 below illustrates the study findings.

Table 4.6: Influence of frequency of formative evaluation on learners performance in mathematics

	Mean	STDev
We conduct frequent formative evaluation in every week to access the progress of children achievement	4.43	0.626
Frequency formative assessment of progress monitoring has proved to have positive impact on student outcomes	4.73	0.450
Formative evaluation enables teachers to adjust their teaching to meet individual student needs, and helps all students to reach high standards	4.90	0.305
Teachers actively involve students in the process of helping them to develop skills that enable them to learn better	4.6	0.563
Effects of administering weekly or biweekly assessments in reading, math and spelling and receiving computer-generated graphs of student progress together with instructional recommendations	3.83	0.791
Students in classrooms receiving graphical progress reports and instructional improves more quickly and achieved higher outcomes	3.71	0.750
We use formative assessment, providing more one-on-one instruction, and facilitating more peer-to-peer instruction	4.43	0.679

From the study findings, the most of the respondents strongly agreed that: formative evaluation enables teachers to adjust their teaching to meet individual student needs, and to better help all students to reach high standards (mean=4.90), frequency of formative evaluation of learners has proved to have positive impact on students outcomes (mean=4.73), and that teachers actively involve students in the process of helping them to develop skills that enable them to learn better (mean=4.61). In addition respondents agreed that they conduct frequent formative evaluation in every week to access the progress of children achievement and that they use frequent formative assessment, reports and instructional recommendations recounted addressing more skills, providing more

one-on-one instruction, and facilitating more peer-to-peer instruction (mean=4.43) respectively. Also respondents agreed that the effects of administering weekly or biweekly assessments in reading, mathematics and spelling and receiving computer-generated graphs of student progress together with instructional recommendations (mean=3.83) and that students in classrooms receiving graphical progress reports and instructional recommendations improved more quickly and achieved higher outcomes (mean=3.7). This implies that frequent formative evaluation enables teachers to adjust their teaching to meet individual student needs, and to better help all students to reach high standards. In classrooms featuring frequent formative evaluation, teachers make frequent, interactive assessments of student understanding. This enables them to adjust their teaching to meet individual student needs, and to better help all students to reach high standards. Teachers also actively involve students in the process, helping them to develop skills that enable them to learn better. The frequency of teacher evaluations, the time teachers spend correcting tests and exercises were found to be related to academic achievement of upper primary school pupils in Argentina and Columbia (Lockhead & Verspoor, 1991). In classes where there is high frequency of formative evaluation learners register better scores in mathematics.

4.6 Influence of Feedback on Formative Evaluation on Learners Performance in Mathematics

In order to determine the influence of feedback on formative evaluation on learner's performance in mathematics, the respondents were requested to indicate the extent to which they agreed with various statements on the influence of feedback on formative

evaluation on learners' performance in mathematics. The responses were rated on a five point likert scale where: - strongly disagree, 2- disagree, 3- neutral, 4- agree, 5- strongly agree Table 4.2 below illustrates the study findings.

Table 4.7: Influence of feedback on formative evaluation on learners performance in mathematics

	Mean	**STDev**
Quick feedback on formative evaluation inform students how well they are progressing	4.83	0.461
Feedback needs to be timely and specific, and should include suggestions for ways to improve future performance.	4.9	0.305
Good feedback should be tied to explicit criteria regarding expectations for students' performance, thus making the learning process more transparent, and modelling "learning to learn" skills	4.73	0.450
Formative evaluation provide direct feedback about the learning and teaching processes and may have beneficial effects for both students and teachers	4.833	0.461
Students obtains better results when they were working toward process goals rather than product goals, and when tracking progress toward overall goals of learning	4.667	0.547
Teachers provide verbal or written feedback on student's work	4.867	0.346
Most of effective feedback is timely, specific and tied to explicit criteria	4.8	0.484
Teachers spend more time on selected assignments and not grade every single piece of student work	4.533	0.776
Teachers became more skilled at writing helpful comments to students as they gained experience in writing comments and shared examples of effective feedback	**4**.33	**0**.215

The study established that most of the respondents strongly agreed that: feedback needs to be timely and specific, and should include suggestions for ways to improve future performance (mean=4.91), teachers provide verbal or written feedback on student's work (mean=4.867), quick feedback on formative evaluation inform students how well they are progressing, and that formative evaluation provide direct feedback about the learning and

teaching processes and may have beneficial effects for both students and teachers (mean=4.83). Respondents further strongly agreed that most of effective feedback is timely, specific and tied to explicit criteria (mean=4.81), good feedback should be tied to explicit criteria regarding expectations for students' performance, thus making the learning process more transparent, and modeling "learning to learn" skills (mean=4.73), and that students obtains better results when they were working toward process goals rather than product goals, and when tracking progress toward overall goals of learning (mean=4.67). Also respondents agreed that teachers spend more time on selected assignments and not grade every single piece of student work (mean=4.53) and that teachers became more skilled at writing helpful comments to students as they gained experience in writing comments and shared examples of effective feedback (mean=4.33). This shows that feedback needs to be timely and specific, and should include suggestions for ways to improve future performance. Feedback is vital to formative assessment, but not all feedback is effective. Feedback will inform students how well they are progressing. Good feedback should be tied to explicit criteria regarding expectations for students' performance, thus making the learning process more transparent, and modeling "learning to learn" skills for students (CERI, 2008). Feedback is vital to formative assessment and that if effectively used it leads to improved learner performance in mathematics.

4.7 Students Performance in Mathematics Continuous Assessment Tests

Table 4.8 depicts the findings of the study on performance of the students on CATs. The researchers conducted test consequently to the students on specific areas of concern to measure whether assignments, CATs, frequency of formative evaluation and immediate feedback influence learners' performance on mathematics.

Table 4.8 Students Performance in Mathematics Continuous Assessment Tests

	CAT 2 vs CAT 1	**Percentage**	**CAT 3 vs CAT 2**	**Percentage**	**CAT 3 vs CAT 1**	**Percentage**
Improved	64	91.43	64	91.43	70	100
No improvement	5	7.14	3	4.29	0	0
Dropped	1	1.43	3	4.29	0	0
Total	**70**	**100**	**70**	**100**	**70**	**100**

The finding of the study is shown in appendix III. The researcher calculated the mean score of students to find the average performance, in comparison of 2nd CAT to 1st CAT the study found that out of 70 (100%) students who participated in the study, 64 (91%) of them improved performance, 5(8%) did not improve at all as they registered the same marks they attained in 1st CAT while 1(1%) dropped by 6marks as compared to 1st CAT. In comparison of 3rd CAT to 2nd CAT, 64(91%) improved significantly, 3(4%) did not improve at all while the rest 3(4%) dropped by small margin a cumulative of -4 as compared to -6 in 2nd CAT. Further the researcher calculated the average improvement of the student by comparing 3rd CAT and 1st CAT. From the findings, 70(100%) of the participant improved significantly with the first 3 higher performers improving up to 54,

53, 53 marks in average while some students improved slightly by 3, 8 and 9 in that order. Mathematics educators such as Fraser and Gillan (1972); Shiton, Kenwood, Moss and Phimpton (1985) agree that among other purposes of evaluation in mathematics, the provision of motivation to learn mathematics is critical. The findings in this study are consistent with those in USA by Berliner & Cassanova (1988) and Butler & Nissan (1986) which showed that evaluation and giving of grades does much to enhance student's extrinsic motivation to learn subject matter but can also have a strong negative effect on students' intrinsic motivation if evaluation is improperly carried out. The greater the number of CATs given to the students the better the performance of the students in mathematics. Teachers should therefore administer mathematics CATs to the students to enhance better performance in the subject.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter depicts the summary of the data findings on influence of formative evaluation on learner performance in secondary school mathematics in Embu County, Kenya. The summary of the findings, conclusions and recommendations are drawn there to. The chapter is therefore structured into conclusions and recommendations.

5.2 Summary of the findings

From the study it was evident that mathematics teachers employ assignments test as a formative evaluation approach to way of measuring student progress in mathematics performance which form an integral part of education system and that frequent assignments given to the students have demonstrated to improve students outcomes. The study also concluded that students are encouraged through peer assessment and self-assessment to re-evaluate their summative assessments to help them understand how their learning might be improved, often including the opportunities to rework test answers in class. When assignments are used formatively, the message is that they are an integral part of the learning process, and through active involvement in doing the assignments, students can see that they actually benefit from them since they help them improve their learning.

The study also concludes that continuous assessments tests are considered as learning process since they are often given to students at the end of the learning in order for

students to demonstrate how much they have learned. The study also found that that standardized tests are created to test knowledge and achievement for school subjects, it is through the differentiations lens that these CATs are most often designed to compare students with each other in a process of norm referencing, rather than criterion referencing. Likewise, the study found that when CATs are used formatively, the message is that CATs are still an integral part of the learning process, and through active involvement in the testing process, students can see that they actually benefit from the CATs since they help them improve their learning.

The study also established that frequent formative evaluation enables teachers to adjust their teaching to meet individual student needs, and to better help all students to reach high standards. Likewise, the study found that teachers have deepened their understanding of the relationship between assessment and student success from the student's perspective, and realize that the student's role in frequent formative evaluation is to understand what success looks like and then use feedback from each assessment to determine how to do better next time. With frequent formative evaluation, students become partners in their own achievement as it is happening. When students reflect about their understanding, teachers can use this to inform future teaching, and the feedback can determine the areas a teacher needs to re-teach or revisit.

From the findings it can be summarized that that feedback needs to be timely and specific, and should include suggestions for ways to improve future performance. The study also found that frequent testing and feedback can help all students, especially low performers, to believe that they can control their own success in making progress towards

the learning targets. Further the study established that use of frequent formative evaluation as part of teaching-learning strategies allows teachers and students to work together to start looking right away to figure out how the learning is going and where there are still learning gaps.

5.3 Conclusions of the findings

The study concludes that mathematics teachers employ assignments test as a formative evaluation approach to way of measuring student progress in mathematic performance which form an integral part of education system and that frequent formative evaluation of students performance has demonstrated to improve student outcomes. There is a strong and significant relationship between formative evaluation in mathematics classrooms and their students' performance in mathematics subjects.

Also the study concludes that frequent formative evaluation is a crucial tool for simultaneously improving classroom practice and students' performance, and that it can enhance teaching and learning by providing a more focused application for learners.

The study also concludes that frequent formative evaluation enables teachers to adjust their teaching to meet individual student needs, and to better help all students to reach high standards. The frequency of teacher evaluations, the time teachers spend correcting tests and exercises were found to be related to academic achievement of students' performance.

From the findings it can be concluded that that feedback needs to be timely and specific, and should include suggestions for ways to improve future performance. The CATs have played a central role in the entire school programme influencing each activity that took

place in the school. As a result of pressure due to CATs the teachers engage all the methods of instruction to attract the learners' interest in class hence teacher centered methods like the lecture methods are avoided. CATs also made teachers not to be selective in the content to be taught.

5.4 Recommendations of the Study

Based on the findings, the study recommended the following, that is, to meet a range of students needs, teachers vary instruction methods. They ensure that lessons include different approaches to explaining new concepts, provide options for independent classroom work, and encourage students who have grasped a new concept to help their peers. The implications of the findings are that teachers should carefully plan and administer mathematics quizzes, out of class assignments, supervised classroom mathematics assignments, end term and end year mathematics examinations. The environmental and social conditions in which teachers handle mathematics formative evaluations and their feedback to learners should be conducive for both boys and girls. This would enhance the learners' motivation to learn mathematics.

One of the alternative ways of assessing and teaching is the notion of implementing formative assessment in different contexts. Incorporating various techniques, formative assessment can enhance teaching and learning by providing a more focused application for learners. Secondary school mathematics teachers should therefore plan carefully for mathematics quizzes, homework, classroom supervised mathematics work, end term mathematics tests and end-year mathematics examinations in order to increase students motivation to learn mathematics.

To be truly effective, assessment should also be “formative” in other words, identifying and responding to the students’ learning needs. In classrooms featuring formative assessment, teachers make frequent, interactive assessments of student understanding. This enables them to adjust their teaching to meet individual student needs, and to better help all students to reach high standards.

Good feedback should be tied to explicit criteria regarding expectations for students’ performance, thus making the learning process more transparent, and modelling “learning to learn” skills for students. The purpose of formative assessment is not accreditation; it should provide direct feedback about the learning and teaching processes and may have beneficial effects for both students and teachers

5.5 Recommendation for Further Study

This study investigated on influence of formative evaluation on learner performance in mathematics in secondary schools in Embu County, Kenya. The study suggests that further research be done on the school based factors influencing learner performance in secondary schools in mathematics with a focus to more counties in order to identify the consistency of the results that reflect the prevalence of mathematics performance.

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APPENDICES

Appendix I: Research Permit

NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/15/21403/8800**

Date: **23rd November, 2015**

Njiru Benjamin Kivuti
University of Nairobi
P.O. Box 30197-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Influence of formative evaluation on learner performance in mathematics in secondary schools in Embu County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Embu County** for a period ending **23rd November, 2016.**

You are advised to report to **the County Commissioner and the County Director of Education, Embu County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

SAID HUSSEIN
FOR: DIRECTOR GENERAL/CEO

Copy to:

The County Commissioner
Embu County.

The County Director of Education
Embu County.

National Commission for Science, Technology and Innovation is ISO 9001: 2008 Certified

Appendix II: Letter of Introductory

Njiru Benjamin Kivuti

P.O Box ……..

Embu

Tel: ……..

Dear Sir/Madam,

REF: REQUEST TO CARRY OUT DATA COLLECTION.

I am a student at University of Nairobi pursuing a Master's Degree of education in measurement and evaluation as a requirement in fulfillment of this degree, am carrying out a study on the '**INFLUENCE OF FORMATIVE EVALUATION ON LEARNER PERFORMANCE IN MATHEMATICS IN SECONDARY SCHOOLS IN EMBU COUNTY, KENYA**'

You have been chosen due to your position to provide reliable information that will enable the study achieve its objectives. I intend to research on the above topic though the use of questionnaires. The identity of the respondents will be treated with confidence and any assistance given will be highly appreciated as it will be used purely for the purpose of the research. A final copy of the document may be availed to you upon request. Your assistance and cooperation will be highly appreciated.
Thank you in anticipation

Yours Faithfully,

Njiru Benjamin Kivuti

Appendix III: Questionnaire for the Mathematic Teachers

Please tick the appropriate box or write your answer for the questions below on the spaces provided.

PART ONE: General Information

1. Name (optional)……
2. Name of your school (optional) ……
3. Designation:

   Teacher [ ] Deputy Principal [ ] Principal [ ]
4. Education qualifications?

   Diploma [ ] Degree [ ] Masters [ ]
5. Length of service?

   1 to 5 years [ ] 6 to 10year [ ] 11 to 15 [ ] 16 years and above [ ]
6. Indicate the classes that you teach mathematic?

   ……..
7. Do you employ formative evaluation approach in teaching mathematic?

   Yes [ ] No [ ]
8. Through formative evaluation approach have you realized learners' improvement in mathematic performance?

   Yes [ ] No [ ]
9. Kindly indicate your level of agreement to the statement below relating to the aspect formative evaluation and it is influence on learner performance mathematics subjects. Use a scale of 1-5, where 1- strongly disagree, 2- disagree, 3- neutral, 4- agree, 5- strongly agree.

Statement	**1**	**2**	**3**	**4**	**5**
Assignments					
I employ assignments test as a formative evaluation approach to way of measuring student progress in mathematic performance					

which form an integral part of education system					
Through utilization of diagnostic assignments with remediation enhances the acquisition and retention learning tasks among students					
I apply different approaches to explaining new concepts to provide options for independent classroom work and encourage students who have grasped a new concept to help their peers					
Frequent assessment of students performance has demonstrated to improve student outcomes					
We use assessments frequently which are modified to improve learning outcomes of the students					
Assessments have proved to help students understand the teacher's learning intentions and what constitutes success in mathematic subject					
Assessments provide students with opportunities to revise and improve their thinking, and help students monitor their own progress over time					
Continuous Assessment Tests					
Continuous assessment tests provide evidence concerning students' achievements, which when interpreted helps the assessors to take measures for further improvements					
Formative continuous assessment tests can enhance teaching and learning by providing a more focused application for learners					
Summative assessment is used to evaluate progress and achievement, assign grades, and appraise programs					
Formative assessment involves getting the best possible evidence about what students have learned and then using this information to decide what to do next					
Formative assessment is a crucial tool for simultaneously					

improving classroom practice and students' performance					
Frequency of Formative Evaluation					
We conduct frequent formative evaluation in every week to access the progress of children achievement					
Frequency formative assessment of progress monitoring has proved to have positive impact on student outcomes					
Formative evaluation enables teachers to adjust their teaching to meet individual student needs, and to better help all students to reach high standards					
Teachers actively involve students in the process of helping them to develop skills that enable them to learn better					
Effects of administering weekly or biweekly assessments in reading, math and spelling and receiving computer-generated graphs of student progress together with instructional recommendations					
Students in classrooms receiving graphical progress reports and instructional recommendations improved more quickly and achieved higher outcomes					
We use formative assessment, reports and instructional recommendations recounted addressing more skills, providing more one-on-one instruction, and facilitating more peer-to-peer instruction					
Feedback on Formative Evaluation					
Quick feedback on formative evaluation inform students how well they are progressing					
Feedback needs to be timely and specific and should include suggestions for ways to improve future performance.					
Good feedback should be tied to explicit criteria regarding expectations for students' performance, thus making the learning					

process more transparent, and modelling “learning to learn” skills for students					
Formative evaluation provide direct feedback about the learning and teaching processes and may have beneficial effects for both students and teachers					
Students obtains better results when they were working toward process goals rather than product goals and when tracking progress toward overall goals of learning					
Teachers provide verbal or written feedback on student’s work					
Most of effective feedback is timely, specific and tied to explicit criteria					
Teachers spend more time on selected assignments and not grade every single piece of student work					
Teachers became more skilled at writing helpful comments to students as they gained experience in writing comments and shared examples of effective feedback					

Thank you for your cooperation & participation!!!!

Appendix IV: Continuous Assessment Test 1 (CAT 1)

AUGUST, 2015

TIME: 50 MINS

Name_____ADM **NO**_____**CLASS**_____

Instructions

a) Write your name and admission number in the space provided above
b) Answer all the questions in the spaces provided below each question

1.The length and width of a rectangle are stated as 18.5cm and 12.4cm respectively. Both measurements are given to the nearest 0.1cm.

a) Determine the lower and upper limit of each measurement. (1 mark)

b) Calculate the percentage error in the area of the rectangle. (3 marks)

2. a) Using binomial expansion, determine the first five terms of the expansion: $\left(2-1/x\right)^8$

(2mks)

b) Use the expansion above to evaluate $(1.75)^8$ (2mks)

3. A customer deposited Ksh.15,500 in a savings account. Find the accumulated amount after 3½ years if interest was paid at 16% per annum compounded semi-annually (3 mks)

4. Solve the simultaneous equation:-

Log (x-1) + 2log y = 2log3 (4 mks)

log x + log y = log 6

5. Make U the subject of the formula (3mks)

$$X = \frac{U^2V}{U^2 2W}$$

6. Simplify (3 mks)

$$\frac{16x^2 - 4}{4x^2 + 2x - 2} \div \frac{2x - 2}{x + 1}$$

7. Use tables of reciprocals and square roots to evaluate

$$\sqrt{\frac{2}{o.5893} - \frac{1.06}{846.3}}$$ (3marks)

8. In a triangle OAB, M and N are points on OA and OB respectively, such that OM:MA= 2:3 and ON:NB= 2:1. AN and BM intersect at X. Given that **OA** = **a** and **OB** = **b**

(a) Express in terms of **a** and **b**:-

(i) BM (1mk)

(ii) AN (2mks)

(b) Taking BX = k**BM** and AX =hAN where **k** and **h** are constants express OX in terms of

(i) **a, b** and **k** only (2mks)

(ii) **a, b**, and **h** only (2mks)

(c) Use the expressions in **(b)** above to find values of k and h (3mks)

Appendix V: Continuous Assessment Test 2 (CAT 2)

SEPTEBER, 2015

TIME: 50 MINS

NAME_____ADM NO_____CLASS_____

Instructions

a) Write your name and admission number in the space provided above
b) Answer all the questions in the spaces provided below each question
c) To be submitted on **Tuesday 01/09/2015**

1. The top of a table is a regular hexagon. Each side of the hexagon measures 50.0cm Find the maximum percentage error in calculating the perimeter of the top of the table (3mks)

2. (a) Expand and simplify the binomial expression $(2 + x)^5$ up to the term in x^3. (2mks)

(b) Use your expression to estimate $(1.97)^5$ correct to 4 s.f. (2mks)

3.A certain amount of money was invested at compound interest of 10% compounded every two years for ten years. Given that the investor invested a total of 500,000/= at the end of the ten years, find the amount of money invested to the nearest shillings (3 mks)

4. Without using logarithms tables or calculator evaluate:- (3 mks)

$$\frac{4}{5}\log_{10}32 + \log_{10}50 - 3\log_{10}2$$

5. Given that $T = \frac{1}{2}\sqrt{\frac{2}{x+y}}$ express y in terms of T and x.

(3mks)

6. Solve the following quadratic equation giving your answer to 3 d.p.

(3mks)

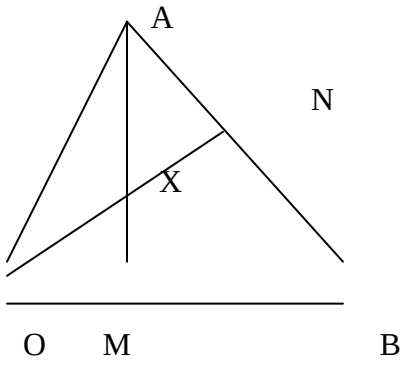
$$\frac{23}{x} - \frac{1}{x^2} - 120 = 0.$$

7. Evaluate using reciprocals, square and square root tables only

$$\frac{\sqrt{(4.652 \times 0.387)^2}}{0.8462}$$

(3mks)

8.



In the figure above, M divides line OB in the ratio 2:3 and N divides AB in the ratio 1:2 AM and ON intersect at X. Given OA = 2a and OM = b:

~ ~ ~ ~

a) Find in terms of a and b (1 marks)

(i) $\underset{\sim}{AB}$ (1 mk)

(ii) $\underset{\sim}{AM}$ (1 mk)

(iii) ON (1 mk)

b) If AX = h **AM** and OX = k **ON** where h and k are scalars

(i) Express **OX** in two ways. (2 marks)

(ii) Find the value of h and k (4 marks)

C) Find the ratio of AM:MX (1 marks)

Appendix VI: Continuous Assessment Test 3 (CAT 3)

OCTOBER , 2015

TIME: 50 MINS

NAME_____**ADM** NO_____CLASS_____

Instructions

a) Write your name and admission number in these paces provided above.

b) Answer all the questions in the spaces provided below each question.

1. The dimensions of a rectangle are 40 cm and 45 cm. If there is an error of 5% in the length and 8% in the width, find the percentage error in calculating the area of the rectangle. (4 mks)

2. (a) Expand and simplify the expression $(x + \frac{3}{x})^5$ in ascending powers of x. (2 mks)

(b) Use your expansion up to the fourth term to evaluate $(10.3)^5$ (2 mks)

3. Mrs Ondieki invested ksh 63,560 in a bank where the interest was compounded quarterly at the rate of 12% p.a. Determine the amount of money she had after 2½ years. (3 mks)

4. Solve for x in the equation

$\log_2(2 + 3x) + 3\log_2 2 = 2 + \log_2(2x + 6)$ (3 mks)

5. Make x the subject of the formula (3 mks)

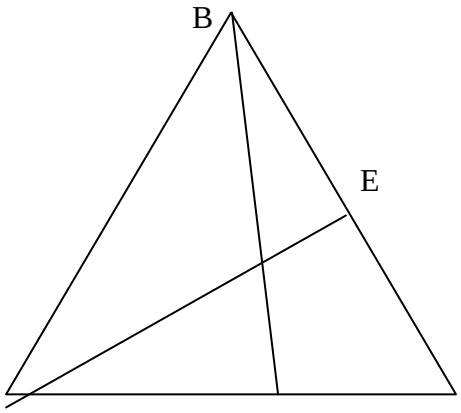
$$H = n\sqrt{\frac{t+kx}{t-kx}}$$

6. Solve for θ in the equation $2\ Cos\ \theta + 5\ Sin^2\ \theta = 2$ for $0^o \leq \theta \leq 360^0$ (3 mks)

7. Use logarithms to evaluate (4 mks)

$$\sqrt[3]{\frac{0.01369396 \times 5092}{log6549 - 0.001912}}$$

8. In the figure below E is the mid point of BC. AD:DC = 3:2 and F is meeting point of BD and AE.



(a) If **AB**= **b** and **AC**= **c**, express in terms of **a** and **b** the value of

(i) **BD** (2 mks)
(ii) **AE** (2 mks)

(b) If **BF** = t**BD** and **AF**= n**AE**, Express **AF** in two different ways and hence find the value of t and n. (5 mks)

State the ratio of BD:BF (1 m

Appendix VII: Marking Scheme CAT I

1. (a) Lower limit 18.45 and 12.35
   Upper limit 18.55 and 12.45

   (b) Error= $\frac{18.55 \times 12.45 - 18.45 \times 12.35}{2}$ = 1.545

   % error = $\frac{1.545}{18.5 \times 12.4}$ x 100%

   = 0.6735%

2. (a) $(2 - 1/x)^8 = 2^8 - 8(2)^7(1/x) + 28(2)^6(1/x)^2 - 56(2)^5(1/x)^3 + 70(2)^4(1/x)^4 + \ldots\ldots$

   $= 256 - 1024/x + 1792/x^2 - 1792/x^3 + 1120/x^4 + \ldots.$

   (b) $(1.75)^8$ = 256 – 256 + 112 – 28 + 4.375

   = 88.375

3. Sh $15500(1 + 16/200)^7$

   = sh $15500(1+8/100)^7$

   = sh $15500(1.08)^7$

   = sh 25564.2762

   =sh 26564.28

4. Log (x-1)+log y^2 = log 9

   $xy^2 - y^2 = 9$

   log xy = log 6

   xy = 6

therefore $6y - y^2 = 9$

$y^2 - 6y - 9 = 0$

$(y - 3)(y - 3) = 0$

$y = 3$

$x = 6/3$

$x = 2$

5. $2XU^2W = U^2V + R$

$2XU^2W - U^2V = R$

$U^2 (2XW - V) = R$

$U^2 = R/(2XW - V)$

$U = \pm \sqrt{\frac{R}{2XW}}$ - V

6. $\frac{4(2x - 1)(2x + 1) \text{ X } (X + 1)}{2(x + 1)(2x - 1) \text{ X } 2(x - 1)}$

$= \frac{4(2x - 1)}{2(x - 1)}$

$= \frac{2x + 1}{x - 1}$

7. $0.5893^{-1} = 0.1697 \text{ X } 10$

$= 1.697$

$846.3^{-1} = 0.001182$

$= (2 \text{ X } 1.697 - 1.06 \text{ X } 0.001182)^{½}$

$= (3.3927)^{½}$

$= 1.8420$

8. (a) (i) 2/5 **a** – **b**

(ii) 2/3 **b** – **a**

(b) (i) OX=B + 2/5 k **a** – k **b**

= (1 – k) **b** + 2/5 k **a**

(ii) OX = **a** + 2/3 h **b** – h **a**

= (1 – h) **a** + 2/3 h **b**

(1- k) **b** +2/5 k **a** = (1- h) **a** + 2/3 h **b**

2h +3k = 3

5h + 2k =5

h =9/11

k=5/11

Appendix VIII: Marking Scheme CAT II

1. Error $= \frac{50.05 \times 6 - 49.95 \times 6}{2} = 0.3$

   % error $= \frac{0.3}{300} \times 100\ \%$

   $= 0.1\%$

2. (a) $(2 + x)^5 = 2^5 + 5(2)^4(x) + 10(2)^3(x)^2 + 10(2)^2(x)^3$
   $= 32 + 80x + 80x^2 + 40x^3$

   (b) $(1.97)5 = 32 + 80(-0.03) + 80(-0.03)2 + 40(-0.03)3$

   $= 32 - 2.4 + 0.072 - 0.00108$

   $= 29.67092$

   $= 29.67$

3. $500000 = P(1 + 10/100)^5$
   $500000 = P(1.1)^5$

   $P = 500000/1.1^5$

   $P = 310460.6615$

   $P = 310461$

4. $\text{Log}_{10}(32)^{0.8} + \log_{10} 50 - \log_{10} 2^3$
   $= \text{Log}_{10}(2^5)^{0.8} + \log_{10} 50 - \log_{10} 8$

   $= \text{Log}_{10}(16 \times 50/8)$

   $= \text{Log}_{10} 100$

   $= 2 \log_{10} 10$

   $= 2$

5. $2T = \sqrt{\frac{2}{X + y}}$

   $4T^2 = \frac{2}{X + y}$

$4T^2 (x + y) = 2$

$4T^2y = 2 – 4T^2x$

$Y = \frac{2 - 4T^2x}{4T^2}$

$Y = \frac{1 – 2T^2x}{2T^2}$

6. $120x^2-23x +1 = 0$

$120x^2-15 x -8 x 1 = 0$

$15x (8x – 1) – (8x – 1) = 0$

$(15x – 1) (8x -1) = 0$

$X = 0.6667$ or 0.15

$X = 0.067$ or 0.125

7. $4.652 \times 0.387 = 1.800324$

$0.8462^{-1} = 1.182$

$(1.800324^2 \div 0.8462) = 1.800324 \times 1.182$

$= 2.127982968$

$= 02.1280$

8. (a) (i) **AB** $= 2.5$ **b** $– 2$ **a**

(ii) **AM** $=$ **b** $– 2$ **a**

(iii) **ON** $= 4/3$ **a** $+ 5/6$ **b**

(b) (i) $OX = 4/3 k a + 5/ 6 k b$

OX $= 2$ **a** $– 2 h$ **a** $+ h$ **b**

$=(2 -2 h)$ **a** $+ h$ **b**

(ii) $4/3 k$ **a** $+5/6 k$ **b** $= (2 – 2h)$ **a** $+h$ **b**

$4 k + 6 h = 6$

$5 k – 6 h = 0$

$K = 2/3$

$H = 5/9$

(c) 9 : -4

Appendix IX: Marking Scheme CAT III

1. Error = $\frac{47.25 \times 43.2 - 42.75 \times 36.8}{2} = 234$

   % error = $\frac{234}{40 \times 45} \times 100\ \%$

   = 13 %

2. (a) $(x + 3/x)^5 = (3/x)^5 + 5(x)(3/x)^4 + 10(x)^2(3/x)^3 + 10(x)^3(3/x)^2 + 5(x)^4(3/x) + x^5$

   $= 234x^{-5} + 405x^{-3} + 270^{-x} + 90x + 15x^3 + x^5$

   (b) $(10.3)5 = 243(10)^{-5} + 405(10)^{-3} + 270(10)^{-1} + 90(10)$

   $= 0.00243 + 0.405 + 27 + 900$

   $= 927.40743$

3. A = sh. 63560(1.03)10

   = sh. 85419.32507

   = sh. 85419.33

4. $\text{Log}_2(2 + 2x) + \log_2 2^3 = \log_2 2^2 + \log_2(2x + 6)$

   $= \log_2(16 + 24x) = \log_2(8x + 24)$

   $= 16 + 24x = 8x + 24$

   $= 24x - 8x = 24 - 16$

   $= 16x = 8$

   $X = 1/2$

5. $H = \sqrt[n]{\frac{t + kx}{t - kx}}$

   $H^2 = \frac{t + kx}{N^2 \quad t - kx}$

   $H^2(t - kx) = n^2(t + kx)$

$H^2t - n^2 t = k \times n^2 + H^2 k x$

$X(k n^2 + H^2 k) = H^2t - n^2 t$

$X = \frac{t (H^2 - n^2)}{K (n^2 + H^2)}$

6. $2 \cos \theta + 5 (1 - \cos^2 \theta) = 2$

   $2 \cos \theta + 5 - 5 \cos^2 \theta = 2$

   $5\cos^2 \theta - 2\cos \theta - 3 = 0$

   Let $\cos \theta = x$

   $5x^2 - 2x - 3 = 0$

   $5x (x - 1) + 3 (x - 1) = 0$

   $(5x + 3) (x - 1) = 0$

   $X = - 0.6$ or 1

   $\cos \theta = - 0.6$ or 1

   $\theta = 0^0$ or 126.87^0 or 233.13^0 or 360^0

7. Log 6549 = 3.8162

   309162 – 0.001912

   = 3.814288

No	Log
0.013 69396	2 . 1364
5092	3. 7069
	1 . 8433
3.814288	0.5814
	1.2619
	3
2.634	0.4206

= 2.634

8. (a) $\mathbf{BD} = -\mathbf{b} + 3/5\,\mathbf{c}$

$\mathbf{AE} = ½\,\mathbf{b} + ½\,\mathbf{c}$

(b) $\mathbf{AF} = ½\,n\,\mathbf{b} + ½\,n\,\mathbf{c}$

$\mathbf{AF} = (1 - t)\,\mathbf{b} + 3/5\,t\,\mathbf{c}$

$½\,n\,\mathbf{b} + ½\,n\,\mathbf{c} = (1 - t)\,\mathbf{b} + 3/5\,t\,\mathbf{c}$

$5n - 6t = 0$

$n + 2t = 1$

$n = ¾$

$t = 5/8$

(c) BD : BF = 8 : 5

Appendix X: Students scored in three CATs

NAME	CAT 1	CAT 2	CAT 3	Improvement Cat 2	Improvement Cat 3
AA	39	41	58	2	17
AB	9	18	29	9	11
AC	44	50	59	6	9
AD	34	44	50	10	6
AE	18	50	69	32	19
AF	15	50	53	35	3
AG	18	24	38	6	14
AH	44	47	59	3	12
AI	9	31	32	22	1
AJ	6	22	24	16	2
AK	56	79	88	23	9
AL	53	56	75	3	19
AM	65	71	84	6	13
AN	59	63	76	4	13
AO	38	44	81	6	37
AP	32	38	56	6	18
AQ	35	50	63	15	13
AR	18	21	63	3	42
AS	29	68	72	39	4
AT	44	62	69	18	7
AU	65	65	84	0	19
AV	26	38	47	12	9
AW	78	85	86	7	1
AX	56	71	84	15	13
AY	26	26	59	0	33
AZ	68	68	78	0	10
BA	41	59	78	18	19
BB	56	65	66	9	1
BC	29	62	61	33	-1
BD	19	68	68	49	0
BE	44	50	76	6	26
BF	18	32	30	14	-2
BG	38	41	53	3	12
BH	68	79	78	11	-1
BI	35	44	50	9	6
BJ	24	24	47	0	23

BK	26	28	35	2	7
BL	21	56	56	35	0
BM	3	21	56	18	35
BN	21	28	31	7	3
BO	32	44	69	12	25
BP	18	22	44	4	22
BQ	24	50	53	26	3
BR	29	38	41	9	3
BS	38	53	59	15	6
BT	18	26	56	8	30
BU	41	53	62	12	9
BV	15	41	53	26	12
BW	6	38	59	32	21
BX	50	59	65	9	6
BY	63	65	74	2	9
BZ	38	44	50	6	6
CA	62	68	92	6	24
CB	50	70	93	20	23
CC	26	50	76	24	26
CD	24	53	66	29	13
CE	9	32	56	23	24
CF	32	56	63	24	7
CG	53	47	62	-6	15
CH	24	35	47	11	12
CI	21	44	44	23	0
CJ	59	62	79	3	17
CK	50	50	53	0	3
CL	21	41	59	20	18
CM	18	44	59	26	15
CN	35	84	88	49	4
CO	25	59	79	34	20
CP	65	79	97	14	18
CQ	21	47	59	26	12
CR	32	40	47	8	7
Average	35	49	62	14	13