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Effects Of Graphic Organizers Experiential Teaching Approach On Secondary School Students' Achievement In Chemistry In Nakuru North Sub-Co Unty, Kenya

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ABSTRACT: The purpose of the study was to investigate the effects of Graphic Organizers Experiential Teaching Approach on students' achievement in Chemistry. The study involved quasi experimental research in which Solomon Four Non–Equivalent Control Group Research Design was used. The study sample comprised 216 Form Two chemistry students in four secondary schools in Nakuru North Sub-County. Purposive sampling was used for the four streams comprising 53, 51, 57 and 55 students in a class. In the experimental groups, GOETA was used while Traditional Teaching Methods (TTM) were used in control groups. Two groups were pre-tested prior to implementation of GOETA. After four weeks, all groups were post-tested using Chemistry Achievement Test (CAT). The instrument was validated and pilot tested before use for data collection to measure Student's achievement in Chemistry. A reliability coefficient of 0.846 for CAT was obtained and was accepted since it was above the threshold of 0.7. The data was analysed using t-test, one way ANOVA and ANCOVA at a significance level of $\alpha = 0.05$ level of significance. The findings show that the students exposed to GOETA had higher achievement than those taught through TTM, while gender had no significant influence on achievement. This implies that if the new approach is incorporated into chemistry teaching, the imbalance in performance between boys and girls would be checked hence improving overall achievement of students in chemistry.

Key Words: Graphic Organizers Experiential Teaching approach (GOETA), Tratitional Teaching Methods (TTM), Secondary School Students, and Achievement in Chemistry.

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I. INTRODUCTION

Chemistry is a practical subject which equips students with concepts and skills that come in handy in solving problems in life (Derek 2007). Chemistry is one subject that interfaces with practically all the other science subjects. It is therefore a universal dynamic and practical oriented subject that arouses interests of students when working in laboratory environment. Chemistry is bedrock of science and technology which every nation strive to attain and advance in. It is one of the basic subjects for the physical science, agriculture, biochemistry, microbiology, pharmacy, medicine, metallurgy and all the fields of engineering. Despite the important potentials embedded in learning chemistry and its importance to mankind the efforts of researchers to improve the quality of its teaching and learning especially at the secondary level has not been very fruitful (Oluwatson, & Ongechi, 2014). The performance of students in Secondary Chemistry in Kenya Certificate of Secondary Education (KCSE) in recent times is not impressive.

Although Chemistry is a key science subject in secondary school curriculum in Kenya, Kenya National Examinations Council (KNEC, 2014) reports that there is low achievement in chemistry at Kenya Certificate of Secondary Education (KCSE). This is an indication that mastery of scientific concepts has been faced with challenges with a major concern being in Chemistry. Though chemistry knowledge has the potential of making positive contributions to a nation's social and economic development the performance has been poor and this may be a challenge to the achievement of vision 2030 in Kenya. Table 1 indicates low achievements in science subjects at KCSE, (KNEC, 2012). Chemistry students continue to perform dismally and there is a worrying gender disparity in favour of boys in the National Examinations. Table 1 also shows students achievement by gender in 2009 - 2013 KCSE examinations in Science subjects. It shows the number of students who sat for the examination and the mean percentage for girls and boys in the three subjects, namely Biology, Chemistry and Physics.

Table 1 : Candidate's National Performance by Gender in, 2009- 2013 KCSE Science Examinations.

Year	Subject	Female		Male	
		No. Sat	Mean %	No. Sat	Mean %
2009	Biology	143,359	25.15	155,943	29.08
	Chemistry	149,755	17.56	179,167	20.43
	Physics	29,233	29.93	74,955	31.88
2010	Biology	148,729	26.99	166,334	31.24
	Chemistry	155,725	22.80	191,653	26.62
	Physics	29,964	33.46	79,108	35.76
2011	Biology	170.764	30.07	193.053	34.53
	Chemistry	179.645	21.47	223.462	25.42
	Physics	32.489	34.55	87.604	37.42
2012	Biology	183,595	24.36	205,926	27.86
	Chemistry	193,426	25.95	237,293	29.54
	Physics	32,295	36.22	87,329	38.48
2013	Biology	190,334	30.15	206,980	32.99
	Chemistry	200,735	23.08	239,206	26.30
	Physics	32,703	38.19	87,159	40.82

KNEC REPORT, (2010 - 2014).

Analysis of candidate's performance in KCSE in the years 2009 - 2013 shows low achievement in Chemistry. The performance in chemistry has low scores compared to other Science subjects while boys seem to perform better than the girls. This poor performance in Chemistry may be attributed to lack of use of innovative teaching approaches by teachers, inadequate skills and understanding of chemistry concepts and inability to use technical terms in scientific communication (KNEC, 2012). The report of KCSE annual report (KNEC (2014) also cites the inability of students to use technical terms in answering questions and writing practical reports as a course of the poor performance in Chemistry. According to KNEC, this is an area in which students experience a lot of difficulties. There is therefore a need to seek other effective methods of instruction over the traditional ones so that pupils could better understand Chemistry concepts and this may improve performance in the subject.

The factors contributing to low achievement in chemistry in KCSE includes ineffective teaching approaches that are teacher rather than student-centred, inadequate mastery of teaching subject content by some teachers, inadequate teaching and learning resources such as text books, audio-visual and laboratory equipment and apparatus (Muraya & Kimamo, 2011). Table 2 shows overall students achievement in KCSE in Nakuru North Sub-County in the years 2010 - 2014. The table indicates poor mean points achieved by students being way below the maximum 12 points.

Table 2: Candidates Performance in KCSE Chemistry in Nakuru North Sub-County in the Years 2010 – 2014

Year	**Total Enrolment**	**Mean points**	**Maximum points**
2010	3050	3.700	12
2011	3195	4.423	12
2012	3233	4.560	12
2013	3585	4.096	12
2014	3477	4.811	12

Source: KNEC (2013, 2015)

Table 2 indicates fluctuating chemistry mean scores in the Sub-County. These mean scores are not only poor but, there is a drop for the year 2012-2013 from 4.560 to 4.096. These results indicate lack of mastery of chemistry concepts hence raising the concern to educators. TTM are predominant in teaching chemistry in

secondary schools. Innovative learning strategies could be used by teachers at all levels of chemistry education to enhance the student's self-concept to learn chemistry (Hanson & Wolf Skill, 2000; Eybe & Schmidt, 2004). Graphic organizers experiential teaching approach (GOETA) is a hybrid teaching strategy linking the application of graphic organizers and experiential learning in teaching of Chemistry. GOETA is a teaching strategy where the learners use graphic organizers and get actively involved in the process of learning.

GOETA could be of particular interest to Chemistry teachers to try and improve achievement in chemistry This would help learners to remember, analyse relationships, comprehending, problem solving, gain conceptual and holistic understanding more quickly (Johnson, 1992a; Johnson & Thomas, 1992; Satchwell, 1996; West, Fanner & Wolf , 1991). The students learn more deeply when they construct their own graphic organizers thereby learning by doing than when graphic organizers are provided (Stull & Mayer, 2007).

GOETA strategy is a learner centred approach presented in this study could be used by teachers to provide a smooth transformation from TTM to learner centred teaching strategies. GOETA could be of particular interest to Chemistry teachers to try and improve achievement in chemistry. This would help learners to remember, analyse relationships, comprehending, problem solving, gain conceptual and holistic understanding more quickly (Johnson, 1992a; Johnson & Thomas, 1992; Satchwell, 1996; West, Fanner & Wolf , 1991). The students learn more deeply when they construct their own graphic organizers thereby learning by doing than when graphic organizers are provided (Stull & Mayer, 2007). The GOETA teaching approach encourages learning by doing rather than by viewing.

Graphic Organizers are series of visual charts and tools used to represent and organize a student's knowledge or ideas (Cassidy, 1991). Graphic Organizers are a form of Advance organizers which are super ordinate concepts with which learners can subsume the new material and relate it to what they already know (Lefrancois, 1997). They are presented at the introductory stage of a lesson. In general, advance organizers can be presented in the form of written text, graphic form, utilize audiovisual support. Advance organizers are especially useful when the material is not well organized and the learners' lack knowledge needed to be able to organize it well for themselves (Ausubel, 1968). The substantive content of a given advance organizer or a series of advance organizers is selected on the basis of its appropriateness for explaining and integrating the material it precedes (Ausubel,1967).GOETA can be integrated in experiential learning by doing and experience. The use of learner-centred teaching approaches results in better achievement of instructional objectives because they promote imaginative, critical and creativity skills (Ministry of Education, 2001).

Experiential learning process is a hands-on collaborative and reflective learning experience in Chemistry which helps the student to learn new skills and knowledge (Hayness, 2007).

During each step of the experience, students usually engage in active experimentation, gain concrete experience with the content, the instructor and with each other as well as in experiential learning situations cooperate and learn from one another in a more semi-structured approach. Experiential learning is a philosophy and methodology in which educators purposefully engage with students in direct experience and focused reflection enable students to acquire knowledge, develop skills, and clarify values (Wurdinger & Carlson, 2010). Experiential education focuses on problem solving and critical thinking rather than memorization and rote learning during the classroom activities. A report by the Association for Experiential Education (AEE) explains that experiential learning is part of an educator's teaching process; the students should be actively involved in the learning process through group work discussions, hands on participation and applying information outside the classroom.

STATEMENT OF THE PROBLEM

The Students performance in chemistry at the Kenya Certificate of Secondary Education (KCSE) has been poor and their self-concept in Chemistry is also low. The instructional approaches used in teaching chemistry have not improved students' achievement in chemistry. GOETA is an approach that can improve students' achievement. However, its effects on students' achievement and self-concept in the subject have not been established. This study therefore was used to investigate the use of GOETA on students' achievement in form two Chemistry.

OBJECTIVES OF THE STUDY

The objectives of the study were: -

i. To determine the effects of GOETA on students' achievement in chemistry and those not exposed to it.
ii. To determine if there is gender difference in students' achievement when taught using GOETA.

HYPOTHESES OF THE STUDY

To achieve these objectives, the following null hypotheses were used at 0.05 alpha level of significance.

H_O1: There is no statistically significant difference in achievement in Chemistry between students taught using GOETA and those taught using TTM methods.

Ho2: There is no statistically significant gender difference in achievement in chemistry among students exposed to GOETA.

CONCEPTUAL FRAMEWORK

The conceptual framework of the study was based on the assumption that the blame for a students' failure depends on the quality of instruction and not lack of students' ability to learn (Bloom, 1981; Levine, 1985). Figure 1 shows the relationship between the variables, the effects of GOETA on students' achievement in chemistry in secondary schools in Nakuru North Sub-County.

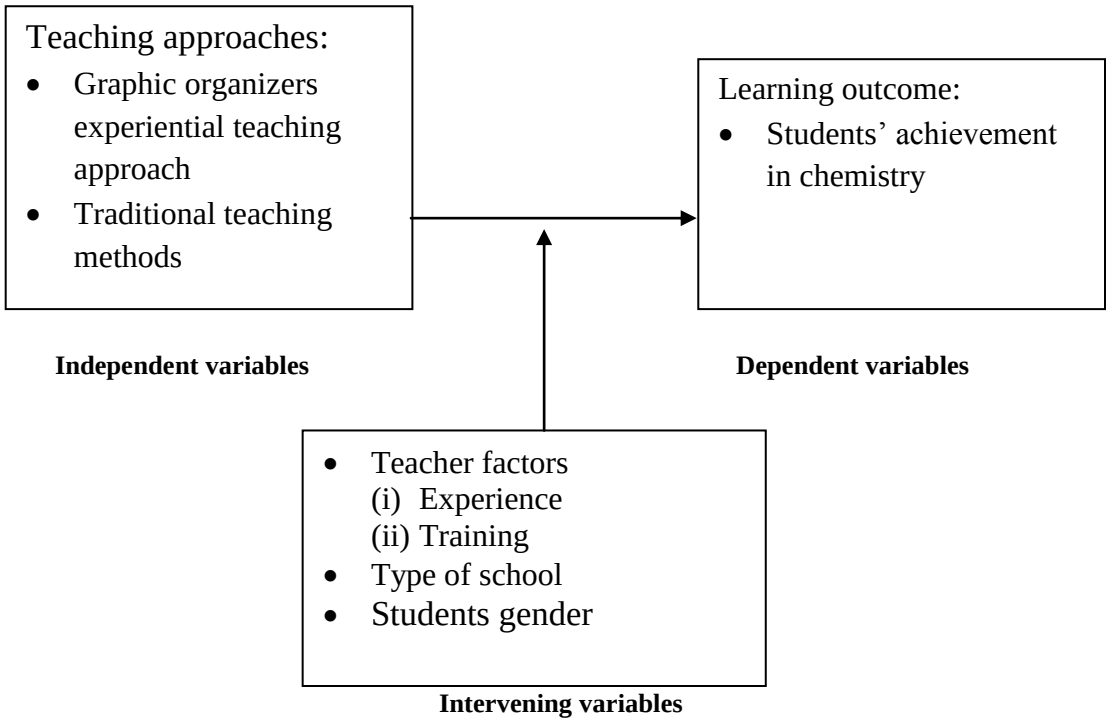

Figure 1: Conceptual framework showing how variables in the study interact.

The conceptual framework represented in Figure 1 shows the relationship between variables for determining the effect of using GOETA on secondary school students' achievement in chemistry. The independent variables were the teaching approaches used in the application of GOETA. The dependent variables were the learning outcomes after application of GOETA. Intervening variable are the various factors that may influence the learning outcomes and they include; teacher experience and training, type of school, learner's academic ability, student's gender and classroom environment. To control these variables, the study involved qualified chemistry teachers with a minimum of two years teaching experience.

The classroom environment was controlled by involving co-educational schools where boys and girls learn together in the same classroom. The type of school was controlled by involving Sub-County secondary schools attended by learners of comparable academic ability in the County. The effect of student gender was studied in the research process.

II. RESEARCH METHODOLOGY

The study involved quasi-experimental research involving the Solomon Four Non-Equivalent Control Group Design (Gall, Borg & Gall, 1996) .The design was preferred because the Form Two classes involved in the study remained intact as the school authorities do not allow randomization process by reconstituting and disrupting classes during the administration of the treatment (Coolican, 1999). The design is considered sufficiently rigorous and appropriate for quasi-experimental studies (Frankel & Wallen, 2000). It assesses the plausibility of pre-test sensitization effects, that is, the mere act of taking pre-test influences scores on subsequent test administration (Clark & Elen, 2006). It also ensures that administration of pre-test to two groups and post-test to all four groups (Gall, Borg & Gall, 1996; Wachanga & Mwangi, 2007). Solomon Four- Non- Equivalent Control Group Research Design is represented by Figure 2:

The Solomon Four Non- Equivalent Control Group Research Design is as follows: -

GROUP I (E 1)	O_1	X	O_2
GROUP II (C 2)	O_3	-	O_4
GROUP III (E 1)	-	X	O_5
GROUP IV (C 2)	-	-	O_6

Source: Gall, Borg & Gall (1996)

Figure2: Solomon Four Non-Equivalent Control Group Research Design

Key:

Where: O_1 and O_3 are pre-tests;

O_2, O_4, O_5 and O_6 are post-tests;

(O) indicates the observations or outcomes;

X is the treatment where students were taught using graphic organizers experiential teaching approach (GOETA);

(----) indicates the use of non-equivalent groups that existed as intact groups;

(-) means no treatment (Mugenda & Mugenda, 1999; Gall, Borg & Gall, 1996).

Group1 (E 1) is the experimental group. This group received the pre-test, the treatment X and the post-test.

Group II (C 1) is the control group, which received a pre-test followed by the Control condition and finally a post-test.

Group III (E 2) received the treatment X and a post-test.

Group IV (C 2) received the post-test only.

Group II (C 1) and IV (C 2) were taught using traditional teaching methods.

Population of the Study

The target population in this study was secondary school students in Sub-County public schools in Nakuru North Sub-County, Kenya. The accessible population was Form Two chemistry students in the Sub-County. Form two students were considered appropriate for this study because they were exposed to the secondary school science curriculum for one year hence are considered to be adjusted to secondary school curriculum.

Sampling Procedure and Sample Size

Purposive sampling technique was used to select four Sub-County secondary schools in Nakuru North Sub-county to ensure that Students involved had comparable academic abilities that formed the study sample. Purposive sampling was necessary to be able to select the four public co-educational Sub-County secondary schools in Nakuru North Sub-County. Simple random sampling was used in schools with more than one Form Two streams. The sample had 216 Form Two students. The streams comprised of (E1) 53, (E2) 51, (C1) 57 and (C2) 55 students in each class that participated in the study. The treatment period was four weeks.

Instrumentation

The study used Chemistry Achievement Test (CAT) instrument for assessing students' achievement. The CAT) was developed by the researcher to measure student's achievement in chemistry. The test items offered consisted of 30 items with different scores ranging from 1-4 with a maximum score of 80 marks from the topic of structure and bonding in Form Two. The CAT was then pilot-tested in two co-educational county schools with similar characteristics as the sample schools from Nakuru Sub-County. The CAT was then administered as a post-test for comparison purposes.

Reliability of the Research Instruments

The CAT was pilot-tested in two secondary schools in Nakuru East Sub-County that were not part of the study but with similar characteristics. Pilot testing of the research instruments in the neighbouring Nakuru East Sub-county was done so as to minimize chances of contamination during treatment period**.** The reliability of CAT was estimated with the use of Cronbanch's alpha coefficient (Wiersma & Jurs, 2009). This was considered appropriate because the research instruments used consisted of items on which different scoring weights are assigned to different test items. The instrument was administered once

Construction and use of Instructional Teaching Module

An instructional manual for chemistry teachers to use during treatment period was developed by the researcher. It was validated by teachers trained and experienced in marking of Chemistry with the Kenya National Examinations Council (KNEC). The treatment period was four weeks that was enough to teach the topic of structure and bonding before the pre-test was administered to, experimental group E1 and control group C1. The scores obtained were used for data analysis. The post-test was administered to all the four groups at the end of the treatment period.

The teachers of the experimental groups were trained by the researcher on the skills of graphic organizers experiential teaching approach for one week. The teachers of the experimental groups taught the students using GOETA approach on the topic of structure and bonding for four weeks to enable them master the skills. The teachers of the experimental groups guided the students to brainstorm the Chemistry concepts by constructing the graphic organizers in groups. The teacher then guides the students to form groups for discussion of various concepts in respective sub-topics of structure and bonding. The teacher then discussed the graphic organizers presented by different groups in the class with students before moving to a new sub topic. The control groups were taught using Traditional teaching methods. At the end of the treatment period a post-test was administered to all the groups E1, E2, C1 and C2. The sampled schools with more than one Form Two stream had all the students in that school taught using a similar teaching approach.

Data Collection Procedures Data Analysis

An introductory letter from Egerton University Graduate School was presented to the National Commission for Science, Technology and Innovation (NACOSTI) for them to grant a research permit for the researcher to conduct the study. The researcher approached the Sub-County director of education, the school principals and the chemistry teachers to allow the study be carried out in the sampled schools.

The CAT was used to collect data with the assistance of chemistry teachers in the schools. The researcher administered the post-tests to the groups and then scored quantitatively. The scores obtained were used for data analysis at the end of the treatment period of four weeks. Quantitative Inferential methods of data analysis of one-way ANOVA and analysis of Covariance ANCOVA and t-test were used with the help of statistical package for social sciences (SPSS). A significance level of $\alpha = 0.05$ was used as a test significance

III. RESULTS AND DISCUSSION

Pre-test Analysis

The Solomon four – Group Design used in this study enabled the researcher to assess the homogeneity of the groups before treatment application (Gall et al., 1996). This arrangement was preferred because it enabled the researcher to find out the effect of pre-test on the pre-tested groups, experimental group E1 and control group C1 and if the groups were similar before the administration of treatment. Differences in Chemistry Achievement Test (CAT) Pre-test mean scores between groups C1 and E1are shown in Table 3.

Table 3: Comparison of CAT Pre-test Mean Scores by Learning Approach

Scale	Group	N	Mean	SD	Df	t-value	ρ-value
CAT	E1	50	6.93	4.58	98	4.906	.000*
	C1	50	3.08	3.14			

The t-test results in Table 3 show that the achievement mean score (M= 6.93, SD = 4.58) for E1 was higher than that (M = 3.08, SD = 3.14) for C1.

The results further indicate that difference between the two means was statistically significant at .05 level, $t(98) = 4.906$, $p<.05$. These results of pre-test CAT significance difference should not be as the research design assumes that the groups are comparable at point of entry. These results may be probably due to sampling. The results show that performance of school E1 in the subject is high. This may be attributed to school factors like learning resources and environment. There is therefore need to carry out ANCOVA in this study. Differences by Gender in Chemistry Achievement Test (CAT) pre-test mean scores are presented in Table 4.

Table 4: Comparison of CAT Pre-test Mean Scores by Gender

Scale	Group	N	Mean	SD	Df	t-value	ρ-value
CAT	Male	51	4.63	4.40	98	-.883	.379
	Female	49	5.40	4.32			

The results in Table 4 indicate that the mean (M= 5.40, SD = 4.32) score of the females was higher than that (M = 4.63, SD = 4.40) of their male counterparts. The results also indicate that the difference between the two means was not statistically significant, t(98) = -.883, p>0.05. The analyses of CAT pre-test mean scores reveal that the male and female students' achievement were comparable at the point of entry.

Effects of GOETA on Students' Achievement in Chemistry

Objective one was to determine the relative effects of GOETA teaching approach on students' achievement in chemistry, an analysis of students' post-test mean scores in Chemistry CAT was carried out. The corresponding hypothesis H_O1 stated that there was no statistically significant difference between secondary school students' taught using GOETA approach and those not exposed to it. To test this hypothesis the analysis of post-test CAT means scores was carried out. Table 5 shows the CAT post-test mean scores obtained by students.

Table 5: CAT Post-test Mean Scores and their Standard Deviations

Group	N	Mean Max = 80	SD
E1	47	47.27	17.70
E2	51	41.31	8.00
C1	47	25.02	9.93
C2	55	19.95	5.58

The results reveal that the mean scores of the experimental groups E1 (M = 47.27, SD = 17.7) and E2 (M = 41.31, SD = 8.00) were higher than those of the control groups C1 ((M = 25.02, SD = 9.93) and C2 (M = 19.95, SD = 5.58). The results suggest that students exposed to GOETA performed better than their counterparts taught using traditional teaching approaches. To find out whether the CAT post-test mean scores were significant, analysis of one way ANOVA was carried out. The results of the one way ANOVA based on these mean scores are shown on Table 6.

Table 6: ANOVA of Post-test Mean Scores on CAT

Scale	Sum of Squares	Df	Mean Square	F-ratio	p-value
Between Groups	25442.46	3	8480.820	69.732	.000*
Within Groups	23837.52	196	121.620		
Total	49279.98	199			

The results of the ANOVA indicate that the difference in mean scores among the four groups E1, E2, C1 and C2 was statistically significant at the .05 level. The results of ANOVA test only show differences among a group of more than three variables, it does not reveal where the differences are. There was need to conduct further analysis on the combination of means to reveal where the differences occurred (post-Hoc tests). There are several Post-Hoc procedures in use depending on the comparisons of interest. Use of Scheffe's procedure with $\alpha = 0.05$ for example, guarantees that the probability of any false rejection among all comparisons made is no greater than 0.05.

This is much stronger protection and controlling the probability of a false rejection at 0.05 for each separate comparison (Tabachnich & Fidel, 2007). In this study, the Scheffe's Post-Hoc procedure was used. The results of Scheffe's multiple comparisons for CAT post-test was conducted to reveal where the differences were as indicated in Table 7.

Table 7: Scheffe's Post-hoc Pair-wise Comparison of the Four Groups

Paired Group	Mean Difference	p-value
E1 versus E2	5.95	.071
E1 versus C1	22.24	.000*
E1 versus C2	27.31	.000*
E2 versus C1	16.29	.000*
E2 versus C2	21.36	.000*
C1 versus C2	5.07	.152

*Significant at .05 level

The results of the multiple comparison show that there were significant differences between pair groups E1-C1 ($p<.05$), E1-C2 ($p<.05$), E2-C1 ($p<.05$) and E2-C2 ($p<.05$). However the differences between E1-E2 ($p>.05$) and C1-C2 ($p>.05$) were not statistically significant. Thus the Experiential groups (E1 & E2) outperformed the control groups (C1 & C2) because of exposure to GOETA as shown in Table 7.

The results of the ANOVA test revealed that there were significant differences among the groups in favour of E1 and E2. These results are not conclusive because ANOVA does not have features for levelling out initial differences. It should be noted that this study employed the Solomon four research design that pre-test only E1 and C1. This means that the entry behaviour of C2 and E2 was not known. Further tests were done using the ANCOVA to mitigate for this weakness. The ANCOVA analysis was conducted using the KCPE scores as the covariate Table 8 shows the adjusted CAT post-test mean scores. The results of adjusted CAT post-test mean scores with KCPE as the covariate are shown in table 8.

Table 8: Adjusted CAT Post-test Mean Scores with KCPE as the Covariate

Group	N	Mean	SE
E1	47	43.40	1.69
E2	51	38.02	1.59
C1	47	30.81	1.89
C2	55	21.38	1.43

The results in Table 8 reveal that the mean scores of the experimental groups E1 ($M = 43.40$, $SE = 1.69$) and E2 ($M = 38.02$, $SE = 1.59$) after adjustments by the covariate were higher than those of the control groups C1 (($M = 30.81$, $SE = 1.89$) and C2 ($M = 21.38$, $SD = 1.43$).

The main threat to internal validity of non-equivalent control group experiments is the possibility that group differences on the post-test may be due to initial or pre-existing group differences rather than to treatment effect (Gall et al., 1996). Since this groups involved non-equivalent control groups it was necessary to confirm the above results by carrying out analysis of covariance (ANCOVA) by comparing with students' Kenya Certificate of Primary Education (KCPE) scores as the covariate. ANCOVA reduces the initial group differences statistically by making compensating adjustments to the post-test means of the groups involved. (Gall et al., 1996; Borg & Gall,1989). The results of the ANCOVA analysis that was used to determine whether the differences among the means are statistically significant are given in Table 9.

Table 9: ANCOVA Test Results Comparing CAT Post-test Mean Scores by Learning Approach

Source	Type III Sum of Squares	Df	Mean Square	F-ratio	p-value
KCPE Scores	2848.86	1	2848.861	26.468	.000
Learning approach	10920.67	3	3640.222	33.82	.000*
Error	20988.66	195	107.634		
Total	267212	200			

The ANCOVA test results indicate that the difference among the groups E1, E2, C1 and C2 were statistically significant at the .05 level, $F(3,195) = 33.82$, $p<.05$.

The multiple comparison (Post Hoc) test was conducted to reveal where the differences were. The multiple comparison test results are shown in Table 10.

Table10: ANCOVA Scheffe's Post-Hoc Comparisons on CAT Mean Scores

Paired Group	Mean Difference	p-value
E1 versus E2	5.38	.011*
E1 versus C1	12.59	.000*
E1 versus C2	22.02	.000*
E2 versus C1	7.21	.009*
E2 versus C2	16.64	.000*
C1 versus C2	9.43	.000*

* - The mean difference is significant at 95% confidence level.

The results of the multiple comparison test show that there were significant differences between all the pair groups E1-E2 (p<.05), E1-C1 (p<.05), E1-C2 (p<.05), E2-C1 (p<.05), E2-C2 (p<.05) and C1-C2 (p<.05).
The results of the ANOVA and ANCOVA tests were rather contradictory. The ANOVA showed that E1 and E2 were comparable while ANCOVA revealed that the difference between the two groups was statistically significant.
Consequently, further analysis was done by comparing the mean scores of the control (C1 and C2 combined) and experimental (E1 and E2 combined) groups using the t-test. The results of comparison of the students' chemistry achievement post-test mean scores between the experimental and control groups are shown in Table 11.

Table 11: Comparison of the Students' Chemistry Achievement Post-test Mean Scores between the Experimental and Control Groups

Group	N	Mean	SD	Df	t-value	ρ-value
Experimental	98	44.17	13.81	198	13.539	.000*
Control	102	22.29	8.25			

The t-test results reveal that the mean (M = 44.17, SD = 13.81) of the experimental group was higher than that (M = 22.29, SD = 8.25) of the control group.
The results further reveal that the difference between the means of the two groups was statistically significant at the .05 level, in favour of the experimental group, t(198) = 13.539, p<.05.

Gain analysis - groups C1 and E1

Gain analysis examines the learning achievement levels of E1 and C1 before and after the program and tries to explain improvements in learning outcomes as measured by the mean scores in Table 12.

Table 12: Students' CAT Pre-test and Post-test Mean Scores, Standard Deviations and Mean Gains by Learning Approach

Stage	Scale	Group	
		E1 n = 47	**C1 n = 46**
Pre-test	Mean	6.93	3.08
	Standard Deviation	4.58	3.14
Post –test	Mean	47.27	25.02
	Standard Deviation	17.17	9.93
	Mean Gain	**37.34**	**21.94**

The results in Table 12 reveal that the CAT pre-test mean (M = 6.93, SD = 4.58) of E1 was higher than that (M = 3.08, SD = 3.14) of C1. The results further shows that the difference between the two means were statistically significant. After the treatment, the mean (M = 47.27, SD = 17.17) of E1 was still higher than that (M = 25.02, SD = 9.93) of C1.
The result also reveal that the mean gain of E1 (M = 37.34) was higher that (M = 21.94). This means that improvement in learning outcomes of the experimental group E1 was higher than that of the control group C1. The t-test was used to establish whether the difference in the two mean gains were statistically significant. The results of differences in mean gains of CAT between E1 and C1 are indicated in Table 13.

Table 13: Differences in Mean Gain on CAT between E1 and C1

Group	N	Mean Gain	SD	Df	t-value	ρ-value
E1	47	37.34	14.38	91	7.606	.000*
C1	46	21.94	8.19			

* Significant at .05

The t-test results show that the difference between the mean gains of E1 (M = 37.34, SD = 14.38) and C1 (M = 21.94, SD 8.19) was statistically significant at the .05 level, in favour of the experimental group, t(91) = 7.606, p<.05. This means that the experimental group had a higher improvement in learning outcomes as measures by the mean gain. That high improvement in the experimental group can be attributed to the treatment. The results of CAT post-test analysis revealed that the difference among the means scores of groups C1, E1, C2 and E2 were statistically significant. On the basis of these results the first hypothesis H_O1, which stated that there is no statistically significant difference in achievement in Chemistry between Students taught using GOETA and those not exposed to GOETA was rejected.

Difference in Chemistry Achievement Test between Boys and Girls Taught using GOETA

Objective three was aimed at finding the gender difference in achievement when students were exposed to GOETA teaching approach. The corresponding hypothesis H_O3 stated that there was no statistically significant difference in chemistry achievement of boys and girls who are taught through GOETA teaching approach. Table 14 shows the post-test CAT mean scores for boys and girls and boys who were exposed to GOETA teaching approach.

Table 14: Differences by Gender in CAT Post-test Mean Scores of Students Exposed to GOETA

Group	Gender	N	Mean	SD	Df	t-value	ρ-value
Experimental	Male	53	44.11	13.63	96	.043	.966
	Female	45	44.23	14.17			

Experimental group – The mean score (M = 44.23, SD = 14.17) of the females was slightly higher than that (M = 44.11, SD = 13.63) of the males. The difference between the two means was however not significant at .05 level, t (96) = .043, p>.05.

Further test were done using ANCOVA.

Rationale – entry behaviour of E2 was not known given that they were not pre-tested. The ANCOVA test was conducted using KCPE scores as the covariate. The adjusted mean scores are contained in Table 15.

Table 15: Adjusted CAT Post-test Mean Scores with KCPE as the Covariate

Group	Gender	N	Mean	SE
Experimental	Male		42.82	1.83
	Female		45.76	1.99

Experimental group - Adjusted mean score (M = 45.76, SE = 1.99) of the females was higher than that (M = 42.82, SE = 1.83) of the males.

The ANCOVA test was conducted to establish whether the difference between the adjusted achievement mean scores of the male and female students was statistically significant. Analysis of post-test CAT mean scores by gender using ANCOVA is shown in Table 16.

Table 16: Comparison of CAT Post-test Mean Scores of Students Exposed to GOETA by Gender

Group	Source	Type III Sum of Squares	Df	Mean Square	F-ratio	p-value
Experimental	KCPE Scores	2275.763	1	2275.763	13.335	.000
	Learning approach	193.194	1	193.194	1.132	.290
	Error	16212.36	95	170.656		
	Total	209671.3	98			

Experimental group

The ANCOVA test results indicate that the difference between the male and female students mean scores was not statistically significant at the .05 level, F(1,95) = 1.132, p>.05. From Table 15 and 16, it can be concluded that the mean scores for boys and girls exposed to GOETA are not significantly different. The results indicate that there is no statistically significant gender difference in achievement when students' are exposed to GOETA. Hypothesis H_O2 is therefore accepted; there is no statistically gender difference in achievement when students are exposed to GOETA.

Results of pre-tests

The use of Solomon four-group design enabled the researcher to assess the presence of any interaction between pre-test and the GOETA treatment, determine the effect of the pre-test relative to no pre-test and generalize to groups which did not receive the pre-test (Wachanga, 2002; Borg & Gall, 1989).

In this study, students were put in four groups such that:

Group E1 was the experimental group, which took the pre-test Group C1 was the control group, which took the pre-test

Group E2 was the experimental that did not take the pre-test

Group C2 was the control group that did not take the pre-test.

The Groups E1 and C1 sat for the pre-test in CAT, which made it possible for the researcher to assess the homogeneity of the groups before treatment application (Gall et al., 1996). If the pre-tests interact with the treatment condition, a greater difference in the post-test scores is expected between groups E1 and C1 than between E2 and C2.

This is due to the fact that a sensitisation effect implies that the pre-test facilitates the learning of the experimental group but not the control group. In this study, the post- test achievement and students' chemistry self-concept did not indicate any interaction between the pre-test and the GOETA treatment.

A comparison of E1and C1 students' pre-test CAT mean score showed statistically significant differences $t(98) = 4.906$, $p<.05$. This shows that the groups were not similar before the treatment started. The results indicate that E1 and C1 were not comparable on CAT before commencement of the study. This was attributed to the fact that the study employed non-equivalence control group design.

This difference in pre-test CAT mean scores may have been contributed by school factors like school culture, classroom environment, better dedicated teachers and the teaching methods they use, availability or better learning resources in the E1 school. To address the initial differences in the groups, analysis of covariance (ANCOVA) was used to make statistical adjustments for any experimental error.

The Effects of GOETA on Students' Achievement in Chemistry

Hypothesis $H_0$1sort to find out if there was statistically significant difference in achievement between those taught through GOETA and those taught through traditional teaching methods. To test the hypothesis, analysis of the students' post-test CAT scores was carried out.

The main threat to internal validity of non-equivalent control group experiment is the possibility that the group differences on the post-test may be due to initial or pre-existing group differences rather than the treatment effect (Gall et al., 1996). Since this study involved non-equivalent control groups it was necessary to confirm the results by performing analysis of covariance (ANCOVA) using the students' Kenya Certificate of Primary Education (KCPE) scores as the covariate. ANCOVA reduces the effects of initial group differences statistically by making compensating adjustments to the post-test means of groups involved (Gall et al 1996; Borg & Gall, 1989).

The results indicate that students who were taught using GOETA approach achieved significantly higher scores in CAT than those taught using TTM approaches. This then implies that the GOETA teaching approach was more effective in enhancing student's achievement than the TTM approaches.

When the two experimental groups E1 and E2 are found to be similar in the post test but dissimilar to the control groups C1 and C2, the researcher may then attribute the differences to the treatment condition (Wachanga, 2002; Gall et al., 1996). Students who had higher achievement in KCPE, considerably improved after learning through GOETA approach. The lower achievers were assisted in learning by the higher achievers who continued doing well in their experiential learning.

An earlier study by Stull and Mayer (2007) of students learning by experience shows that the students learn more deeply when they construct their own graphic organizers. This teaching approach helps to activate prior knowledge to provide conceptual flame work for integrating new information and would this would lead to meaningful learning. The findings of Wachanga, Arimba & Mbugua (2013) that showed that the use advance organizers in the teaching learning process has significant positive effect on students' chemistry achievement than the regular teaching methods are in agreement with this study. If secondary schools in Kenya implemented this method in learning of chemistry, the students' achievement and especially in co-educational secondary schools are encouraged to use this method in their teaching. According to Kibos, Wachanga & Changeiywo (2015) the students would remember better what they participated in doing because they involve more science organs than just their prior knowledge in meaningful learning and knowledge construction.

The Effects of GOETA on the Achievement of Boys and Girls.

This study aimed at investigating the effect of GOETA on achievement of boys and girls in chemistry. Hypothesis H_O2 of the study sought to establish whether there is statistically gender difference in achievement in chemistry among students exposed to GOETA teaching approach. The results of these students have shown that there is no statistically significance difference between the achievement of boys and girls who are exposed to GOETA Teaching approach. In Kenya, comparatively girls perform poorly due to their poor attitude towards sciences (UNESCO, 2004).

In a study aimed at improving the participation and performance of girls in science and mathematics in primary and secondary schools, it was reported that one of the factors stated for keeping girls out of school is failing in mathematics and science. (FAWE, 2007). These girls were discouraged by some teachers making comments knowingly or unknowingly that discourage the participation of girls' in learning (UNESCO, 2004). Teachers often consider girls as less intelligent and destined to less well-paid jobs than boys.

The findings of the study disagree with the research because the results indicate that girls and boys exposed to GOETA show no significant difference in chemistry achievement. A study carried out by Abungu et al (2014) indicated that boys and girls exposed to science process skills teaching approach show no significant difference in Chemistry achievement.

IV. CONCLUSIONS

Based on the results of this study the following conclusions have been arrived at, with regard to co-educational secondary schools.

(i) The GOETA approach enhances students learning and achievement in chemistry than those taught through TTM.
(ii) Gender does not affect students' achievement in chemistry when they are taught using GOETA approach.

V. RECOMMENDATIONS

The findings of this study indicate that GOETA approach enhanced a higher students' achievement than the traditional teaching approaches. This implies that GOETA approach if adapted can be used to address the low performance in chemistry. Since the boys and girls had comparable achievement in the study gender disparity in chemistry performance would be addressed by use of GOETA approach.

(i) The teaching approach should therefore be used to supplement other teaching approaches because the findings indicated that it can improve student' achievement.
(ii) Chemistry educators in universities and colleges should incorporate GOETA approach in teacher education curriculum. This will help develop programmes aimed at producing teachers that would encourage hands on activities by experiential learning of chemistry in secondary schools.
(iii) Kenya Institute of Curriculum Development (KICD) should include GOETA approach when preparing learning materials like teachers' guides and text books for use in chemistry syllabus implementation in secondary schools.
(iv) The In-service courses for teachers organized by NACOSTI and SMASSE should incorporate GOETA approach for effective application of the teaching approach.

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