

Effect Of Open Ended Teaching Learning Approach On Secondary School Students' Mathematics Achievement In Learning Three Dimensional Geometry

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Abstract: Mathematics is globally valued for use by an individual and society. It plays a significant role in the development of modern science and technology. Despite its importance, students' motivation to learn and achievement at national examinations globally and at the KCSE mathematics examination in Kenya particularly has been dismal over the years. The learners' low achievement in the subject has been attributed to the didactic teaching methods that the teachers use among other factors. The study of geometry in Mathematics poses a number of difficulties to learners which are different in nature from those of arithmetic and algebra. This is because geometry is primarily abstract in nature. The purpose of this study was to determine the effects of Open Ended Teaching and Learning Approach (OETLA) on Secondary School students' mathematics achievement in learning Three Dimensional Geometry (3DG). The study employed Solomon four non-equivalent control group design. The two experimental groups (E1& E2) received OETLA treatment while the control groups (C1&C2) were taught using the conventional teaching and learning methods. Only E1& C1 took a pre-test and a post test for all the groups. The target population for this study was form four 17 year old students of secondary schools in Marani Sub County in Kisii County. Purposive sampling was used to obtain the four county mixed-sex secondary schools for the study. A total of 152 students formed the sample size. Students' Mathematics Achievement Test (SMAT) was used to collect data. The instruments were validated by three experts from the department of curriculum and instruction of Egerton University and three Secondary School Mathematics Heads of Department. The reliability of the instruments were established using Cronbach's Alpha. A reliability coefficient of 0.92 was obtained and thus considered acceptable. The SMAT was administered to two groups as a pretest before the treatment and as a posttest to all the four groups to yield scores. ANOVA and t-test were used for data analysis. The level of significance for acceptance or rejection of hypothesis was coefficient alpha value of 0.05. This study concludes that the use of OETLA resulted to a higher academic achievement in learning Three Dimensional Geometry when compared to the traditional method of learning mathematics. This study recommends that mathematics teachers in secondary schools make use of OETLA to improve their academic performance in the subject.

Index Terms: Open Ended Teaching Learning Approach (OETLA), Achievement, Three Dimensional Geometry (3DG), Mathematic

1 INTRODUCTION

Mathematics is a science of number, quantity, and space, either as abstract concepts (pure mathematics), or as applied to other disciplines such as physics and engineering (applied mathematics). Mathematics makes our life orderly and prevents chaos. Certain qualities that are nurtured by mathematics are power of reasoning, creativity, abstract or spatial thinking, critical thinking, problem-solving ability and even effective communication skills (The Indian Times, August 2015). Students' mathematics achievement is often associated with the future economic power and competitiveness of a country. Therefore, the desire to understand and identify factors that may have meaningful and consistent relationships with mathematics achievement has been shared among national policy makers and educators around the world (TIMMS, 2011). There is increasing use of mathematical techniques as a Management tool in commerce and industry. The Research and Development (RAND) mathematics study panel in United States of America (USA) emphasizes the importance of mathematics and declared that it is essential that students develop mathematics proficiency (RAND, 2010). Thus, improving mathematics and science education has been the priority of the policy making agenda (Anon, 2005). In Nigeria research has shown that the teacher factor in terms of number of teachers and their competence, teaching strategy, attitude among other factors affect students' performance in Mathematics (Chika, 2011). The same scenario cuts across other African countries including Kenya (Mji & Makgato, 2006; Miheso & O'Conner, 2000). In all countries the teacher factor in terms of competence and mode of delivery seemingly is very crucial in learners' performance in mathematics as a

subject (Ukeje, 1997): hence, this research investigates whether the use of OETLA can improve teachers' competence in delivery of the mathematics content to enhance students' motivation to learn and achievement in the subject. No Child Left Behind (NCLB, 2001) act in USA, directed that research about effective practices be a guide in changing the way mathematics is taught to meet the required standards leading to an improvement in achievement. This expectation however is not conceivable when students continue to perform dismally in the subject at National examinations. In Kenya, the Ministry Of Education Science and Technology (MOEST) noted that about 10% of the children like and are willing to study mathematics, (MOEST, 2007), the rest have to be persuaded or forced to study mathematics because it is compulsory. The continued dismal performance of students in the subject at National examinations has continued to trigger concern as reflected in the Kenya Certificate of Secondary Education (KCSE) mathematics results, (KNEC, 2013). Kisii county produces the bulky of bottom performing schools in national examinations at both primary and secondary school levels (SMASSE, 2004). Despite the important role that Mathematics plays in society, there has always been poor performance in the subject at national examinations, this is demonstrated on Table 1 in Kenya Certificate of Secondary Education (KCSE).

Table 1: KCSE mathematics mean scores Nationally and Kisii county levels for the years 2012-2015

Year	National	Kisii county
2012	17.62	4.26
2013	12.24	4.32
2014	16.26	4.90
2015	18.73	4.86

Source: KNEC, 2012 - 2015, Kisii County Examination Office 2015

The students' performance in mathematics in terms of index mean scores in Kisii county in comparison to other commonly compulsory science subjects (chemistry and biology) offered and examined at secondary school are relatively low in the county as shown in Table 2.

Table 2: KCSE mathematics, biology and chemistry mean scores for the years 2012-2015 Marani, Kisii county

Year	Gender	Mathematics	Biology	Chemistry
2012	Female	1.39	3.42	2.50
	Male	2.34	3.79	3.04
2013	Female	1.29	2.72	2.45
	Male	2.84	3.81	2.94
2014	Female	2.52	3.90	2.27
	Male	2.89	3.98	3.57
2015	Female	2.74	4.50	2.91
	Male	3.60	4.80	4.10

Source: Kisii County Examination office, 2015

Prevailing conventional teaching methods that are predominantly teacher centered have been cited as contributing to the dismal performance in sciences at the KSCE (Changeiywo, 2000). Thus, the need for student centered methods such as Open Ended Teaching and Learning Approach (OETLA) which it is hoped will improve learners' Mathematics achievement and their motivation to learn the subject. In this study OETLA that emphasizes active learning will be studied and its effects on achievement and motivation determined. The long-term use of concrete instructional materials by teachers knowledgeable in their use and hands on experiences, improved student achievement and attitudes learning (Grows & cebulla, 2000). Students are expected to evaluate each other's ideas and reasoning in ways that are not critical of the sharer (Kupari, 2006). This helps to create an environment in which students feel comfortable sharing ideas and discussing each other's methods and reasoning. OETLA is a teaching learning process where intentionally, students are offered opportunities to integrate prior knowledge and skills, their way of thinking and to encourage them to pose and solve new problems under the teacher's guidance (Miheso & O'Conner, 2000). An Open Ended problem is presented for students to solve using words, numbers, and pictures and to follow up with a written explanation. It offers a proficient problem solver with flexibility through the expansion of knowledge required for solving non routine problems (Salomon & Perkins, 1989). Hodgson and Watland (2004), in talking about OETLA, said: "Through groups and other learning interactions with their online peers, students acquire deeper understanding because of the opportunities for exposure to multiple perspectives and interpretations. There has been a lot of concern about the poor performance of students in Mathematics and evident gender disparity at KCSE national mathematics examinations in

Kenya. The poor performance may be due to the use of traditional teaching and learning strategies and students' lack of motivation to learn mathematics (Githua, 2002). The Kenyan government with the assistance from the government of Japan hopes to strengthen the teaching and learning of mathematics and science education (SMASSE) through professional development of science and mathematics teachers. This started as a project in piloted Sub-Counties in Kenya though lately, it is compulsory to all science and mathematics teachers. One of the approaches recommended by SMASSE is OETLA. There is however inadequate research studies on the effect of SMASSE on students' performance at the KCSE national mathematics examinations. There is need therefore, to investigate the effect of Open Ended Teaching and Learning Approach that is encouraged in SMASSE in Three Dimensional Geometry. The purpose of this study was to determine the effects of Open Ended Teaching-Learning Approach on secondary school students' achievement in learn Three Dimensional Geometry (3DG) in Mathematics.

2 METHODOLOGY

The study used the Solomon's 4-group non equivalent control group design which is appropriate for quasi-experimental studies (Changeiywo, 2000). Quasi-experimental design was used for the study because random assignment of subjects was not possible since schools do not allow classes to be reconstituted. The Solomon four group design has an advantage of avoiding some of the difficulties associated with the pretest-posttest design (Shuttleworth, 2009). This study was carried out in Marani Sub County, Kisii County, Kenya. The study area was chosen because of its poor education facilities and performance. The target population for this study was 1400 form four students in Marani Sub County, Kisii County. The form four classes have been chosen for the study because the 3DG in the study is covered at this level of the KCSE Mathematics syllabus (KLB, 2009). Random sampling was used to select the four co-educational secondary schools as required in the Solomon 4-group design, and then randomly assigned groups of subjects to treatment (McGahee & Tingen, 2000). Each school formed a group to minimize interaction during the teaching giving a sample size of 152 students. The teachers in the experimental schools were briefed on the use of OETLA while those in the control groups were expected to use conventional methods in the instructions. The study used the following instruments, a Student Mathematics Achievement Test (SMAT) and a Teacher's Guide (TG). The researcher sought expert opinion on the instruments in a secondary school in neighboring Manga Sub County, Kisii County with similar structures as the sampled schools. Content and Face validity was done by three Secondary school SMASSE trained mathematics heads of department, and three experts from the department of Curriculum Instruction and Education Management, Egerton University. The reliability co-efficient of Students Mathematics Achievement Test (SMAT) was calculated using Kuder-Richardson formula 21 (KR-21) (Gronlund, 1988). This is because the items were scored zero (0) for any wrong responses and one (1) for correct responses. This formula determines the reliability of the instrument in a single administration. The researcher sought permission from the Ministry of Education before the commencement of the study. Statistical Package for Social Sciences (SPSS) was used for data analysis. One-Way analysis of variance (ANOVA) and t-

test was used in testing the hypotheses at alpha(α) level 0.05. One way ANOVA is suitable where there are more than two groups and, t-test with only two groups (Amit, 2009). Since there is one factor (OETLA) and four groups, One way ANOVA was used to establish if there is any significant difference in Achievement between the students exposed to OETLA and those not exposed to it.

3 RESULTS AND DISCUSSIONS

Four groups were constructed in this study; two experimental groups and two control groups. Each school formed a group to minimize interaction during the teaching. Table 3 shows a summary of the students' distribution into different groups.

Table 3: Student distribution into different study groups

School	Group	Males	Females	Totals
Kenyoro	E1	25	15	40
Motonto	E2	23	12	35
Nyagesenda	C1	26	13	39
Entanda	C2	25	13	38
Totals	-	99	53	152

The experimental groups (E1 and E2) comprised the form four students from Kenyoro and Motonto secondary schools while the control groups (C1 and C2) comprised the students from Nyagesenda and Entanda secondary schools. There were 40 and 35 students in groups E1 and E2, respectively and 39 and 38 students in groups C1 and C2, respectively. Prior to treatment, subjects in experimental and control groups E1 and C1 were subjected to Students Mathematics Achievement Test (SMAT). This was meant to make it possible for the researcher to assess the homogeneity of the groups before treatment application. Table 4 summarized the SMAT pretest scores obtained by groups E1 and C1.

Table 4: Pre-test Mean Scores on Students Mathematics Achievements Test (SMAT) scores and T-test Results

Study groups	N	Mean	Std. dev.	df	t-test	p-value
Experimental 1 (E1)	40	48.81	7.73	7	1.08	0.194
Control 1 (C1)	39	42.73	7.42			

Mean Difference = 6.08, Critical T-value = 1.99

The results shown in Table 4 indicates that the differences between the mean scores of groups E1 and C1 on the SMAT was not statistically significant at 5% level. The t-test results shows that the p-value was less than 0.05 significance level. This implies that the groups were homogeneous and thus suitable for the study. Further comparison by gender of students on SMAT pretest scores was done and results summarized in Table 5.

Table 5: Comparison of SMAT pretest scores by gender of students

Gender	N	Mean	Std. Deviation	df	t-value	p-value
Male students	51	48.67	8.482	77	0.104	0.081
Female students	28	45.31	9.174			

Mean Difference = 3.36, Critical T-value = 1.99

Table 5 shows that the mean pre-test SMAT scores by males was 48.67 while that of females was 45.31. The results further indicate that the mean difference for the pretest SMAT scores obtained by male and female students was 3.36. The mean difference was however not significant at 5% level (the calculated t-value of 0.104 was less than the critical t-value of 1.99). This is an indication of homogeneity of the two gender groups and therefore the results are comparable. This study was to evaluate the effects of Open Ended Teaching and Learning Approach on students' mathematics achievement in Three Dimension Geometry. The use of mean gain analysis and T-test analysis was employed. The mean gain analysis results for E₁ and C₁ are shown in Table 6.

Table 6: Mean Gain Analysis on Students Mathematics Achievements Test (SMAT) scores

SMAT scores	E ₁	E ₂	C ₁	C ₂
Pre-test mean	48.81	N/A	42.73	N/A
Post-test means	57.64	49.72	44.92	41.53
Mean gain	8.83	N/A	2.19	N/A

The pre-test and post-test SMAT scores for E₁ were 48.81 and 57.64, respectively while that of C₁ were 42.73 and 44.92, respectively. The post-test scores for E₂ and C₂ were 49.72 and 41.53, respectively. These results show that the mean gain for E₁ SMAT post-test scores (8.83) is greater than that of C₁ (2.19). This may have been as a result of the treatment that was given to E₁. In order to determine if there existed a statistically significant difference in the mean gains in E₁ and C₁ the use of independent samples T-test analysis was employed. Table 7 shows the descriptive statistics on academic achievement (SMAT) for E1 and C1.

Table 7: Summary statistics for academic achievement (SMAT) mean gains between E1 and C1

Parameters	Mean	N	Std. Deviation	Std. Error Mean
E ₁ Mean scores gain	8.83	40	4.92	.682
C ₁ Mean scores gain	2.19	39	5.05	.700

The results in Table 7 shows that the mean score gain for E1 and C1 was 8.83 and 2.19. The difference in mean score gains between E1 and C1 was 6.64. Table 8 shows the T-test results of mean comparison between the E₁ and C₁ mean gains.

Table 8: T-test results for the Difference in Academic Achievement (SMAT) Mean Gains between E1 and C1

Parameters	N	Mean	Std. Deviation	df	t-value	p-value
E ₁ Mean scores gain	40	8.83	4.92	150	8.384	.000
C ₁ Mean scores gain	39	2.19	5.05			

Mean Difference = 6.64, Critical T-value = 1.98

The results in Table 8 shows that the mean difference in mean score gains between E1 and C1 was significant at 5% level (T-value = 8.384, P-value = 0.000). Students Mathematics Achievements Test (SMAT) mean scores gain for students

exposed to OETLA (E₁) of 8.83 was significantly higher than that of students not exposed to OETLA (C₁). The SMAT scores for groups E₁, E₂, C₁ and C₂ is summarized in Table 9. The post-test means for groups E₁ and E₂ was 57.64 and 49.72, respectively. On the other hand, the post-test means for groups C₁ and C₂ was 44.92 and 41.53, respectively.

Table 9: Summary statistics for academic achievement scores (SMAT) among the various groups

SMAT scores	N	Post-test means	Std. Deviation	Std. Error
E ₁	40	57.64	7.72813	.19460
E ₂	35	49.72	5.54772	.24495
C ₁	38	44.92	6.42066	.04410
C ₂	39	41.53	6.27748	.05916

The use of One Way Analysis of Variance (ANOVA) was employed to determine the existence of significant difference among the various groups (E₁, E₂, C₁ and C₂) together in order to determine the superiority of any of the two methods of teaching mathematics (traditional and OETLA) in the academic achievement (SMAT). The results are shown in Table 10.

Table 10: One Way ANOVA results for the difference in academic achievement scores (SMAT) among the various groups

Source of Variation	Sum of Squares	Df	Mean Square	F	P-value
Between Groups	1231.27	3	537.44	14.474	0.000
Within Groups	13.32	148	38.64		
Total	1244.59	151			

$$F\text{-Critical}_{(3, 148)} = 2.667, P < 0.05$$

The post-test results analysis for the SMAT scores shows that there was a statistically significant difference in academic achievements among the four groups. The calculated F-ratio (14.474) was higher than the critical value (2.667). The results indicate that experimental groups E₁ and E₂ (57.64, 49.72) achieved higher mean scores than the control groups C₁ and C₂ (44.92, 41.53) respectively. This shows that use of OETLA had an effect in academic achievement due to its improvement of SMAT scores as compared to traditional methods. A close analysis of Turkey post-hoc test results revealed that each of the post-test means was significantly different from the other at 5% level. These results are depicted in Table 11.

Table 11: Tukey's Post-hoc test results for the mean difference in post-test scores

Variable (I)	Variable (J)	Mean Difference (I-J)	Std. Error	Sig.
E ₁	E ₂	7.92*	.20137	.006
E ₁	C ₁	12.72*	.18057	.000
E ₁	C ₂	16.11*	.21944	.000
E ₂	C ₁	4.80*	.24890	.006
E ₂	C ₂	8.19*	.23669	.005
C ₁	C ₂	3.39*	6.42066	.044

* means significant at 0.05 level

Results from the Table 11 showed that groups E₁ and E₂, E₁ and C₁, E₁ and C₂, E₂ and C₁, E₂ and C₂ and groups C₁ and C₂ did show statistically significant difference in their SMAT post-test scores. This indicates that there was statistically significant difference between the four groups (C₁, C₂, E₁ and E₂). Since the mean difference in post-test SMAT scores between the groups E₁ and E₂ and groups C₁ and C₂ were statistically significant at 5% level, this study therefore rejected the null hypothesis that there was no statistically significant difference in academic achievement between students who are taught mathematics through OETLA and those who are not exposed to it. The use of OETLA resulted to a higher academic achievement as compared to the traditional method of learning mathematics. There was however a statistically significant difference in E₁ and E₂ as well as C₁ and C₂ due to teachers' poor mastery of content in the experimental group (E₂) and control group (C₂). Teachers in group E₂ and C₂ were skipping the topic on three dimension geometry and thus leading to low student performance. Mastery of content was responsible for differences in performance among various schools in Nigeria where the teachers' factor among other factors affected students' performance in Mathematics (Chika, 2011). The same scenario cuts across other African countries including Kenya (Miheso & O'Conner, 2000). In South Africa poor teachers' content and knowledge was found to contribute to poor performance in mathematics (Mji & Makgato, 2006). These results agree with Mahlobo (2007) whom on a study on effects of OETLA on grade II mathematics learners in two schools (one experimental and one control) noted that an open-ended approach towards teaching and learning of mathematics enhances understanding of mathematics by the learners. The monitored group outperformed both the control group and the unmonitored experimental group as far as average performance in the post-test was concerned. However, there was no statistical difference in performance between the unmonitored group and the control group. According to National Research Council (2004), higher educational achievement and enjoyment of the student can be enhanced by the use of OETLA. Similarly, SMASSE (2004) argued that use of OETLA can increase performance of students in mathematics since it arouse interest (motivation) through its great emphasis on group activities and use of models. Githua and Mwangi (2003) observed that OETLA enhances mathematics achievement through learners perceived probability of success in the subject. In Tharaka south, lack of use of OETLA contributed to poor performance (Eric & Gakii, 2013). This scenario is no different in particular Kisii County where there has been relatively lower performance in mathematics as shown in the K.C.S.E results (KNEC, 2013) where OETLA is not adequately implemented though being among the SMASSE piloted project districts.

6 CONCLUSIONS AND RECOMMENDATIONS

There was a statistically significant difference in academic achievement between students who are taught mathematics through OETLA and those who are not exposed to it. The use of OETLA resulted to a higher academic achievement as compared to the traditional method of learning mathematics. This study recommends that mathematics teachers in secondary schools should pay greater attention to the ways in which their chosen approach of teaching can become more problem solving and where the students are offered an

opportunity to integrate the skills they already have, learning discussions and then extend it to new problems. The use of OETLA can enhance students' academic performance in the subject. OETLA make use of concrete experiences which includes hands on activities. This encourages more learning activities which calls for creativity and improvisation making mathematics a practical subject. This aspect ensures proper planning of the teaching and learning activities which will promote the classroom content delivery. Thus, the curiosity and attention of the learners is aroused which in turn will improve their performance.

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