Effectiveness of Differentiated Instruction on Secondary School Students Achievement in Mathematics

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Abstract

Mathematics is a fundamental human activity- a way of making sense of the world. Achievement in mathematics has caused deep concern in many countries over the years. In Kenya, mathematics competence is necessary for entry into science, technology, engineering and mathematics disciplines in institution of higher learning. The purpose of the study was to investigate the effectiveness of Differentiated instruction on students' achievement in mathematics in secondary schools in Meru County in Kenya. The study sought to determine whether there was a difference in achievement when students were instructed using Differentiated Instruction approach. The study employed the Quasi-experimental design and in particular Solomon Four-Group design. The research was carried out in 8 provincial secondary schools in Meru County, Kenya. The subjects were form three students and the sample size was 374 students. Simple random sampling technique was used to select the participating schools. Mathematics Achievement Test provided the needed data. The hypothesis was tested at $\alpha = 0.05$ level of significance. Results indicated that Differentiated Instruction significantly improved the students' achievement in mathematics which may lead curriculum developers to include Differentiated Instruction in approaches to teaching mathematics to improve achievement in the subject.

Keywords: Achievement, Differentiated Instruction and Conventional Instructional

1. Introduction

Mathematics is an essential discipline recognized worldwide and it needs to be augmented in education to equip students with skills necessary for achieving higher education, career aspirations and for attaining personal fulfillment. Mathematics is the base for all technologies in the world. Mathematics is employed as a key instrument in a diversity of fields such as medicine, engineering, natural science, social science, physical science, business and commerce. Due to its significance, there is greater pressure for children to succeed in mathematics more than in any other subject (Fraser &Gilan, 1992).

According to Eshiwani (1993) some of the major objectives of mathematics education in Kenya are the development of thinking ability and logical thought. Mathematics aims at developing numerate and rational citizens, useful in the home, society and nation. Due to its importance and use in the learning of other subjects and its application in industry and real life situations, mathematics is compulsory for all students in Kenya. As such, students' performance in mathematics is of great concern to education stakeholders.

Different approaches of teaching mathematics have been proposed by educators and the knowledge of these methods may help in working out a better teaching strategy. It is not appropriate for a teacher to commit to one particular method. A teacher should adopt a teaching approach after considering the nature of students, their interest and maturity and the resources available. All the approaches may not be equally appropriate and suitable for all levels of mathematics teaching. After the teacher has known all the methods, their merits and demerits, he or she should be able to make his or her own method by imbibing the good qualities of all the approaches. The approach adopted by the teacher must ensure maximum participation of the student, proceed from concrete to abstraction and provide knowledge at the understanding level (Merchant, 2010).

Differentiated instruction is an approach that assumes there is a diversity of learners in every classroom and that all learners can be reached if a variety of methods and activities are used. Differentiated instruction is a way of diagnosing the needs of individual students and making accommodations in the classroom to meet their needs. All students are not alike, that is, students learn in different ways and at different rates.

Based on this knowledge, differentiated instruction applies an approach to teaching and learning that gives students multiple options for taking in information and making sense of ideas. Differentiated instruction is a teaching approach based on the premise that instructional approaches should vary and be adapted in relation to individual and diverse students in classrooms. The model of differentiated instruction requires teachers to be flexible in their approach to teaching and adjust the curriculum and presentation of information to learners rather than expecting students to modify themselves for the curriculum (Tomlinson, 2003). Based on the idea that a change in instructive approaches can help overcome the ineffectiveness of educational systems and their malfunction in corresponding to students' needs, there is need to investigate if using the teaching learning approach of Differentiated instruction could improve students' achievement in mathematics in secondary schools in Kenya.

2. Statement of the Problem

Learners' achievement in mathematics has been low over the years. This has been attributed to many factors such as inadequate facilities, learners' poor attitude towards mathematics, student inability to relate and organize material in time allowed and inappropriate teaching strategies. Shifting from conventional ways of teaching mathematics to innovative strategies like constructivist approach, mastery learning and problem-solving approaches is being practiced to address the problem. Despite the adoption of those varied approaches students' performance at the KCSE examinations is still poor. New innovative teaching approaches such as Differentiated instruction are being employed to improve achievement in mathematics. There is however limited information on its effectiveness hence this study investigated the effects of differentiated instruction on students achievement in mathematics in secondary schools in Kenya to fill the knowledge gap.

3. Objective

The objective of the study was to determine whether there is a difference in achievement between the students that are exposed to Differentiated instruction and those exposed to conventional instructional approach.

4. Hypothesis

There is no statistically significant difference in achievement in mathematics between students exposed to Differentiated instruction and those exposed to conventional instructional approach.

5. Methodology

The study involved Quasi-experimental design that allows researchers to randomly select sample from the population and they do not require the random assignment of individual cases to the comparison groups. It also allows researchers to carry out studies in natural, real-life settings using probability samples. It involves the study of more than one sample often over an extended period of time. The study used a quasi-experimental design as the students are already constituted by the school administration and the researcher worked with existing streams (Nachmias & Nachmias, 2004).

The researcher used in particular Solomon Four-Group design, which is appropriate for experimental and quasi-experimental studies. Solomon Four-Group is the most rigorous designs that can be used in quantitative studies for it involves two control groups as compared to other experimental designs (Ogunniyi, 1992). The design provides the researcher confidence in the significance of the study results since it guards against both threats of internal and external validity. The general procedure is one or more independent variables are manipulated to determine their effect on a dependent variable. Solomon Four-Group enables a researcher to make a more complex assessment of the cause of changes in the dependent variable and even tell whether changes in the dependent variable are due to some interaction effect between the pretest and the treatment. The design permits four meaningful comparisons on a particular dependent variable. The design combats many internal validity issues that can plague research by randomization so that the observed effect on the dependent variable can be attributed solely to the treatment. It allows researcher to exert complete control over the variables and to check that the pretest did not influence the results (Shuttleworth, 2009).

Group E1 received pretest (O1), treatment (X) and posttest (O2). Group C1 received pretest (O3), no treatment and posttest (O4). Group E2 received no pretest but received treatment (X) and posttest (O5). Group C2 received only posttest (O6). The posttest O5 and O6 rule out any interaction between testing and treatment. Within each treatment condition, there was a group that is pretested (E1) and the one that is not (E2).

The various combinations of tested and untested groups with treatment and control groups allow the researcher to ensure that confounding variables and extraneous factors have not influenced the results (Spector, 1981). The pretest and posttest was treated as a normal test that is administered to students. The experimental and control groups were from different schools to avoid interaction of subjects. The students were taught by their teachers so that the students were not aware of experimentation. For a reliable results, several sets of four tests could be applied and the means used.

Stratified random sampling technique was used to select the participating schools for it ensures inclusion in the sample of subgroups which otherwise would be omitted entirely by other sampling methods because of their small numbers in population. With stratified sampling technique there is a higher statistical precision because the variability within the subgroups is lower compared to variations when dealing with the entire population. It ensures better coverage of population (Mugenda & Mugenda, 1999). The population was divided into groups or strata using a given criterion and then a given number of cases were randomly selected for each population subgroup. The criterion or variable used for stratification was gender in that there were two categories namely boys' and girls' secondary schools. For each category simple random sampling was used to select schools that were used for the study. Two sets of four groups were applied that is four schools for each category were chosen because the Solomon Four-Group requires four groups and each school form a group. Simple random sampling was used to assign the four schools into experimental and control groups. This was done to reduce the possibility of bias entering the selection of sample schools.

The instrument used was Mathematics Achievement Test (MAT). The MAT comprise of questions covering knowledge, comprehension, application and analysis in mathematics. MAT had 11 items with a total score of 50. The instrument was expected to display the effectiveness of using the differentiated instruction approach.

6. Results

In order to determine the resulting impact of differentiated instruction on students' achievement in mathematics, the scores of the Mathematics Achievement Test were analysed.

A comparison was done on students' improvement from the pretest to the posttest in experiment group. It was found out that there were no students who experienced a decline in achievement in mathematics, 89% of students experienced an improvement in achievement in mathematics and 11% of students experienced no change in their mathematics achievement. The largest percentage (89%) of students in experiment group that was instructed with differentiation performed better in the posttest than pretest. This implies that there was students' improvement in mathematics achievement in the experiment group that was exposed to differentiated instruction. The findings of the study agree with the findings of Goddard and Goddard (2007) who demonstrated that differentiated instruction when fully implemented, can significantly improve student achievement. The findings were also consistent with Lewis and Bates (2005) who posits that more students have the chance to achieve academic success in classroom when instructions are differentiated.

A comparison was done on students' improvement from the pretest to the posttest. Data on Table 1 shows the mean scores and mean gain obtained by students in experiment group E1 and control group C1 in the MAT.

Table 1: Mean Scores and Mean Gain obtained by Students in the MAT

Group	E1	C1
N	81	92
Posttest Mean Score	69.36	44.76
Pretest Mean Score	18.44	13.57
Mean Gain	50.92	31.19

Key: E1 – Experiment group with pre and posttest.
C1 – Control group with pre and posttest.

Results on Table 1 shows that the post test mean scores for experiment groups E1 and control group C1 were 69.36 and 44.76 respectively. The mean score for experiment group that was exposed to differentiated instruction is higher than the mean score for control group C1 that was instructed by conventional instructional approach. The pre test mean scores for experiment groups E1 and control group C1 were 18.44 and 13.57 respectively. Results on Table 1 shows that the experiment group E1 had a mean gain score of 50.92 and control group C1 had 31.19. This means that E1 had a higher mean gain and so gained more than C1.

Thus the group E1 that was taught using differentiated instruction had a higher mean gain score than the control group C1 that was taught by conventional instructional approach. The experiment group had increased their scores to a greater degree than the control group. This implies that using differentiated instruction improved students' achievement in mathematics and the gains in score can help close the gap in performance and provide some students with points they may need to pass their KCSE mathematics in order to be promoted to the next level. The findings of the study were consistent with Hodge (1997) who found out that students prepared for tests using differentiated instruction showed statistically significant gains in their mathematics scores.

The results are also consistent with Koutselini and Gagatsis (2003) who found out that differentiated teaching facilitated to construct students' knowledge by maximizing motivation for cognitive and meta cognitive growth that will eventually improve academic outcomes for all students. The findings also concur with the findings of Beecher and Sweeny (2008) posits that achievement gains occurred across student groups that used differentiation. The results also concur with the findings of Tieso (2002) who posits that achievement gains are found across economic and achievement levels through pre/ post-test results for students in effectively differentiated classrooms.

The interaction between pretest and posttest in MAT for students in experiment group and control group is represented in Figure 1.

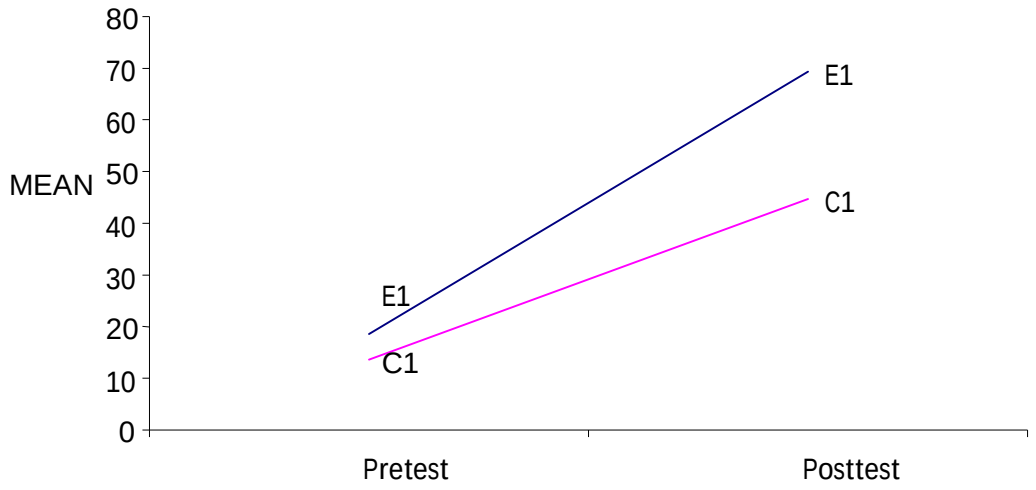

Figure 1: Graphical Representation of Students Achievement in Pretest and Posttest on MAT of Experiment and Control Group.

Key: E1 – Experiment group with pre and posttest.
C1 – Control group with pre and posttest.

Information on Figure 1 shows the achievement line for mean scores of students in experiment group and control group for the MAT. The difference between the mean scores of students in experiment group and control group for the MAT is shown by the slope of the achievement line. The mean score of students in experiment group started slightly above that of the control group in pretest and in post test the mean score for experiment group was far much above that of control group students. The slope of the experiment group achievement line is greater than the slope of achievement line of control group suggesting that progress in the experiment group was significantly higher than the progress of the control group in MAT.

This implies that differentiated instruction adversely widens the achievement gap between students in experiment group and control group. When students are matched to instruction suited to their learning patterns through differentiated instruction, they achieve significantly better. The results concur with McAdamis (2001) research findings that showed an important academic improvement from low academic outcomes after differentiated instruction. The results are also agree with the findings of Brimijoin (2001)who found evidence of strong achievement gains on a state standards test for students in an effectively differentiated elementary classroom.

Data on Table 2 shows the posttest mean scores obtained when students were exposed to differentiated instruction in experiment groups and to conventional instructional approach in control groups.

Table 2: Posttest MAT Mean Scores for Experiment and Control group

Group	N	Mean	S.D
iment groups	186	68.17	16.87
Control groups	188	34.79	19.89

The results on the Table 2 show that the mean score of students in experiment groups and control groups for posttest were 68.17 and 34.79 respectively. The mean score of students experiment group that was instructed using differentiation was almost double the mean score for control group. The MAT results were very encouraging. The results suggest that the use of differentiated instruction promote student achievement in that the students exposed to it performed far much better than those that were exposed to conventional instructional approach. Differentiated instruction provides learning environments that maximize the potential for student success. The results agree with Kim (2005) research findings that provided evidence for positive effects on students' achievement when exposed to differentiated instruction. The results also concur with Tieso (2005) who posits that those students who were taught using a differentiated instruction demonstrated significantly higher achievement on the post test scores than did the students who were taught using traditional methods.

An independent sample t-test procedure was utilized to examine the stated hypothesis that is to determine whether there was statistically significant difference in mean scores among the experiment and control groups E1 and E2, C1and C2. Information on Table 3 shows the comparison of mean scores of posttest of the experiment and control groups by use of t-test.

Table 3: t-test of the Posttest on Exposure to Differentiated Instruction and to Conventional Instructional Approach

Group	N	Mean	S.D	t-value	t-critical
Experiment group	186	68.17	16.87		
Control group	188	34.79	19.89	3.23	1.96

The results on Table 3 show that the t- computed is greater than t- critical ($t_{computed}$=3.23 and $t_{critical}$ = 1.96 , $p<0.05$) and so the difference between the two groups is significant at the 5% confidence leveland the null hypothesis is rejected. The t-test results analysis reveals that the means are statistically different at 0.05 α-level and that there is difference between the mean scores for experiment and control groups. There is statistically significant difference in mathematics achievement between students exposed to differentiated instruction and those exposed to conventional instructional approach. This implies that differentiated instruction significantly improve student achievement in mathematics.

The change in academic achievement was statistically significant and a few points is all that many students need to meet the KNEC standards. The results coincides with Tieso (2005) who concluded that differentiating the curriculum, along with creating purposeful flexible grouping may significantly improve students' mathematics achievement. The results are also consistent with the findings of Brighton, Hertberg, Moon, Tomlinson and Callahan (2005) who found out that students in differentiated middle school classrooms showed statistically significant achievement outcomes compared to students in control group. The results also concur with the findings of Ferrier (2007) who posits that students in the differentiated instructional classes were found to score significantly greater than their traditionally instructed peers.

By correlating the results from Table 2 that the mean for experiment group is higher and Table 3 that there is statistically significance difference in mean scores for experiment and control group then the evolution of the experiment group was superior to the evolution of control group which proves the efficiency of differentiated instruction. This implies that differentiated instruction enhance students achievement and led to a higher achievement levels in experiment group .The results concur with the findings of Lim (2005) who showed that differentiating by product often translates to improved student achievement due to the positive correlation between student engagement, appropriate academic activities and high achievement. The results coincide with Ladson-Billings (1994) who concluded that curriculum and instruction that matches learning style and intelligence preference of students has positive impacts on learner outcomes. The findings are also consistent with Sternberg (1997) who concluded that when students are matched to instruction suited to their learning preferences, they achieve significantly better than comparable students whose instruction is not matched to their learning preferences.

7. Conclusions

The findings of the study demonstrated that differentiated instruction is more beneficial in improving academic scores. It was determined through examining the data collected that using differentiated instruction does have a positive effect on students' achievement. That is implementing differentiated instruction has had a positive impact on student achievement. Students who were taught using differentiated instruction performed better than those taught using conventional instructional approach. Differentiated instruction is a promising approach for supporting the diverse needs of all students for it consistently had positively affected student achievement. The conclusions of this study encourage the use of differentiated instruction because it is of substantial benefit to students who may be struggling in the classroom and is responsible teaching in that it acknowledges not only the strengths and differences among learners, but also the increasing diversity in the modern classroom. Differentiated instruction is an effective method of teaching mathematics for it gives students hands-on learning and more opportunities to communicate with their classmates as compared to conventional instructional approach.

8. Recommendations

Based on the findings and conclusions made in this study, it is recommended that use of differentiated instruction be adopted for mathematics instruction. Evaluation of education goals of mathematics and a massive restructuring of the curriculum should be done to incorporate the use of differentiated instruction approach on various topics. This is due to the positive influence exerted on the students' achievement in mathematics when differentiated instruction approach was used. Mathematics curriculum developers should include differentiated instruction approach in the teaching of mathematics during the training of mathematics teachers that is teacher education institutions should develop and provide pre-service and in-service programs that use differentiated instruction. Training sessions and professional development for differentiated instruction that require concerted response from all stakeholders including school principals, teachers and school authorities should be done.

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