International Journal of Humanities Social Sciences and Education (IJHSSE)
Volume 4, Issue 2, February 2017, PP 8-18
ISSN 2349-0373 (Print) & ISSN 2349-0381 (Online)
http://dx.doi.org/10.20431/2349-0381.0402002
www.arcjournals.org

Using Computer Based Cooperative Mastery Learning to Enhance Students' Achievement in Secondary School Chemistry in Bomet County, Kenya

John K. Keter, Prof. Samuel W. Wachanga, Dr. Zephaniah O. Anditi

Faculty of Education of Community Studies, Egerton University, Kenya

Abstract: *Chemistry occupies a significant position in secondary school curriculum because of its applications in everyday life. In spite of this importance, the academic performance of Kenyan students in the subject in has remained poor over the years. The fundamental challenge in teaching of chemistry is how to enhance students' achievement in the subject. Innovative, research-based and learner-centred teaching methods engage the learners in the learning process. Such methods are effective for mastery of concepts and also enhance learners' achievement in the subject. Although Computer Based Cooperative Mastery Learning (CBCML) may help in enhancing students' achievement in chemistry, its effects had not been determined in Bomet County. This was the focus of the study. Solomon Four Non-equivalent Control Group Design was used. The study sample comprised of 238 form three students from four schools purposively chosen from 21 County Co-educational secondary schools in the county. The study involved four groups; two Experimental Groups taught through CBCML and the other two Control Groups taught through the Conventional Teaching Methods (CTM) for six weeks. A Chemistry Achievement Test (CAT) was administered a pre-test and later on re-organised and administered as a post-test. The reliability coefficient of the instrument was 0.85 estimated using Kunder-Richardson (K-R21) formula. Data analysis was carried out using descriptive as well as inferential statistics. The differences between the group means were checked for statistical significance using t-test, ANOVA and ANCOVA. The findings of the study showed that the students exposed to CBCML had relatively higher scores in the CAT than those taught through CTM. Thus, CBCML enhances students' achievement in Chemistry more than CTM. Therefore the researchers recommend that chemistry teachers incorporate CBCML in their teaching.*

Keywords: *Computer Based Cooperative Mastery Learning, Secondary School, Chemistry Achievement.*

1. INTRODUCTION

The Government of Kenya recognizes the importance of Science and Mathematics in the attainment of its Vision 2030 where the community seeks to become a globally competitive and prosperous country by 2030 (Kerich, 2004). Apart from providing trained teachers to handle the subjects, the Government institutionalized in-service education and training (INSET) for science and mathematics teachers under Strengthening of Mathematics and Science in Secondary Education (SMASSE). In spite of all these, one great challenge teachers are facing is how to improve students' performance nationally in Chemistry as its pass rates in KCSE examinations are relatively low compared to that of Biology and Physics (Barchok, 2006). Table 1 shows the overall performance nationally in KCSE for the three science subjects from 2010-2014.

Table1. *Students' National KCSE Percentage Mean Scores in Chemistry, Biology and Physics from 2010-2014*

Subject	2010	2011	2012	2013	2014	Average
Chemistry	24.89	23.65	27.93	24.83	32.16	26.69
Biology	29.20	32.44	27.21	31.63	29.84	30.06
Physics	36.11	36.64	37.86	40.10	38.29	37.80

Source. *KNEC (2011- 2015)*

The data in Table 1 shows that the average performance in chemistry has been generally low (26.69) compared to that of the other science subjects (30.06 and 37.80) over the five years considered. The highest mean score is 32.16% recorded in the year 2014 and the least score being 23.65% recorded in the year 2011. However, an improvement in performance from a mean of 24.83% in 2013 to 32.16% in 2014 was noted.

Among the factors that have been identified to contribute to this poor performance include class size, poor methods of instruction, students' attitude, teachers' attitude, laboratory inadequacy, and poor science background (Ugwu, 2007). Science is also taught in most schools as a bundle of abstractions without practical experiences due to ill-equipped laboratories. This has resulted in students' low acquisition of science process skills which has become more evident in mass failure of students in the subject in national examinations. Inability of students to carry out practical activities in chemistry results in low scores especially in questions that test practical abilities.

Practical work stimulates and engages students' learning at varying levels of inquiry, challenging them both mentally and physically in ways that are not possible through other science education experiences (Millar, 2004). Quality practical work promotes engagement and interest among students. It also helps in developing a range of skills, science knowledge and conceptual understanding (Lunetta, Hofstein, & Clough, 2007).Learning, according to Taber (2009), is a personal activity and each student has to construct his or her own knowledge from it. For meaningful and effective learning to be realized, students should reflect on what is taught; develop interest on subject matter and construct new knowledge based on their understanding of the concepts. Science teaching therefore, ought to be proactive and student-centred.

Chemistry should be taught through hands-on activities which engage the learners fully during the teaching/learning process. Enquiry based approach to teaching and learning is the norm worldwide and Kenya should not be left behind (KNEC, 2014). Conventional Teaching Methods of teaching such as lecture method of instruction are less effective than interactive approaches (Knight & Wood, 2005). According to Harlen (1993), use of appropriate teaching methods by the science teachers could play a key role in helping learners develop their ideas and science process skills such as observing, hypothesizing, predicting, investigating, drawing conclusions and communicating. This can be possible if teachers play their role well and select appropriate teaching methods which facilitate meaningful learning of school science (Grabe & Grabe, 2007).

The use of computer technology for teaching in Kenyan schools is a relatively new approach that is currently being included in the school curriculum.This new intervention has proved effective in the teaching of both science and art subjects. A study by Tanui, Kiboss, Walamba and Nassiuma (2003) observed that the use of Computer Based Instruction (CBI) simulations has proved successful in teaching difficult concepts in Business Studies. Another study by Wekesa, Kiboss and Ndirangu (2006) observed that Computer Based Instruction improved students' understanding and perception of cell theory in Biology. In addition, Ronoh, Wachanga and Keraro (2013) found out that learners taught Biology using Computer Based Mastery Learning outshined their counterparts taught using Conventional Teaching Methods. Research on computer use by students in science shows that their self-esteem is enhanced (Robertson, Ladewig, Strickland & Boschung, 1987). This may also account for the increased interest in science by lower achieving students who have computers incorporated into their curriculum.

Conventional Teaching Methods of instruction focus on the acquisition of content, with little development of the skills and attitudes necessary for scientific inquiry. The teacher transmits information to students, who receive and memorize it. Assessment of knowledge typically involves one right answer. The curriculum is loaded with many facts and a large number of vocabulary words, which encourages a lecture format of teaching. This kind of teaching approach encourages rote learning.

The attainment of stated instructional objectives in chemistry teaching, as well as enhanced students' performance is a collective responsibility of both teachers and students (Udo, 2011). The selection of appropriate instructional strategy enhances smooth delivery and effective achievement of instructional objectives. Adesoji and Olatunbosun (2008) maintain that chemistry teaching can be result-oriented if students are willing to learn, and appropriate methods are used by the teachers. Thus, the method of instructional delivery is a significant variable in the teaching-learning process. It can arouse and sustain the learners' interest thereby ensuring result oriented teaching-learning session. The goal is to develop critical thinking and problem-solving skills by posing and investigating relevant questions whose answers must be discovered. Eventually meaningful learning is realized.

In this study, the elements of Mastery Learning and CBI simulations were incorporated into the Cooperative Learning Groups for use during lesson introduction, explanation of procedures and self-check tests. The simulations used are contained in the Form 3 Chemistry data DVD developed by Kenya Institute of Curriculum Development (KICD). Most of the lessons during the intervention involved carrying out practical in the laboratory while some were presented using computers. During computer based instruction lessons, students went through the simulations in the topic Volumetric Analysis as explained in the Chemistry Practical Teachers Manual. At the end of each lesson topic are self-check questions. The students were required to answer and upon attaining 80% they were allowed to move to the next lesson topic. This approach is referred to as Computer Based Cooperative Mastery Learning (CBCML). This study sought to determine the effect of CBCML on students' achievement in chemistry.

2. Statement of the Problem

The poor performance in chemistry by secondary school students in the subject as reflected by the KCSE Examinations results has continued to trigger a lot of concern among educationists and other stakeholders nationally and in Bomet County over the years. The poor performance could be as a result of lack of interest in the subject caused by Conventional Teaching Methods used by most teachers. Such methods of teaching make the learners to be passive during the teaching and learning process. Chemistry is an experimental science which relies primarily on the harmony between theory and practical. It should therefore be taught as such. It follows therefore that, understanding of concepts in practical chemistry may assist in enhancing student's understanding of chemistry. Although CBCML approach to teaching may enhance students' achievement in the subject, its effects have not been determined in Bomet County. In view of this gap, the study sought to determine the effect of CBCML on secondary school students' achievement in Chemistry in Bomet County, Kenya.

3. Objective of the Study

The study sought to find out the effect of CBCML on students' achievement in Chemistry when students are taught through CBCML compared to those taught through CTM.

3.1. Hypothesis of the Study

$H_0$1: There is no statistically significant difference in achievement in chemistry between students exposed to CBCML and those taught through CTM.

3.2. Conceptual Framework

The conceptual framework for this study was based on the constructivist theory of learning. In this theory, the teacher serves as a facilitator who attempts to structure the learning environment so as to enable the learner to organise meaning at a personal level (Cooper, Jackson, Nye & Lindsay, 2002). The study was also based on the assumption that the blame for a students' failure rests on the quality of instruction and not lack of student's ability to learn (Bloom, 1981; Levine, 1985). The framework is represented diagrammatically in Figure 1. Computer Based Cooperative Mastery Learning (CBCML) is likely to enhance students' learning in chemistry more than the Conventional Teaching Methods (CTM) because it enables them to take responsibility for their learning and that of others through cooperation during practical work and interaction through computer simulations.

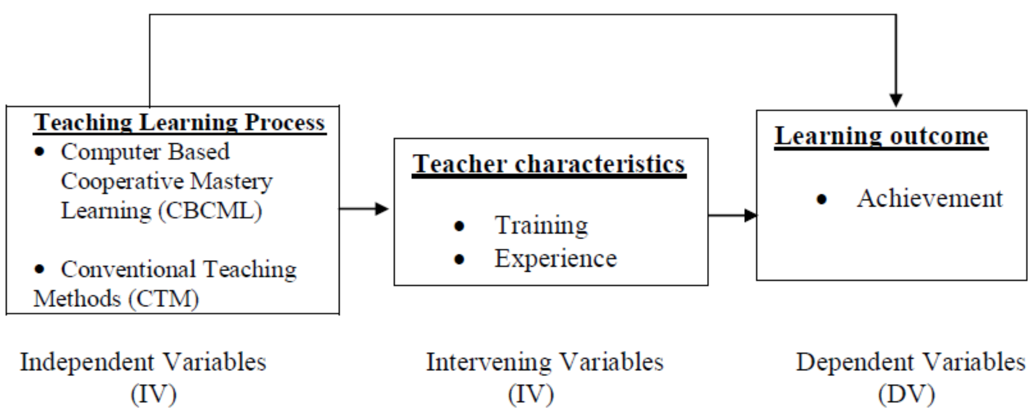

Figure1. *The Conceptual Framework for determining the effect of CBCML teaching method on Students' Achievement in Chemistry*

4. RESEARCH METHODOLOGY

4.1. Research Design

The study used Solomon's Four Non-equivalent Control Group Design which is rigorous enough hence appropriate for experimental and quasi-experimental studies (Wachanga & Mwangi, 2004). The design controlled for all major threats to internal validity except those associated with interaction of selection and history, selection and maturation, and selection and instrumentation (Cook & Campell, 1979). To control for teachers' gender, training and experience as sources of internal validity, only male teachers of equivalent training and experience were chosen. This design involved a random assignment of intact classes to four groups. The design is shown in Figure 2.

Group 1	O_1	X	O_2	E1
Group 2	O_3	____	O_4	C1
Group 3	____	X	O_5	E2
Group 4	____	____	O_6	C2

Key: Pre-tests: O_1 and O_3 Treatment: X
Post-tests: O_2, O_4, O_5 and O_6 No pre-test or no-treatment: ____
Experimental groups: E_1 and E_2Control groups: C_1 and C_2
Non-equivalent control groups: --------------------------------

Figure2. *Solomon's Four Non-Equivalent Control Group Research Design*

Group 1 received a pre-test, treatment (X) and then a post-test while Group 2 received a pre-test and post-test. On the other hand, Group 3 were not given a pre-test but received the treatment (X), followed by a post-test while Group 4 received the post-test only as shown in Figure 2. This implies that in this study, Groups 1 and 3 were taught through the CBCML and therefore were the Experimental Groups while Groups 2 and 4 were the Control Groups taught through CTM.

4.2. Sampling Procedures and Sample Size

The unit of sampling was secondary school rather than individual learners because secondary schools operate as intact groups (Borg & Gall, 1996). Purposive sampling was used to select secondary schools that offer computer studies in the County. This ensured that the students have the pre-requisite skills on the use of computers for learning. Form Three classes were purposively selected for the study because the topic to be covered is usually taught in Form Three. The Form Three classes in the four Co-educational County secondary schools were randomly assigned to experimental and control groups.

To ensure that the four schools are located far apart from each other so as eliminate diffusion of information regarding treatment from the Experimental Groups to the Control Groups, one school was picked from each of the four sub-counties. Table 2 shows the total number of students per group involved in the study.

Table2.*Assignment of sampled schools and students to the Experimental and Control Groups and distribution among the four Sub-counties*

Group	Type of Group	No. of Students (N)	School	Sub-County
Group 1	Experimental 1 (E1)	59	1	Bomet
Group 2	Control 1 (C1)	60	1	Chepalungu
Group 3	Experimental 2 (E2)	52	1	Konoin
Group 4	Control 2 (C2)	67	1	Sotik
Total		**238**	**4**	

Table 2 shows a sample size of 238. According to the Solomon's Four Non-equivalent Control Group Design used, the schools selected for use in the study represents the county as a whole.

4.3. Instrumentation

Data were collected using a Chemistry Achievement Test (CAT). The items in this instrument were adapted from KNEC chemistry past examination papers and modified to make them suitable for use in the study. The instrument contained items to test the students general achievement in chemistry practical before the treatment as well as the conceptual understanding of the topic; Volumetric Analysis after intervention. The items were structured in such a way as to start with those of low order thinking skills and progressively move to slightly more complex ones. This instrument was used to measure the learners' level of achievement in chemistry before and after treatment.

4.4. Validity and Reliability of Research Instruments

Validity

Validity refers to the extent to which an instrument measures what it is intended to measure. The CAT was validated by the university supervisors and chemistry teachers. It was then moderated by three education specialists from the Department of Curriculum, Instruction and Educational Management of Egerton University and markers of Chemistry registered with Kenya National Examinations Council (KNEC). Comments from these specialists were used to improve the instruments and make them suitable for use in the study. Items which were found inadequate for measuring the variables were either discarded or modified.

Reliability

The instrument was pilot-tested in the neighbouring Narok West Sub-County in selected secondary schools whose students were assumed to have similar characteristics with that of the sampled schools. The Kunder-Richardson (K-R21) formula was used to estimate the reliability of CAT. The reliability coefficient for the CAT was found to be 0.85. According to Fraenkel and Wallen (2000), an alpha value of 0.7 and above is considered suitable to make possible inferences that are accurate. The items in the questionnaires were therefore suitable for use in the study.

4.5. Data Collection Procedures

Data were collected in two stages. At the beginning of the study, the CAT was administered to the Experimental Group 1 (E1) and Control Group 2 (C1) as a pre-test. This was followed by exposure of the Experimental Groups to treatment which lasted six weeks. Students in the Control Groups were taught the same chemistry content through the Conventional Teaching Methods (CTM). At the end of the six-week period, the items in the instruments were re-organised and administered by the researchers as a post-test with the assistance from the chemistry teachers in the respective schools. The researchers then scored the tests to get quantitative data.

4.6. Data Analysis

Data obtained from the instruments during the pre-test and post-test were coded and analysed using means, t-test ANOVA and ANCOVA. This enabled the researchers to find out whether there was any statistically significant difference between the performance of the two groups, before and after the treatment and therefore determine the impact of CBCML on students' achievement chemistry.

5. RESULTS

5.1. Analysis of Pre-test Scores on CAT

To assess the homogeneity of the groups before treatment, a pre-test was administered to Experimental Group 1 (E1) and Control Group 2 (C1). To test whether there was any significant difference in the two means; an independent samples t-test was performed. The results of this test are presented in Table 3.

Table3. *Independent Sample t-test of Pre-test Scores on CAT for Groups 1 and 2*

Scale	Group	N	Mean	SD	df	t-value	p-value
CAT	1	59	1.02	1.63	117	0.768	0.956(ns)
	2	60	1.03	1.60			

ns: *non-significant mean difference at $p>0.05$ level; CAT Maximum Score = 25*

The results in Table 3 shows that the CAT pre-test mean scores for Groups 1 and 2 and for the students were not significantly different (t(117)=0.768 p>0.05). This implies that the groups had comparable characteristics at the beginning of the treatment. Therefore, the groups were suitable for the study.

5.2. Analysis of Post-Test Scores on CAT

The post-test of the four groups are shown in Table 4.

Table4. *Students' Post-test CAT Mean Scores*

Type of Group	**E1**	**C1**	**E2**	**C2**
Group	**1**	**2**	**3**	**4**
N	59	60	52	67
Mean Scores	16.76	8.88	16.40	9.94
Std. Deviation	5.13	6.44	5.43	6.47

CAT Maximum Score = 25

The CAT mean scores were 16.76, 8.88, 16.40 and 12.64 for groups 1, 2, 3 and 4 respectively out of a maximum score of 25. The results in Table 4 indicate that the CAT post-test mean scores of Experimental Groups 1 and 3 (16.76 and 16.4) were much higher than those of the Control Groups 2 and 4 (8.88 and 9.94). This shows that the experimental groups performed better than the control groups in the CAT.

One-way ANOVA was carried out to determine the effect of CBCML on student's achievement in chemistry. Table 5 shows the results of one-way ANOVA on the CAT post-test scores.

Table5. *One-way ANOVA of Post-test Mean Scores on the CAT*

	Sum of Squares	df	Mean Square	F	p-value
Between Groups	3262.606	3	1087.535	30.876	.000(s)
Within Groups	8242.037	234	35.222		
Total	11504.643	237			

s. *significant mean difference at p<0.05 alpha level; CAT Maximum Score = 25*

The results in Table 5 show that the computed p-value (0.000) was less than the set alpha value of 0.05. Therefore, the differences in CAT mean scores among the four groups were statistically significant at 0.05 alpha level ($F(3, 234) = 30.876$, $p<0.05$).

ANCOVA test was carried out, in an attempt to reduce the effect of the initial group differences that might have existed. Table 6 shows the adjusted CAT post-test mean scores for ANCOVA using KCPE mark as covariate.

Table6. *Adjusted CAT Post-test Mean Scores for ANCOVA with KCPE as Covariate*

Group	Type of group	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	E1	16.764(a)	.774	15.238	18.289
2	C1	8.883(a)	.768	7.369	10.396
3	E2	16.404(a)	.825	14.779	18.030
4	C2	9.462(a)	.727	8.031	10.894

a. Covariates appearing in the model are evaluated at the following values: KCPE Mark = 293.1176.

When the adjusted CAT post-test mean scores of the Experimental Groups were compared with those of the Control Groups, the results showed that the Experimental Groups which received treatment had better mean scores as compared to the Control Groups despite Control Group, C1 receiving pre-test. This showed that the pre-test did not influence the achievement of the students who were pre-tested. This therefore implies that the high level of achievement in chemistry by the Experimental Groups was as a result of exposure to CBCML. Table 7 shows the ANCOVA results for the CAT post-test scores using KCPE scores as covariate.

Table7. *ANCOVA of the CAT Post-test Scores with KCPE Mark as Covariate*

Source	**Sum of Squares**	**df**	**Mean Square**	**F**	**p-value**
Corrected Model	3262.702(b)	4	815.676	23.059	.000
Intercept	310.791	1	310.791	8.786	.003
KCPE	.097	1	.097	.003	.958

GROUP	3260.167	3	1086.722	30.722	.000(s)
Error	8241.941	233	35.373		
Total	49547.000	238			
Corrected Total	11504.643	237			

a. Computed using alpha = .05

b. R Squared = .284 (Adjusted R Squared = .271)

ANCOVA test results in Table 7 confirmed that the differences between the group means were statistically significant at 0.05 alpha level (F (3, 233) = 30.722), $p<0.05$). To find out where the difference in achievement existed, a *Bonferroni post-hoc* analysis was carried out. The results of this analysis are presented in Table 8.

Table8. *Bonferroni post-hoc ANCOVA Pair-wise Comparisons of the Post-test CAT Mean Scores for the four groups*

(I) Type of group	(J) Type of group	Mean Difference (I-J)	Std. Error	Sig.
E1	C1	7.8794(*)	1.08813	.000
	E2	.3589	1.12887	1.000
	C2	7.3000(*)	1.05957	.000
C1	E1	-7.8794(*)	1.08813	.000
	E2	-7.5205(*)	1.12445	.000
	C2	-.5794	1.05487	1.000
E2	E1	-.3589	1.12887	1.000
	C1	7.5207(*)	1.12445	.000
	C2	6.9412(*)	1.09684	.000
C2	E1	-7.3000(*)	1.05957	.000
	C1	.5794	1.05487	1.000
	E2	6.9412(*)	1.09684	.000

** The mean difference is significant at the 0.05 alpha level.*

Bonferroni post-hoc pair-wise comparisons of significance for a difference between any two means results in Table 8 show that there was a statistically significant difference between the pairs of CAT post-test means for groups E1 and C1, groups E1 and C2, groups C1 and E2 and groups E2 and C2 at 0.05 alpha level. However, there was no statistically significant difference in the means between Groups E1 and E2 and Groups C1 and C2. Consequently, $H_0 1$ was rejected.

The results in Table 9 shows the mean gain between students' CAT pre-test scores and post-test scores, which was significantly higher for the Experimental Group than the Control Group.

Table9. *Comparison of Students' Mean Scores with their Mean Gain in the CAT*

	Group 1 (N=59)	Group 2 (N=60)	Overall (N=119)
Pre-test mean scores	1.02	1.03	1.03
Post-test mean scores	16.76	8.88	12.82
Mean Gain	**15.74**	**7.85**	**11.79**

CAT Maximum Score = 25

The results in Table 9 indicate that both Groups 1 and 2 gained from the teaching. However, the CBCML group had a higher mean gain than the control group implying that the CBCML method resulted in higher achievement than the CTM. Therefore, CBCML improved the achievement of students who were in the experimental groups more than those in control groups which were taught through CTM. This implies that CBCML enhanced students' achievement in chemistry more than the CTM.

6. Discussion

In an effort to improve students' cognition and achievement in science, educational psychologists and science educators have continued to search for variables that could be manipulated in favour of academic gains. CBCML teaching strategy is an approach that puts together mastery learning, cooperative learning approaches and the use of computer technology. It is therefore a hybrid of the three approaches and therefore, likely to motivate the students by not only appealing to their cognitive domain but also their affective domain as well as the psychomotor domain. Consequently, it is likely to promote students achievement.

In this study, Computer Based Cooperative Mastery Learning was defined as an instructional strategy in which students at various performance levels work together in small groups towards a common goal while enhancing their learning using computers. The teachers' role is to facilitate learning by grouping the students in groups of mixed ability, assigning roles to group members, organising subject matter, selecting and organising learning resources including computers and DVDs, construction of worksheets for practical lessons and ensuring that the learning environment is organised well in advance.

Students working cooperatively are responsible for one another's learning as well as their own (Wachanga, 2002). In this learning approach, each student was allowed to proceed on to the next learning segment after passing the criterion test. The criterion test had to be passed by the student with a minimum cut-off score of 80% indicating mastery of the learners' on-going learning segment (Kulik, Kulik & Bangert-Drowns, 1990). A student who does not pass the criterion-referenced test is given individual guidance by the instructor and peer-tutors. This remediation enables the student to repeat the learning segment and take retests until he attains the required pass-mark. The mastery learning model places focus on aspects such as behavioural objectives, small learning segments, self-pacing, individual attention and criterion-referenced testing (Aggarwal, 2004).

CBCML is one example of a group task in which students can work together to accomplish a given task with the help of computer technology. Through this approach, students were expected to learn in their cooperative groups to achieve a certain level of mastery of the concepts by constructing knowledge about the topic. The students worked on the task until all group members have successfully understood and when the task was over the teacher evaluated the academic success of each student, (Wachanga, 2002).

The knowledge learnt, should enable them to apply in real life situations and show how it affects people in their daily lives. The approach is therefore likely to motivate students by engaging them in a group task in which they are expected to realise that they are mutually responsible for one another's learning and academic success hence a higher level of achievement is likely to be attained.

In this study, achievement was perceived at two levels; the first level was a superficial one, where students' presentation in CAT pre-test was scored in terms of whether the answer given was correct or wrong with an aim of establishing homogeneity in the level of achievement of the participants from the two groups before treatment. The second level of achievement was deeper in that the student's work was assessed for understanding. Here the students' responses were scored in terms of their ability to demonstrate understanding of concepts and principles tested irrespective of whether the final answer was correct or wrong. Assessment in the second level was achieved by scoring students' detailed responses as well as all the steps involved to obtain the final answer.

An analysis of CAT pre-test results showed that the pre-test mean scores between the experimental and control group were not significantly different. The group therefore had comparable characteristics, hence were suitable for use in the study.

The post-test ANOVA results show that the difference between the groups is statistically significant at 0.05 alpha level ($F(3,234) = 30.876$, $p<0.05$). This therefore, shows that CBCML improved the achievement of students in the experimental groups compared to those in control groups. ANCOVA test results with the KCPE mark as covariate indicates that the difference in the mean scores of the groups were statistically significant at 0.05 alpha level ($F(3, 233) = 30.722$), $p<0.05$). These results show that there is statistically significant difference between Experimental Groups and Control Groups.

Moreover, the results of *Bonferroni post-hoc* pair-wise test for significance difference between any two means show that there was a statistically significant difference between the pairs of CAT post-test means for the Experimental groups and Control groups in favour of the experimental groups at 0.05 alpha level. However, there was no statistically significant difference in the means between Groups E1 and E2 and Groups C1 and C2. Therefore, these results show that CBCML improved the achievement of students who were in the Experimental Groups compared to those in Control Groups. This implies that CBCML has a positive effect on achievement in chemistry. Consequently the null hypothesis of the study was rejected at 0.05 alpha level in favour of the alternative hypothesis.

From these findings it is evident that weak students benefit from interaction with brighter students. This is because of the fact that when bright students explain their ideas to others, they learn the material they are explaining in more depth and remember it longer (Johnson & Johnson, 1992; 1998).

In a cooperative learning group, bright students are also seen as resources and are valued by team-mates (Wachanga, 2002). The CBCML teaching strategy exhibited these qualities, hence the higher achievement reported.

The findings of this study is in accordance with earlier studies by Wachanga, (2002) that compared the effects of traditional and Cooperative Class Experiment (CCE) learning strategies on achievement and motivation in secondary school chemistry also found significant difference in achievement. Moreover, a research done in the teaching of physics by Wambugu (2006) using Mastery Learning Approach (MLA) revealed that students taught using the approach outshined their counterparts taught using CTM. This result is similar to the findings of Wachanga and Gamba (2004) that investigated the effects of using Mastery Learning Approach on secondary school students' achievement in Chemistry and found that Mastery Learning Approach facilitates students learning of Chemistry better than the regular teaching method. It also agrees with the findings of Ngesa (2002) who reported that Mastery Learning Approach resulted in higher student achievement in Agriculture than the Regular Teaching Methods.

Studies by Awotunde and Bot (2003), Yildrin and Adyin (2005), found out that mastery learning is effective and if employed in classroom teaching would improve students' achievement in a given task. This means that Mastery Learning approach increases the performance of students exposed to it than students exposed to the regular teaching strategies.

7. Conclusion

The achievement of students in the Experimental Groups was higher than those in the Control Groups. This shows that students who are taught chemistry through CBCML learn the subject better than those taught through CTM. Therefore, CBCML facilitates students' achievement more than CTM.

References

Adesoji, F. A., & Olatunbosun, S. (2008). Student, teachers and school environmental factors as determinants of achievement in secondary school Chemistry in Oyo State, Nigeria. *J. Int. Res.* 1(2):13-34. Retrieved June 18, 2012 from http/www.sosyalarastirmalar.com/sosyalar astirmalar_ English/index_eng.htm

Aggarwal, J. C. (2004). *Essentials of educational technology: Teaching learning innovations in Education* New Delhi: UBS Publishers' Distributors PVT Ltd.

Awotunde, P. O. & Bot, T. D. (2003). Using mastery learning approach to improve performance of students in geometry in the secondary school, *Journal of Educational Studies*. 7 (1) 2-14.

Barchok, H. K. (2006). *The influence of secondary school students' self-concept of ability and gender stereotyping of science subjects on their attitudes towards science*: *A case study of Bomet District*, Kenya. Unpublished M.Ed. Thesis. Egerton University, Kenya.

Bloom, B. S. (1981). *All our children learning*: New York, NY: McGraw-Hill.

Borg, W. R., & Gall, M. D. (1996). *Educational research; An Introduction (6th ed.).* White Plains, NY: Longman.

Cook, T. D. & Campbell T. (1979). *Quasi experimentation: Design and analysis issues for field settings*. New York, NY: Rand McNally.

Cooper, H., Jackson, K., Nye, B., & Lindsay, J. J. (2002). A model of homework's influence on the performance of elementary school students. *Journal of Experimental Education, 69*, 181–199.

Fraenkel, J. R., & Wallen, N. E. (2000). *How to design and evaluate research in Education,* New York, NY: Mc Grawhill Companies Inc.

Grabe, M., & Grabe, C. (2007). *Integrating technology for meaningful learning* (4th ed.). Boston: Houghton Mifflin.

Harlen, W. (1993). Education for teaching Science and Mathematics in the primary school, Edinburgh: Scottish Council for Research in Education.

Johnson, D. W., & Johnson, R. (1992). *Positive interdependence: Activity manual and guide*.

Edina, MN: Interaction Book Company.

Johnson, D. W., & Johnson, R. (1998). *Learning together and alone: Cooperative, competitive, and individualistic learning* (5th ed.). Boston: Allyn & Bacon.

Kenya National Examination Council. (2014). *The 2013 K.C.S.E. examination report.* Self.

Kerich, K. R. (2004). *The importance of Science and Mathematics in secondary school Education in Kenya*. A paper presented during the opening ceremony for Bomet and Transmara Districts SMASSE Course at Siongiroi, 24th August, 2004.

Knight, J. K., & Wood, W. B. (2005) "Teaching More by Lecturing Less". *Cell Biology Education* 4: 298–310.

Kulik, C. C., Kulik, J. A., & Bangert-Drowns, R. L. (1990). Effectiveness of mastery learning programmes - a meta-analysis., *Review of Educational Research,* 60(2), 265-299.

Levine, D. (1985). *Improving Student Achievement through Mastery Learning Programs.* San Francisco: Jossey-Bass.

Lunetta, V. N., Hofstein, A., & Clough, M. P. (2007). Teaching and learning in the school science laboratory. An analysis of research, theory, and practice. In *Handbook ofresearch on science education* (ed. S. K. Abell and N. G. Lederman), pp. 393–431. Mahwah, NJ: Lawrence Erlbaum Associates.

Millar, R. (2004). *The role of practical work in the teaching and learning of science.* Paper

prepared for the Committee on High School Science Laboratories: Role and Vision, National Academy of Sciences, Washington DC. York: University of York.

Ngesa, F. U. (2002). *Impact of experiential and mastery learning programmes on academic achievement in secondary school agriculture.* Unpublished PhD Thesis, Egerton University, Kenya.

Robertson, E. B., Ladewig, B. H., Strickland, M. P., & Boschung, M. D. (1987,). Enhancement of self-esteem through the use of computer-assisted instruction. *Journal of Educational Research,* 80(5), 314-16. EJ 358 691.

Ronoh P. K., Wachanga S. W., & Keraro F. (2013). Effects of computer based mastery learning teaching approach on secondary school students' achievement in Biology Bomet District, Kenya. *International Journal of Social Science & Interdisciplinary Research* (IJSSIR), Vol. 2 (12).

Taber, K. S. (2009). Progressing the constructivist research programme to advance teaching and learning about the nature of Science. In I. M. Saleh & M. S. Khine (Eds.), *Fostering Scientific Habits of Mind: Pedagogical Knowledge and Best Practices in Science Education*. Rotterdam, The Netherlands: Sense Publishers, pp.37-57.

Tanui, K. E., Kiboss, J. K., Walamba, A. A., & Nassiuma, D. (2003). Teachers' changing roles in computer assisted roles in Kenyan secondary schools. *Educational Researchand Review Vol. 3 (8), pp. 280- 285.*

Udo, M. E. (2011). Effects of reformulation of knowledge and expository teaching strategies on students' performance in chemistry. *African Research Review*: *5*(1):354-364.

Ugwu, A. (2007). Inculcation of practical skills in students and teachers. *Journal of STAN* 21.

Wachanga, S. W. (2002). *Effect of co-operative class experiments teaching method on secondary school students motivation and achievement in Kenya*. Unpublished PhD Thesis, Egerton University.

Wachanga, S. W., & Gamba, P. P. (2004). Effects of mastery learning approach on secondary

school students' achievement in Chemistry in Nakuru District Kenya: *Egerton Journal. Humanities, Social Sciences and Education,* 5(2), 221-235

Wachanga, S. W., & Mwangi, J. G. (2004). Effects of cooperative class experiment teaching

method on secondary school students' chemistry achievement in Kenya's Nakuru District. *International Education Journal,* 5(1), 26-36.

Wambugu P. (2006). *Effects of mastery learning approach on secondary school students' achievement, motivation and self-concept in Physics in Kieni East Division of Nyeri District, Kenya*. Unpublished MEd Thesis, Egerton University.

Wekesa, E., Kiboss, J., & Ndirangu M. (2006). Improving Students Understanding and Perception of Cell Theory in School Biology Using a Computer-Based Instruction Simulation Program. *Journal of Educational Multimedia and Hypermedia. Volume*: 15. Issue: 4

Yildiran, G. & Aydin, E. (2005). The effect of mastery, cooperative, competitive and individualistic learning environment organizations on achievement and attitudes in mathematics. *Journal of Korean of Mathematics Education*. 9(1), 55-72.

AUTHORS' BIOGRAPHY

John K. Keter is a high school teacher who is in the final stages of his Ph.D studies. He is experienced in teaching of Chemistry and Mathematics and hopes to join University teaching on graduating with his Ph.D. His recent research focused on mastery learning in the teaching process. He considered learners' achievement and motivation when they ear taught through mastery learning.

Samuel W. Wachanga is a full professor of Chemistry Education in Egerton University's Faculty of Education & Community Studies. Recently, he was appointed acting Deputy Vice-Chancellor (Administration, Planning & Development). Previously he served as Dean of the Faculty of Education and Community Studies.His research interest is in the use of Cooperative Learning in teaching. How cooperative learning affects learners acquisition of affective, cognitive and psychomotor outcomes of teaching.

Zephaniah O. Anditi is a Senior Lecturer in the Department of Curriculum, Instruction & Educational Development in Egerton University. He also serves as the teaching practice coordinator. His recent research studies investigated learners acquisition of science process skills. How variables such as age and gender affect acquisition of these skills.