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RESEARCH ARTICLE

EFFECTS OF CONSTRUCTIVIST TEACHING STRATEGY ON STUDENTS CHEMISTRY ACHIEVEMENT IN SECONDARY SCHOOLS

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Abstract

Chemistry is a major career subject in secondary education that is done by most of the secondary school students in Nandi North District. However, the subject has not been performed well in the past years. This could be attributed to inappropriate teaching methods employed in teaching and learning. Constructivist teaching strategy may help in improving teaching and learning of scientific concepts, but this had not been established in the District. The aim of the study was to determine the effects of using constructivist teaching strategy on students' achievement and motivation to learn Chemistry. Solomon-Four Group Non-Equivalent Control Group Design was used. Four co-educational schools were chosen using simple random sampling out of the thirty two schools in the district. One hundred and twenty students and four teachers were involved in the study. The instrument that was used is Chemistry Achievement Test (CAT) . A teaching module was developed for teaching the topic: 'Effects of Electric Current on substances' in Form Two for eleven lessons in a period of two weeks. Piloting was done in a different school within Nandi North District to ascertain the reliability and validity of the instruments. Kuder-Richardson formula 21 (KR-21) were used for establishing reliability of CAT . Reliability was established to be 0.74 . Data were analyzed using ANOVA, and ANCOVA. Hypotheses was tested at co-efficient alpha (α) = 0.05 level of significance. Results of the study indicates that constructivist teaching strategy enhances students' chemistry achievement. The results of this study are may help in enhancing teaching and learning of chemistry. This method is recommended for teachers of chemistry as a complement for the conventional teaching methods. Teacher trainers can train teachers on constructivist teaching strategy. KIE can organize seminars workshops and refresher courses for chemistry teachers.

INTRODUCTION

Chemistry is an important subject in secondary school curriculum. It allows student entry into careers like pharmacy, medicine, biochemistry and others. It also prepares learners for other scientific vocations and assists in learning of other science subjects like Physics and Biology through lateral transfer of knowledge. In addition, it is involved in production of foods, drugs, plastics and others (KLB 2010). Therefore it should be taught using constructivist strategy since it helps students to actively engage in personal constructed theory building (Driver & Oldham 1986).

In Kenya, chemistry foundation is the science subject that is examined in KCPE, while in secondary schools, it is an independent subject which is examined in KCSE. In 1963 when secondary chemistry curriculum was formulated

and developed by the K.I.E, the emphasized syl

labus resulted in teacher and book approach. Since then, chemistry syllabus has undergone several changes aimed at finding the best approach for teaching and learning of the subject. The search for a better teaching method has been going on for years (Okere, 1986).

In the current 8-4-4 system, during KCSE chemistry examination, students' sit for three Chemistry examination, paper 233/1- theory for two hours, paper 233/2 - theory for two hours and paper 233/3 – practical for two and a quarter hours. A student's score is determined by converting the three papers into percentage and determine the average mark.

Maximum score is the total possible scores from the three chemistry examination papers.

A mean score is the percentage average mark for a given number of candidates of that year.

Standard deviation is the difference between the score and the mean. Improvement Index in percentage is derived from the differences in mean scores of the subsequent years.

Research in teaching behavior indicates that there are some teaching methods that influence students' achievement than others (Wenglinsky, 2000). The dismal improvement index on the subject in National examination from Table 1, may be attributed by poor methods, over enrolment or lack of resources for teaching and learning of the subject.

A steady decline in academic achievement of high school in sciences as well as low enrolment in science courses has caused a deep concern in many countries (Ogunninyi ,1996) In Kenya for instance the KNEC report (KNEC , 2007) indicates the overall achievement of students in KCSE Chemistry has been a downward trend although in the year 2002 there was a slight improvement. This underachievement could be associated with low student motivation.

In Nandi North district chemistry is done by all the students. Table 2 shows overall chemistry performance in Nandi North district for the past six years.

Source: SMASSE Report 2011 Nandi North.

From table 2, there is a dismal positive improvement except for the year 2006 and year 2009 when there was a drop. The number of registered candidates also increases yearly. An improvement observed in year 2007 could be due to a slight change in the syllabus. A slight improvement was seen in the year 2005.

Cheek (1992) described constructivist strategy as a state when learners, actively take knowledge, connect it with previously assimilated knowledge and make it their own by constructing their own interpretations. In chemistry education, children attempt to make sense of information they receive and construct individual ideas into conceptual framework. According to Driver (1983), this conceptual framework and the ideas which they contain are often not congruent with scientific understanding. In constructivist approach, the role of the teacher is to assist students to replace pre-existing ideas. The goal of the learner is to reflect on the accepted explanations or methodology expostulated by the teacher (Caprio, 1991). Unlike traditional teaching dealing with transmission of static knowledge, constructivist teaching requires that teachers extend freedom of choice to students and create the climate where students may feel free to raise their own questions and spur their own development. In Driver (1989) words 'the principles of constructivist pedagogy- encouraging collaboration, prompting activity and exploration, respecting multiple points of view, emphasizing authentic' problem solving which facilitate a more creative synthetic motivation towards learning. Nevertheless, present studies indicate that encouragement of collaborative interaction in classroom learning is likely to cause learners to interact vicariously and thereby develop positive learning experiences (Johnson and Johnson, 1992, Kiboss, 1998). In Science education, instruction involves a conceptual change rather than infusion into a vacuum (Brunner 1971).

From 2006 K.C.S.E. report that chemistry performance had risen slightly in the previous year after steady drop in the District. Among the poorly done paper two questions was Electrochemistry one, which is Form Four work. The basis of the topic is mainly on 'Effects of Electric Current on Substances' which is mainly Form two work. The topic is also linked to 'Structure and Bonding' form two work which is also under performed. Therefore, constructivist strategy can be employed in teaching prior topic for a better understanding of the current under achieved related topic

Constructivist Teaching-Learning Model.

The model proposed by Driver and Oldman (1986) is shown in fig.1 below. This model illustrates the five phases; orientation, elicitation, restructuring, application and review. The phases overlap to some extent

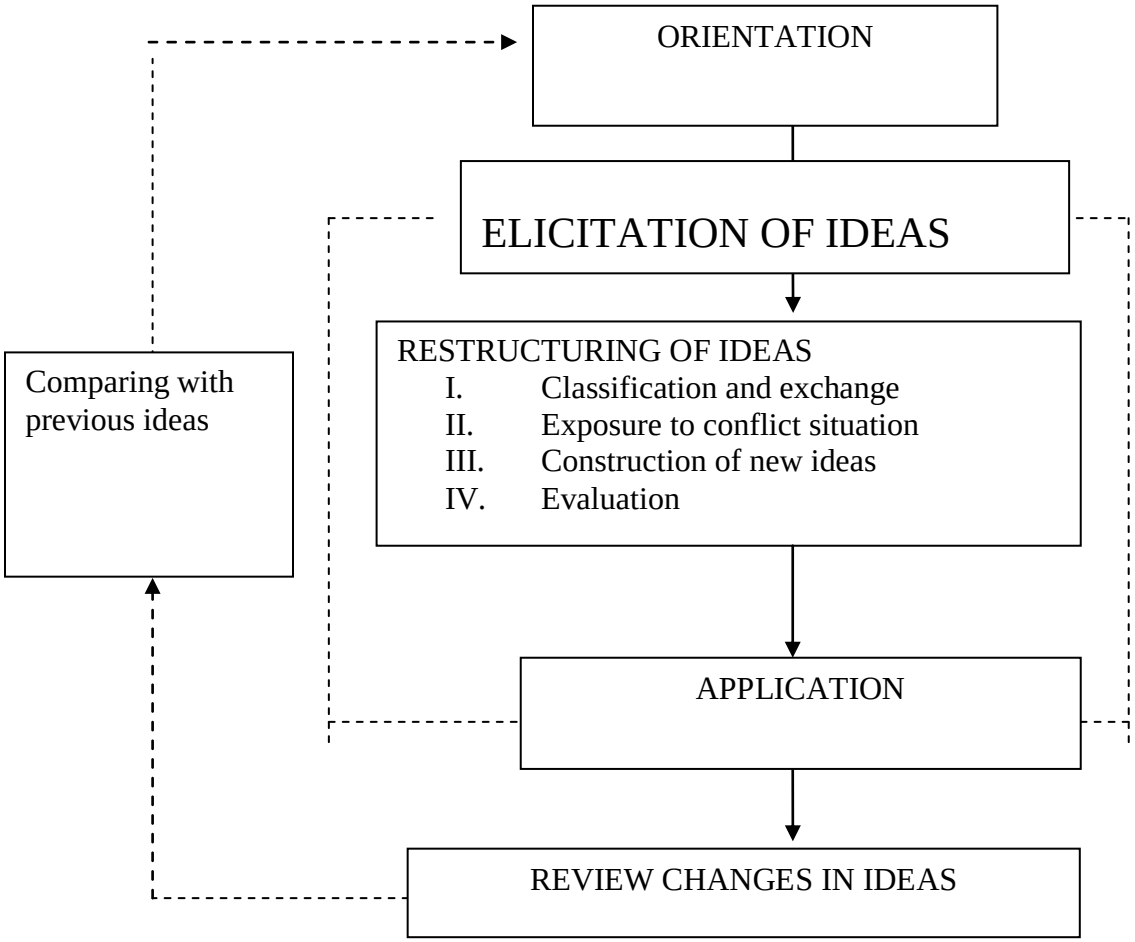

Fig.1: A Constructivist Teaching Sequence (Driver & Oldman,1986:119).

This study will be based on constructivist theory which shows five phases; Orientation, Elicitation, Restructuring, Application and Review.

Orientation phase gives learners a chance to develop a sense of purpose and motivation for learning the topic. This is an introductory phase where relevant and appropriate set of ideas are presented.

In the elicitation phase, learners express their ideas explicitly and develop awareness, which can be achieved by variety of activities like group discussion or poster making. It may also involve presence of concept to focus thinking. In this phase, the teacher probes learners' preconceived ideas about the topic to be learnt by use of open ended questions. The teacher accepts the learners' ideas for they form a basis for further discussion and activities aimed at the construction of meaning. This increases motivation. In other words provide learners with situations which challenge their existing thinking.

The restructuring phase, the teacher presents activities that will construct meaning on the topic of discussion. It is done through an experiment or models. Students' activities are conducted through discussions in collaborative groups then presented by one group to the rest of the class. The teacher acts as a facilitator in exchange of views. The phase has different aspects since learners' ideas are already out in open in the elicitation phase, clarification and exchange of ideas occurs through the discussion. In this way learners' constructed meanings and language may be reconstructed due to their exposure to conflicting situations. In this stage, students compare their ideas into the alternative and possibly conflicting news of out; exchange of views may lead to disagreement among learners. The teacher by may do an alternative method explicitly creating or promoting 'conceptual conflict through use of non-confusing demonstrations'. The conflict is also referred to as 'discrepant event' (Driver & Oldman, 1986). In this phase the learner may develop an appreciation that there can be a range of different notions to explain or describe the same concept. This is motivating mainly to the active ones. The alternative ideas and possibly scientific ones are evaluated. This may result in dissatisfaction among learners with existing conception and hence openness to change (Resnick 1988,Lord 1994).

In the application phase learners use their restructured ideas in different situations by applying the constructed knowledge in new context. The teacher can explain new ideas using relevant examples. Hence, the new conceptions are integrated and reinforced by extending the context within which they are used.

In the review phase learners are encouraged to look back to their own ideas developed by making comparisons between thinking now and at the start of the lesson. Learners in small groups will negotiate meaning on particular concepts effectively.

Purpose of the Study

The purpose of this study is to determine the effects of using constructivist teaching strategy on secondary school students' achievement in chemistry in Nandi North District, Kenya.

The Objective of the Study

The specific objective of the study was to find out the effects of using constructivist teaching strategy on students' chemistry achievement among secondary schools in Nandi North District.

Research Hypothesis

The research hypothesis of this study include:-

H_O1: There is no statistically significant difference between chemistry achievement scores of students' who are taught using constructivist teaching strategy and those who are taught using conventional methods.

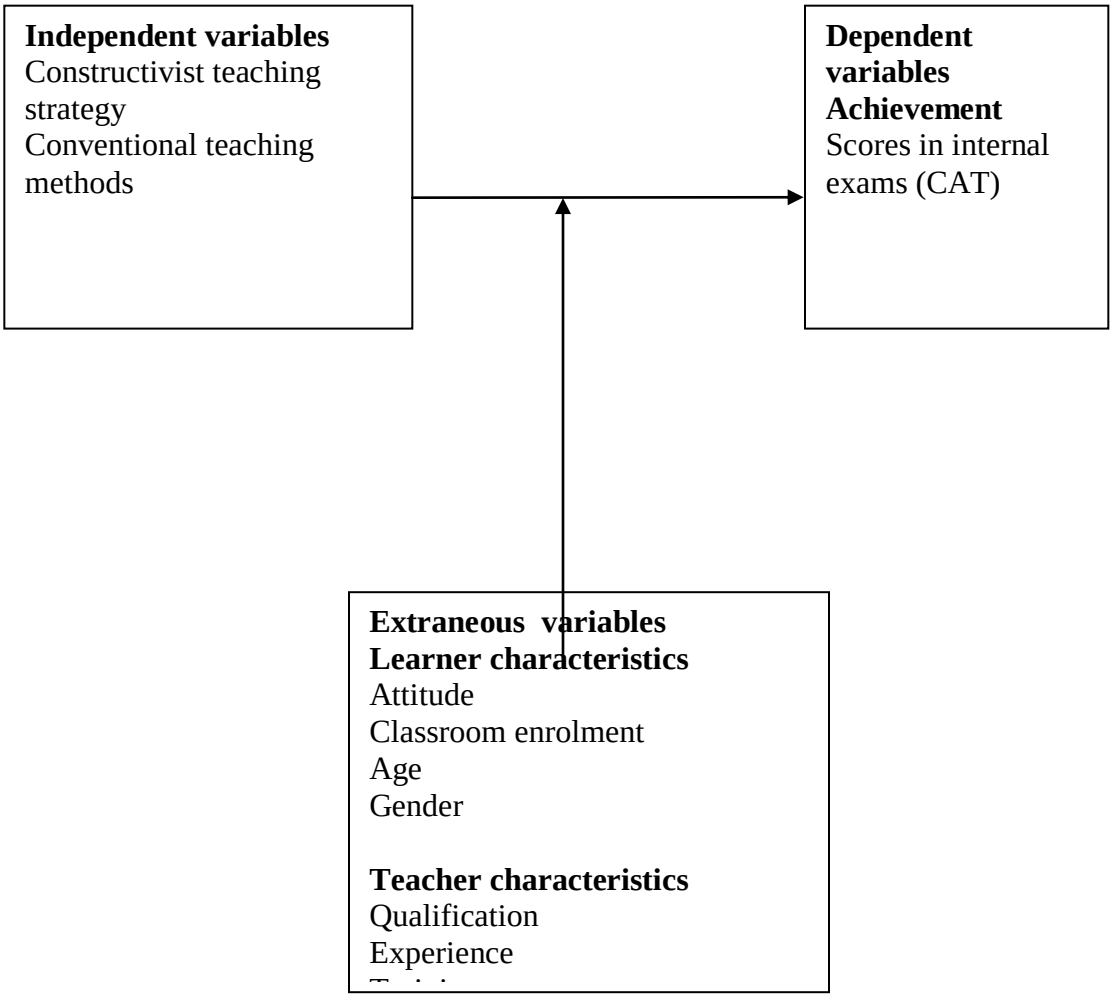

Figure 1: Conceptual Framework for determining the effect of constructivist strategy on chemistry achievement

Methodology

Research Design

This was a quantitative study involving Quasi-experimental research design where Solomon Four Non-equivalent Control Group design was adopted. This is a form of pre-test –post-test non-random control group design (Changeiywo & Wambugu, 2008). The design eliminated variations that may arise due to different experiments that contaminate internal validity of the study (Ogunninyi, 1992, Kiboss 2000). Furthermore, it is appropriate because the study was conducted in District co-educational schools in which classes are already established and was be possible to reorganize in order to employ randomization procedures (Koul l993, Borg 1987). In this study, instrumentation and selection as threats of internal validity will be controlled by ensuring the conditions under which instruments are administered are similar. The schools were randomly assigned to control and treatment groups to control selection, and maturation interaction (Aryl, Jacobs & Razavich ,1992)
It involves four groups of Form Two classes illustrated as follows:-

Group I	O_1	x	O_2
Group II	O_3	–	O_4
Group III		x	O_5
Group IV		–	O_6

Figure 2: Solomon Four Non-equivalent Control Group Research Design.

Source: Fraenkel and Wallen (2000 p.291) , Changeiywo and Wambugu (2008).

Where O_1 and O_3 are pre-tests, O_2, O_4, O_5 and O_6 are post-tests; X is the treatment where students' will be taught using constructivist strategy.
Group I is an experimental group which received pre-test, treatment X and post-test.
Group II administers a pre-test control conditions and then the post-test.
Group III did not administer a pre-test, but got treatment and post-test.
Group IV only administered a post-test. Group1 and III was taught using constructivist strategy while Group II and IV will be taught using conventional methods.

Study Location

The proposed study was carried out in four district co-educational schools in Nandi North District. It is one of the seventeen districts in the Rift Valley province and shares borders with four other districts, Nandi South to the East, Vihiga to the South, Lugari to the West and Uasin-Gishu to the North. The District has got a variety of schools of district status, provincial public and private with no national school.

Population of the Study.

The target population consisted of all Form Two students in Nandi North District while the accessible population consists of one twenty Form Two students in the district co-educational public secondary schools.

Sampling Procedures and Sample Size

The sampling frame composed of one-twenty Form Two students and four teachers from public co-educational schools in Nandi North District. Purposive sampling was used to identify schools based on availability of learning resources

Instrumentation

The study made use of one instrument namely; chemistry achievement test (CAT). CAT was constructed by the researcher from sources like KIE 1992, KLB 1987, KLB 2009 Wamae and Njeru 1989 then moderated by the chemistry teachers then validated by the experts in science education.

Reliability of the Instruments

The chemistry achievement test (CAT) were pilot tested on independent group of form two students in Nandi North district to ascertain its reliability. The reliability co-efficient is 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 determined the reliability of the instrument in a single administration as 0.7396. A reliability co-efficient of 0.70 and above is recommended for consistency levels. The reliability co-efficient should be more than 0.70 which acceptable value for any study (Fraenkel & Warren 2000).

The Construction and Use of Instructional Materials.

The researcher developed lesson plans for teaching twelve lessons for teachers of the experimental groups. The teachers were inducted on the use of constructivist teaching strategy before the intervention period. A pre-test was administered to groups E1 and C1. This was followed by intervention period for three weeks. At the end of the intervention period, a post-test was administered to all the four groups.

Data Collection Procedures

The researcher administered the instrument with the assistance of chemistry teachers in the respective schools. Groups E1 and C1 were given the pre-test before the start of the treatment. The treatment took three weeks. After the treatment, the researcher with the assistance of chemistry teachers from the sampled groups will administer the post–test to all groups. The content to be used in this research was based on the revised chemistry syllabus (KIE, 2005). A guiding manual based on this syllabus was constructed for teachers from the experimental groups E1 and E2. These teachers were trained by the researcher on how to use the manual. These teachers taught using the approach on a different topic other than 'Effects of electric current on substances', like 'Salts' to enable them master the skill. In this study CAT was used collect data on student achievement in chemistry.

Data Analysis

Data was analyzed using descriptive and inferential statistics. Descriptive statistics includes the mean, frequencies, percentages and standard deviations used to describe the summarized raw data. Hypothesis was analyzed using one-way, ANOVA and ANCOVA . ANOVA was used to determine if the four groups differed significantly among themselves on experimental variables at alpha level of 0.05. ANCOVA was used to cater for initial differences among groups by using the KCPE mark as a covariate. A t-test was used to test differences between the pre-test mean scores because of its superior quality in detecting differences between two groups (Gall, Borg & Gall, 1996).

Results and Discussion

Table 1

Candidates National Overall Performance in Chemistry from the Year 2000-2007 in Kenya

Year	Number of Candidates	Maximum score	Mean Score	Improvement index (%)	Standard deviation
2000	115968	190	41.84		21.38
2001	181,238	190	30.72	-11.12	18.00
2002	187,261	190	34.27	+3.55	21.29
2003	198,016	190	37.42	+3.15	22.86
2004	214,520	200	39.62	+2.2	20.00
2005	253,508	200	38.05	-1.57	23.00
2006	237,831	200	49.82	+11.77	32.00
2007	241,368	200	50.76	+0.94	31.00

Source: Kenya National Examination Council (KNEC, 2009)

Table 2:

Nandi North District overall performance in KCSE Chemistry year 2003-2010

Year	Number of Candidates	Maximum Score	Mean (%)	Improvement index
2003	1603	190	35.5	
2004	2045	200	36.2	+0.7

2005	1961	200	40.1	+3.9
2006	2062	200	39.92	-0.18
2007	2382	200	49.7	+9.78
2008	3160	200	50.1	+0.4
2009	4200	200	35.83	-14.27
2010	4360	200	37.5	+1.67

The Pre-test Analysis

The main reason for conducting a pre-test is to check whether the groups were similar before exposing them to the treatment. Pre-test analysis was done by using the learning method .

Table 5 shows the pre-test analysis of CAT of groups C1 and E1.

Table 5.

Comparison of pre-test mean scores of C1 and E1 groups on CAT by learning method.

Test	group	N	mean	SD	df	t-value	p-value
CAT	C1	48	60.00	9.84	92	9.023	0.000*
	E1	46	41.09	10.48			

Table 5 shows the results of pre-test scores on CAT $t(92)=9.02$ $p<0.05$ hence for groups E1 and C1 showed a statistically significant difference with p-value =0.000 hence < 0.05. This indicated that the groups used in the study did not exhibit comparable characteristics. The differences in CAT could be due to variation in teaching resources among schools. Measures were put in place to make the groups suitable for study when comparing the effect of constructivist teaching strategy with the use of conventional methods on achievement in chemistry.

Effects of Constructivist Teaching Strategy on Students' Chemistry Achievement - CAT

Effect of treatment on CAT has been determined using mean gain analysis and post-test analysis.

Table 7 shows the mean gain analysis.

Table 7

Mean gain analysis.

Learning method	N	post-test X	pre-test X	mean gain	df	t-value	p-value
C1	48	76.77	60.00	16.77	92	2.789	0.006*
E1	47	65.21	41.09	24.35			

*$t(92) = 2.789$ $p<0.05$

The results $t(92)=2.789$ $p<0.05$ showed that there was a significant mean gain in favour of E1 group. The higher pre-test mean seen in the C1 could be associated to differences in school's learning resources, teachers' number and varied schools' reading culture. However this does not show whether the differences among other groups were significant hence there is need for post-test analysis.

Post-test Analysis of CAT

The post-test analysis was done through ANCOVA and ANOVA.

Table 8 shows the post-test mean score for CAT at a maximum of 100 marks obtained by students in the four groups

Table 8

Descriptive of CAT mean scores and standard deviation by Learning method

Group	N	Mean	SD
C1	48	76.77	9.97
E1	47	65.21	2.31
C2	19	54.21	11.34
E2	16	62.19	15.19

The data in table 8 shows that C1 had the highest mean (M=76.77,SD=9.97)scores followed by E1 (M=65.21, SD=2.31). This shows that control groups had better results than experimental groups. To check whether there are differences among the groups, ANOVA test was done. Table 9 shows comparison of post-test scores among groups by use of ANOVA.

Table 9

Analysis of Variance(ANOVA) on Post-test CAT Mean scores

Scale	SS	df	Ms	F-ratio	p-value
Between Groups .	8178.553	3	2726 .184	15.519	0.000*
Among Groups	22133.947	126	175.666		
Total	30312.500	129			

*($p < 0.05$, $df = 3$, $F = 15.519$)

Table 9 shows the results of ANOVA post-test scores on CAT. The table shows that there was a statistically significant difference between groups $F(3,126)=15.519$, $p<0.05$. This means that F factor is significant at $p<0.005$ and between squares is statistically significantly greater than within means square. This shows that there is a highly significant overall treatment effect. This means that, the null hypothesis will be rejected which states that there is no statistically significant difference between achievement scores of students who are taught using constructivist strategy and those taught using conventional methods. It can also concluded that there is probably at least one significant difference among possible comparisons of two means in the four groups. There was therefore need to find out where this experimental effect was located. This made it necessary to carry out scheffe's (multiple comparison) test of significance for a difference between two means to reveal where the difference is.

Table 10

Post-hoc : Scheffe's Multiple comparison of the CAT post-test means.

	I Group	J Group	Mean difference(I-J)	P-Value
Scheffe's	E1	C1	-11.56	0.001*
		E2	3.03	0.891
		C2	11.00	0.029*
	C1	E2	14.56	0.003*
		C2	22.56	0.000*
	E2	C2	7.98	0.374

*$p<0.05$ represent a statistical significant difference.

Table 10 shows the results of scheffe's test of significance for a difference between any two means. The results show that pairs of CAT means of groups E1 and C1, groups E1 and C2, groups C1 and E2, groups C1 and C2 showed statistically significant difference. While groups E1 and E2 and groups E2 and C2 were not statistically significant difference at the 0.05 α-level. C1 and C2 showed significant difference associated with teaching resources like the CDF sponsored schools have more apparatus or teacher characteristics. C2 and E2 did not show any significant difference which could be associated with the CTS implementation time having taken 11 lessons, three weeks which is a shorter time. The effectiveness of the training of teachers on the new strategy whereby some teachers might not have internalised the process properly. This study involved non-equivalent control group design and there was therefore need to confirm the results by performing analysis of covariance (ANCOVA) using the students' Kenya Certificate of Primary Education (KCPE) scores as covariate.

Table 11

Descriptives after adjustment with the KCPE covariate

Group	**mean**
C1	69.39
E1	71.39
C2	54.85
E2	65.44

ANOVA did not have features to adjust initial differences at the entry point .Therefore ANCOVA of CAT post-test by learning method was done.

Table 12
Analysis of co-variance (ANCOVA) of post-test scores with KCPE as a covariate

	Ss	df	ms	f-ratio	p-value
Contrast	3384.494	3	1328.165	8.998	0.000*
Error	18451.497	125	147.612		

*(F=8.998, df=3, p<0.05**)**

Table 12 shows that there is statistically significant difference in the CAT scores of the four groups F (3,125) = 8.998 , p<0.05). This confirms that the differences between the means are statistically significant at 0.05 α-level. And therefore the differences were as a result of treatment effect since all conditions were the same except the learning method.

However, the results do not reveal where the differences are. Therefore it is necessary to use multiple comparisons (scheffe's). Table 13 shows ANCOVA post-hoc.

Table 13
ANCOVA post-hoc

Group	**Mean difference**	**p-value**
E1-C1	1.999	0.5789
E1-E2	5.947	0.098
E1-C2	-16.535	0.00*
C1-E2	3.951	0.337
C1-C2	14.539	0.00*
E2-C2	10.588	0.012*

*p< 0.05 represent statistical significant difference

Results from the table showed that groups E1 andC1,E1 and E2 and groups C1and E2_did not show any significant difference. However groups E2 andC2 E1 andC2 and groups C1 and C2 showed a significant difference.

CONCLUSIONS, RECOMMENDATIONS AND IMPLICATIONS

Conclusion

From the findings presented above, the following conclusion was reached :-

1. Students who were taught chemistry through constructivist strategy learn better than those who were taught using conventional teaching methods.

Implications

A close scrutiny of the findings of this study has a number of implications. First, constructivist teaching strategy enhances students' chemistry achievement than conventional teaching methods. It facilitated social interaction and instilled confidence among the students.

Recommendations

Based on the findings of this study, it is evident that constructivist instructional strategy, is an effective method in teaching chemistry. It is therefore recommended that;

(1) The constructivist teaching strategy should be emphasised in teacher education curriculum at all levels to enable good background of the strategy.
(2) Textbook authors should expose readers more to the use of constructivist strategy by writing about it in their books.
(3) Teachers should as much as possible use constructivist teaching strategy in teaching topics in chemistry topics
(4) KICD and the ministry of education should organise workshops ,seminars at intervals on use of constructivist strategy in teaching chemistry or incorporate the use of the strategy in SMASE training sessions.

Suggestions for Further Research

The following are suggestions for further research namely:-

(1) It is also necessary for the method to be investigated over a longer period of time like over a month or a term to determine its effectiveness.

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