Baraton Interdisciplinary Research Journal (2016), 6(Special Issue), pp 32-38

RETHINKING PRIMARY SCHOOL MATHEMATICS TEACHING: A FORMATIVE ASSESSMENT APPROACH

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Abstract

The performance of mathematics at national examinations at the end of primary is worrying all over the globe and researchers and scholars continue to examine how student's achievement in the subject can be raised. Formative assessment classroom teaching strategy, 'FACTS' is an interactive teaching strategy which involves observing and gathering valuable information during instruction process about a student's thinking as they solve mathematics tasks. The strategy is grounded in the instructional cycle of engaging students in interesting learning activities, assessing, analyzing and providing corrective instruction. The main purpose of the study was to determine the effect of 'FACTS' on mathematics academic achievement among primary schools pupils. The sample of the study consisted of 140 students in class 6 from public primary school in Kenya. Data was collected by administering a pretest and a posttest of a standardized achievement exam to the experimental and control groups. The reliability of the exam was tested through experts' judgment who established that the instrument had strong content and internal validity. The data was analyzed using Analysis of covariance (ANCOVA) and the significant level of 0.05 was used in order to determine the effect of the strategy on mathematics academic achievement. Research findings revealed that there is a significant effect of 'FACTS' on pupil's mathematics academic achievement as shown by statistical results of $F=131.14$, $p=0.00<0.05$.

Keywords: Experimental research, formative assessment, mathematics, achievement

Introduction

Kenya's strategic plan popularly known as 'vision 2030', singles out education as a means for transforming the nation into an industrialized middle-income economy by the year 2030 (GOK, 2008). To be industrialized, scientific and technological knowledge is vital and mathematics has been cherished worldwide to be the foundation of scientific and technological knowledge vital for social-economic development of the citizens; it lays the foundation for fields such as engineering, medicine, computer and technological specializations (Githua, 2013).

The subject, according to Makeo (2013) and Nur (2010), affects all aspects of man's life, which includes the social, political, economic, geographical, scientific and technological and contributes to the wealth of an individual as well as the entire country. The same sentiments are shared by Githua (2013) who pointed out that mathematics is the basis and an instrument for modern socioeconomic, scientific and technological development, cherished by societies worldwide. This calls up on all students, not just those aspiring to pursue scientific career, to be literate in mathematics.

Unfortunately, learners' performance in the subject at national examinations at the end of primary and secondary schools education is worrying all over the globe and researchers and scholars continue to examine how students' achievement in the subject can be raised. Among the given ways of raising performance in mathematics is use of learner centered teaching approaches, improved learning resources, teacher' learning resources, but still there is dismal mathematics achievement (Miheso, 2012). Table 1 shows mathematics KCPE national performance from 2006-2012 in Kenya.

Table 1

Mathematics Mean Score in Kenya Certificate of Primary Examination (2006-2012)

Year	2006	2007	2008	2009	2010	2011	2012
Mean score	49.48%	49.40%	49.81%	49.35%	49.53%	49.62%	48.8%

Adopted from KNEC (2012)

Performance in Mathematics, as reflected by the Kenya Certificate of Primary Examination (KCPE) results, has remained poor over the years. Hence, there is need to seek more ways of reversing this trend so as to raise achievement in mathematics. This study, in an attempt to seek more ways of raising achievement in mathematics, carried out an experimental study involving formative assessment classroom teaching strategies (FACTS) to investigate whether it has any effect on primary school pupils' affective and academic achievement in mathematics.

According to Polly et al. (2013), mathematics specialists, practitioners, researchers and policy makers continue to examine how to best increase student achievement in mathematics. But still, much uncertainty and vagueness about which specific instructional strategies or practices can best be linked to good performances in mathematics. Mullis, Martin, Foy, and Arora (2012), in their findings, indicated that achievement in mathematics depends on instructional methods that capture the learners' interest towards the subject. They indicated that incorporation of formative assessment in the teaching and learning of mathematics have proved to have positive impact in mathematics overall achievement.

Formative Assessment

The term formative assessment does not have a tightly defined and widely accepted meaning. All too often, the term formative assessment conjures images of quizzes and tests, while in reality, according to Heritage (2010), formative assessment is a process used by teachers and students during instruction that provides feedback to adjust ongoing teaching and learning. Along similar lines, Regier (2012), Cowie and Bell (1999), and Black and William (2004) defined formative assessment as the process used by teachers and students to recognize and respond to student learning in order to enhance learning. It is a process that uses informal assessment strategies to gather information on student learning. It comprises of all those activities undertaken by teachers and by their students that provide information to be used as feedback to modify the teaching and learning activities in which they are engaged.

Formative assessment, according to Halverson (2010), is a philosophy of teaching and learning grounded in the instructional cycle of engaging students in interesting learning activities, assessing, analyzing the data (teachers and students), providing corrective instruction, and re-assessing. It consists of aligning lesson objectives and content with assessments; strategically selecting instructional strategies to meet the needs of all learners, including opportunities for assessment within instruction instead of after instruction; and guiding the day-to-day, minute-to-minute instructional decisions of teachers.

According to Mullis et al. (2012), formative assessment is a teaching strategy which is concerned with daily classroom interaction between the teacher and the pupils to assist them in their learning. It involves observing and gathering valuable information about a student's thinking as they solve mathematics tasks to inform instruction.

Origin of Formative Assessment

Michael Scriven coined the terms formative and summative evaluation in 1967, and emphasized their differences both in terms of the goals of the information they seek and how the information is used (Herman, 2013). For Scriven, formative assessment involved gathering of information to assess the effectiveness of a curriculum and guide school system choices as to which curriculum to adopt and how to improve it. Benjamin Bloom took up the term in 1968 in the book 'Learning for Mastery' to consider formative assessment as a tool for improving the teaching-learning process for students (Guskey, 2010). In his subsequent book entitle 'Handbook of Formative and Summative Evaluation', showed how formative assessments could be linked to instructional units in a variety of content areas. It is this approach that reflects the generally accepted meaning of the term today (Guskey, 2010). For both Scriven and Bloom, an assessment, whatever its other uses, is only formative if it is used to alter subsequent educational decisions (William, 2006).

Subsequently, however, Black and William (2004) suggested that this definition is too restrictive, since formative assessments may be used to provide evidence that the intended course of action was indeed appropriate. They propose that: Practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited (Black & William, 2004).

Along similar lines, Herman (2013) pointed out that the landmark of the current use of formative assessment lies with Black and William who conducted a meta-review of studies relate to classroom formative assessment. Herman further claim that formative assessment does not take the form of a particular instrument or task, but is defined by its purpose which is to help form, or shape, a student's learning during the learning process. The central idea of formative assessment, according to Foster and Poppers (2009), is that it is evidence eliciting procedure used to adjust instruction to better meet student learning needs. Students and teachers use evidence of learning to adapt teaching and learning to meet immediate learning needs. Teachers provide a selected assessment task to the learners to work on after which the outcome are examined and analyze to generate some findings. These findings will inform the teacher in designing and teaching the lesson by addressing learners needs. Foster and Poppers (2009) illustrated formative assessment strategy in a general cycle as shown in figure 1.

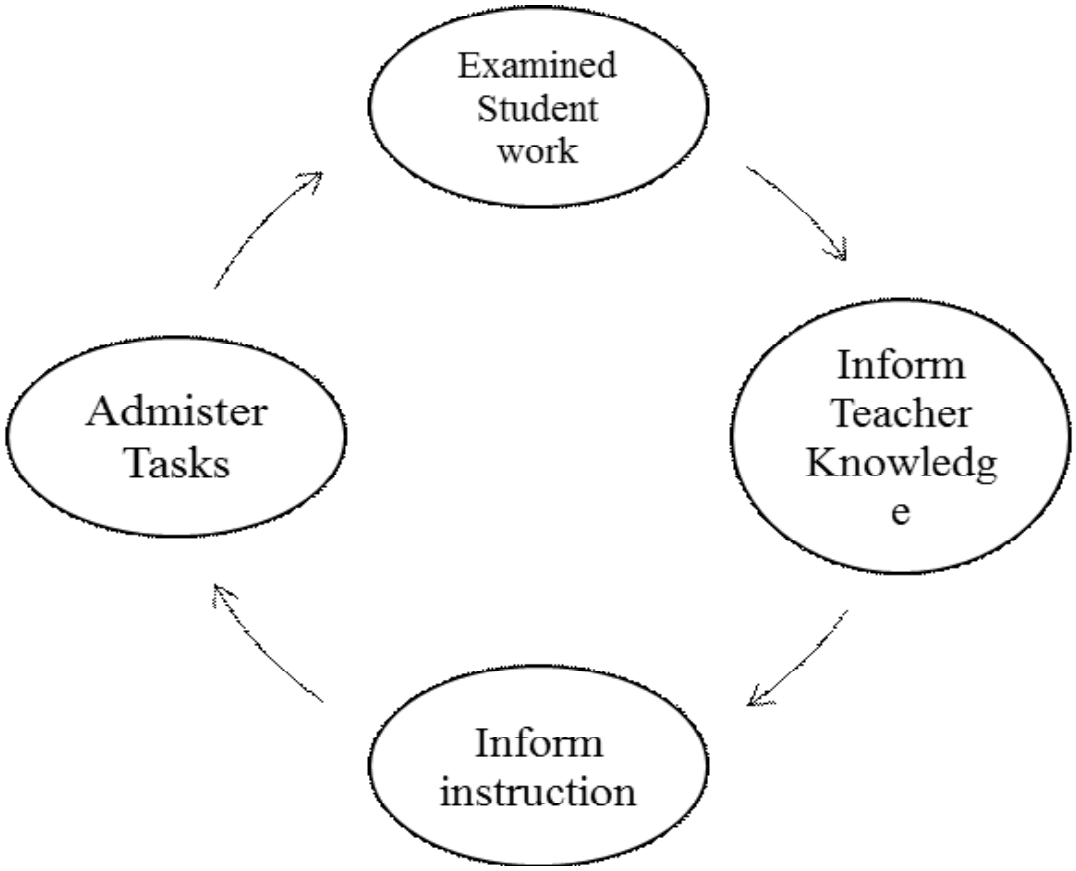


Figure 1. Formative assessment cycle. Adopted from Foster and Poppers (2009

From the above figure it can be concluded that the teacher uses or administers a variety of different tasks to assess student readiness for a particular unit of study and to plan their instruction around the needs the learner demonstrated. The teacher:

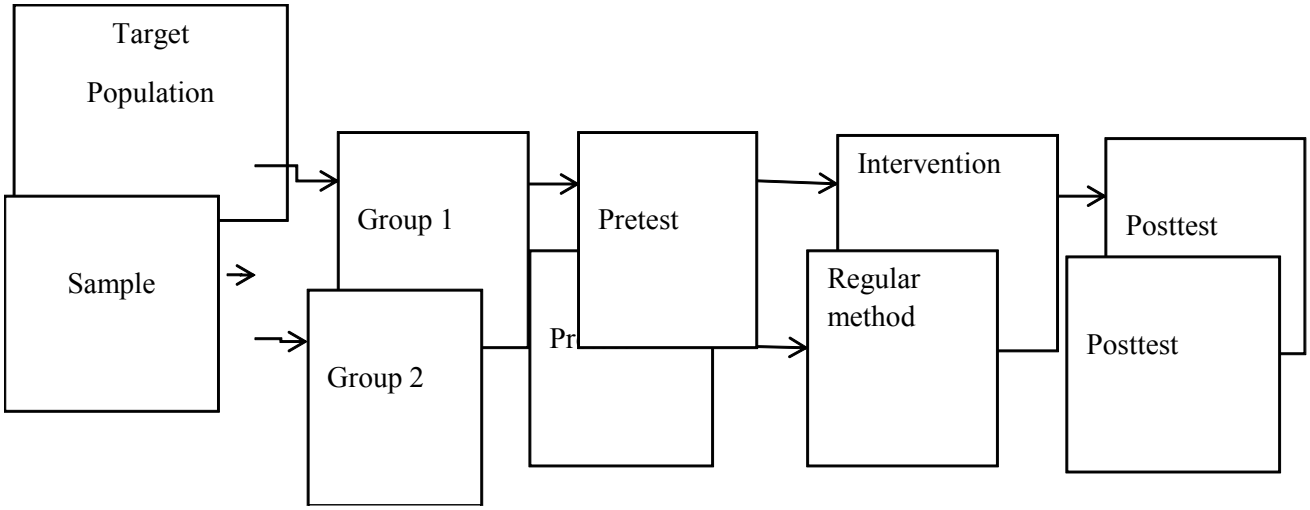
1. selects and administers a worthwhile assessment task,
2. examines and analyze students work or responses,
3. uses the findings to inform and enhance teacher's knowledge and finally
4. designs and teaches lesson(s) to address the learning needs of students.

Methodology

Research Design

This study utilized experimental research design called Two Group Pretest- Treatment-Posttest design. The Two Group Pretest-Treatment-Posttest design requires researchers to have both a control and an experimental group and also require that a pretest and posttest be administered (Mertler & Charles, 2008). The experimental group was taught using the new strategy 'Formative Assessment Classroom Teaching Strategy' (FACTS) while the control group was taught using regular teaching methods as provided for in Kenya primary school class six mathematics teacher's book.

Both groups were administered with a posttest. This design is diagrammed as follows:



Procedures

The researcher trained the participating teachers on how to implement the new strategy in the classroom before the beginning of the school calendar. Formative assessment classroom teaching strategy was introduced to them, giving them directions on how to apply and implement the strategy step by step by going through the pupils' and teachers' materials and demonstrations of how to conduct formative assessment classes. A thorough orientation and implementation of the experimental design were also discussed in detailed.

When schools opened for the first term, pupils were divided into two similar groups based on their previous mathematics achievements as suggested by Carol (2013), that groups must be of almost reasonably equal, identical or similar characteristics to ensure that there is internal validity in experimental research. The researcher, ranked pupils based on mathematics scores from the highest to the lowest. Then researcher purposely divided into two groups (group A and group B) of similar characteristics in terms of mathematics achievement scores such that if two pupils had similar marks, they were put into separated groups. Researcher then ran descriptive statistics to check and to ensure that the two groups (group A and group B) were similar in terms of achievement in mathematics. The statistical results (table 2) below revealed that the two groups were no significantly different but identical as seen by equal means of 51.42 and standard deviations of 12.95 and 13.93.

Table 2

Descriptive Statistics Showing Group A and Group B Mean Scores

	N	Mean	Std. Deviation	Std. Error Mean
GROUP A	70	51.4167	12.95449	2.64432
GROUP B	70	51.4167	13.92501	2.84243

Random sampling technique was used to choose experimental and control groups from group A and group B and group A was picked as experimental group while group B became control group, each group was placed in separate classroom. After a few days when pupils were settled, researcher administered a pretest achievement exam to both the control and experimental group.

The new strategy was implemented in experimental classes while regular teaching strategy as provided for in teachers' text books were used in the control class. The experiment ran smoothly for 8 teaching weeks of about 56 lessons each 35 minutes. At the end of the period, a post-test achievement exam

was administered to both experimental and control group.

Data Analysis

The following null hypothesis was tested for at a significance level of 0.05 margin of error: H01: 'There is no significant effect of 'Formative Assessment Strategy' on mathematics academic achievement of primary school pupils'.
The data collected were analyzed using SPSS version 20.0 by conducting one-way analysis of covariance (ANCOVA) to determine the effect of Formative Assessment Strategy on mathematics academic achievement of primary school pupils.

Findings and Discussions

The research findings, F=131.14, p=0.00<0.05 (table 3) shows that there is a significant effect of 'Formative Assessment Strategy on mathematics academic achievement. The implication of these findings was that formative assessment teaching strategy had an effect on improving mathematics academic achievement of primary school learners.

Table 3

Analysis of Covariance (Posttest Scores)

Tests of Between-Subjects Effects

Dependent Variable: Post test scores

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	26012.075[a]	2	13006.038	331.551	.000
Intercept	7878.524	1	7878.524	200.840	.000
Pretest	21440.647	1	21440.647	546.567	.000
Group	5144.179	1	5144.179	131.136	.000
Error	5374.210	137	39.228		
Total	615112.000	140			
Corrected Total	31386.286	139			

a. R Squared = .829 (Adjusted R Squared = .826)

This finding are similar to the findings of Halverson (2014) and Dunn and Mulvenon (2009) who asserted that formative assessment has been proven as one of the most effective instructional tools to positively influence student achievement by improving students' mathematics achievement. When teachers, students, and their peers effectively utilize formative assessment, Halverson said that they are making conscientious decisions about the next steps in the instructional and learning processes that will be optimal for improved learning. Formative assessment creates a responsive and agile learning environment where teachers and students can self-correct based on assessment data to increase the likelihood of all students mastering the standards and meeting their learning goals.

This finding also supports the work of Black and William (1998), who demonstrated that when teachers effectively utilize formative assessment strategies, student learning increases significantly. Similarly in CCSSO (2012), it is claimed that when teachers used formative assessment during their instruction process, it leads to improved students' achievement, because teachers using formative assessment, can quickly adapt instructions to meet learners' needs and interests.

A study by William (2006) also reported on the place of formative assessment and instruction whereby teachers who were given support to implement formative assessment techniques in their classrooms were able to rapidly close student achievement gaps by 50 percent. Similarly, Ali and Iqbal (2013) posit that effective implementation of formative assessment practices in a mathematics classroom results in students' improved learning and achievement directly or indirectly. They further claimed that formative assess-

ment classroom practices improve students' motivation, confidence and self-esteem, because of its promising pedagogical potential; a sentiment that is also shared by Kingston and Nash (2011).

Conclusion and Recommendations

The researcher recommends that formative assessment to be an integral part of teaching professional practice, which needs to be made as a major investment in teachers. Teacher training colleges and universities need to include in their curriculum courses on formative assessment so that no teacher exits training program without the knowledge to integrate assessment with instruction.

The findings of this study further revealed that formative assessment classroom teaching strategy improved achievement in primary schools mathematics. It is recommended that mathematics teachers utilize formative assessment classroom teaching in their teaching. Teachers need to use a variety of different strategies to assess pupils' readiness for a particular unit of study and to plan their instruction around the needs the pupil demonstrate. Through formative assessment teachers determine what pupils understand and what they still need to learn to master a goal or outcome.

Acknowledgment

` The author wishes to thank Prof. Elizabeth Role and Prof. Lazarus Ndiku of the University of Eastern Africa, Baraton for their contributions, commitment and support during this study.

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