

Full Length Research Article

Effects of Concept and Vee Mapping Strategy on Students' Achievement in Biology in Secondary Schools in Uasin – Gishu District, Kenya

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This study investigated the effects of using concept and Vee mapping strategy (CVMS) teaching approach on secondary school student's achievement in Biology. A non – equivalent control group design under the Quasi – experimental research was used in which a random sample of 4 co-educational secondary schools was obtained in Uasin – Gishu District. These 4 schools were randomly assigned to four groups. Each school provided one Form Two classes for the study hence a total of 144 students were involved. Students in all the groups were taught the same Biology content but in two groups they were taught through CVMS approach while the rest were taught through regular teaching methods. Before the four weeks course started, the students were trained in concept and Vee mapping learning techniques. Two groups were pre-tested prior to the implementation of CVMS treatment. At the end of teaching, all therefore groups were post – tested using the Biology Achievement Test (BAT). The data was analyzed using one- way ANOVA and t-test. The results show that students exposed to CVMS approach have significantly higher achievement than those taught through regular methods. The resources conclude that CVMS is an effective teaching approach which Biology teachers should be encouraged to use.

Key words: Motivation, Achievement, Concept Mapping, Vee Mapping, Conventional Teaching Methods

INTRODUCTION

Biological knowledge has made contribution to the welfare of mankind in various fields. It provides students with vulnerable concepts, life skills and career options. It helps to give learners a greater appreciation for the world and its inhabitants, strong problem – solving skills and research know-how (FAO, 1995). Biology Education contributes to society's development by helping students develop into more responsible citizens who would help to build a strong economy, contribute to a healthier environment and bring about a brighter future (UNESCO, 1986). However, in spite of this importance of Biology, the Kenya Certificate of Secondary Education (KCSE) Examination results show that most students have been performing poorly (Kenya National Examinations Council KNEC, 2004). The Kenya National Examinations Council (2002) identifies the approach used in teaching Biology as a key factor which contributes to this poor student's performance.

In particular, the use of expository teaching approaches has been blamed for the poor performance. Concept and Vee mapping is a hybrid teaching approach which draws from concept mapping and Vee mapping teaching strategies. In CVMS approach, organize Biological concepts in a hierarchical manner from the more inclusive concept (major) to the more specific, less inclusive (minor) ones (Kinchin, 2000). The students also make a V-shaped representation that helps them to discover for themselves, the ten elements which constitute the structure of knowledge especially when dealing with problems of laboratory instruction (Narok and Gowin,

1984). This study attempted to find out from an experiment mode how students' achievement is affected by use of CVMS teaching approach. It also attempted to find out how the students gender affects their achievement.

Conceptual Framework

The conceptual framework used in this study was based on the constructivist theory of learning. In this theory, the teacher serves as a facilitator who attempt to provide an environment in which the learner organizes meaning at a personal level (Driver and Erickson, 1993). The study was based on the assumption that a teaching method that involves students participation and activity is more likely to lead to a worthwhile learning than a transmission method (Hanharan, 1998). The study therefore involved students in construction and reconstruction of concept maps and Vee maps. Diagrammatically, the framework is represented as follows:

Conceptual framework showing variables that interact to influence students' achievement in Biology

The study involved trained Biology teachers who had more than two years of teaching experience. Involving Form Two students who were approximately the same age controlled the variable of student's age. Purpose and objectives of the study. This study was designed to determine the effect of using CVMS approach on students' achievement in Biology its specific objectives were:

- To determine whether there is a statistically significant difference in student's achievement in Biology between

those taught using CVMS and those taught using regular methods.

- To determine whether there is a statistically significant gender difference in Biology achievement when students are exposed to concept and Vee mapping strategy (CVMS)

CONCEPTUAL FRAMEWORK

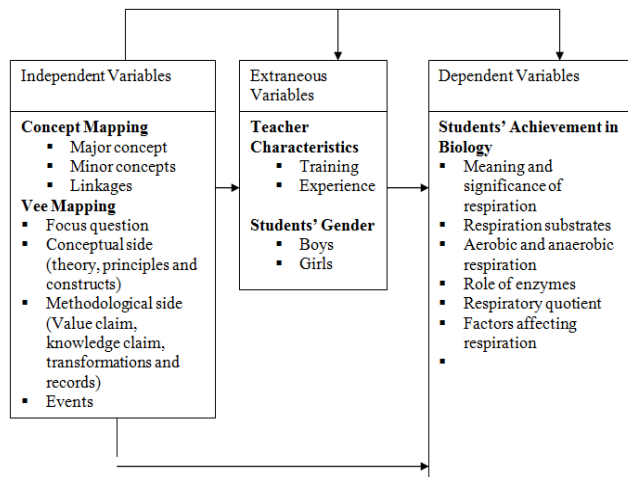


Figure 2

HYPOTHESIS OF THE STUDY

The following null hypothesis were tested in this study

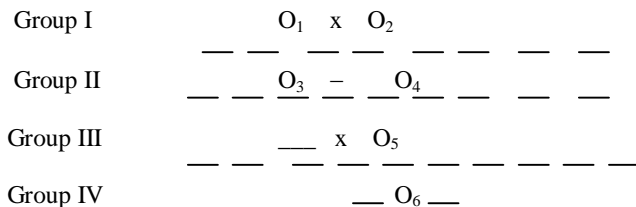
H₀₁ There is no statistically significant difference in achievement in Biology between students' taught using the Concept and Vee mapping teaching strategy and those taught using the conventional methods

H₀₃ There is no statistically significant gender difference in achievement when students' are taught using Concept and Vee mapping teaching strategy.

RESEARCH DESIGN

In this study, a quasi-experimental research design was used. This is because there was non-random assignment of subjects to the groups since the school authorities do not normally allow the classes to be dismantled so that they can randomly be re-constituted for the purpose of research (Gall, Borg & Gall, 1996). The design that was adopted in this study is Solomon Four – Group Design.

The Solomon Four – Group Design is as follows:-



Where:

O₁ and O₃ are pre-tests: O₂, O₄, O₅ and O₆ are post – tests. X is the treatment where students were taught using Concept mapping and Vee-mapping strategies.

__ means no treatment. It refers to the control group.

Group I is the experimental group, which received the pre-test, the treatment (X) and the post-test.

Group II is the control group, which received a pre-test followed by the control condition and lastly a post-test.

Group III received the treatment X and a post-test but did not receive the pre-test.

Group IV received the post-test only.

Group II and IV were taught using conventional teaching methods.

The Solomon Four – Group Design was used because as Gall, Borg & Gall (1996) argue, it is considered suitable in achieving the following purposes:-

- Assess the effect of the experimental treatment relative to the control treatment.
- To assess the effect of a pre-test relative to no pre-test.
- To assess interaction between pre-test and treatment conditions.
- Determine the extent to which the groups are uniform before giving the treatment.

The Solomon Four Group design controls for all major threats to internal validity except those associated with interactions of selection and history, selection and maturation and selection and instrumentation (Cook & Campbell, 1979). To control for interaction between selection and maturation, the schools were assigned randomly to the control and treatment groups. No major event was observed in any of the sample schools that would have introduced interaction between selection and history. The conditions under which the instruments were administered were kept as similar as possible in all the sample schools to control for interaction between selection and instrumentation.

SAMPLING PROCEDURES AND SAMPLE SIZE

The sampling unit was the secondary schools and not individual students since students operate as intact groups. The study used provincial secondary schools to ensure that students involved in the study had academic abilities that were comparable. A list of provincial secondary schools in Uasin Gishu District was used as a sampling frame. Purposive sampling technique was used to select four schools that formed the study sample. This sampling technique was preferred because the District has only five mixed provincial schools. The sampled schools are far apart and this minimized experimental treatment diffusion. In schools that had more than one form two stream, simple random sampling was used to select one stream for the study. The schools were randomly assigned to the four groups. The schools in each group were as follows:-

Group I (Experimental group), N = 32
 Group II (Control group), N = 30
 Group III (Experimental group), N = 44
 Group IV (Control group), N = 38

A total of 144 form two students participated in the study.

INSTRUMENTATION

Biology Achievement Test (BAT)

The Biology Achievement Test was developed by the researcher and used as a pre-test. The items were re-organized for it to be used as a post-test again. The test had 30 items, which carried different scores ranging from 2 – 10. All items added to a total of 100 marks. The test items were open-ended. The items tested knowledge, comprehension, application, analysis and evaluation of what they had learned (See appendix I). The test was based on the Form Two biology topic; respiration. The test was given to five experts in science education and five secondary school Biology teachers for validation. The researcher had more interest in content validity, which was assessed by determining the degree to which BAT represented the teaching objectives of the topic respiration. According to Lewis (1976), achievement tests are usually content validated. The validation was done by comparing the content of the BAT to the syllabus outline of the subject content that was covered in the topic of respiration. As Lewis further argues, this is criterion related validity and receives the greatest attention in educational measurement. The criterion in this case is the judgement of the subject-matter experts.

The test was pilot-tested using two secondary schools with the same characteristics as the sample schools from North Nandi District. This was used to validate and estimate the reliability. Since the items were not scored dichotomously, the reliability coefficient of the test was estimated using cronbach's coefficient alpha (Thorndike & Thorndike, 1994)

$$a = \frac{K}{K - 1} \left[1 - \frac{\sum S^2_i}{S^2_x} \right]$$

Where K =Number of items on the test.

S^2_x =Variance of test x

S^2_i =Variance of item i

This is the most appropriate reliability tool used to assess homogeneity of items and can be determined using only one administration of the instrument (Kathuri & Pals, 1993). A reliability coefficient for the BAT was found to be 0.90. This is far above the minimum acceptable reliability coefficient of 0.70 (Kathuri & Pals, 1993; Nsubuga, 2000). An alpha value of above 0.70 is considered suitable to make possible group inferences that are accurate enough. Therefore the BAT instrument was reliable enough. The instrument was then used to collect data that is analysed and discussed in chapter four.

The Development of Instructional Materials

The subject content used in the study was based on the Kenya National Examinations Council (KNEC, 2002) and the Kenya

Institute of Education approved Biology syllabus (KIE, 2002). The Concept & Vee mapping strategy required the teacher to have a manual (booklet) throughout the teaching period. The manual (appendix G) was prepared by the researcher and contained the content outline, teaching and learning activities. The following subtopics were covered:

- Definition and significance of respiration
- Respiratory substrates
- Aerobic respiration
- Anaerobic respiration
- Comparison between Aerobic and Anaerobic respiration
- The role of enzymes in respiration
- Respiratory Quotient
- Factors affecting respiration

The researcher inducted teachers for the experimental groups for one week. Prior to the commencement of the treatment, a pre-test was administered to the learners in group I and II. The treatment was then administered for a period of 1 month (4 weeks) to the experimental groups. Each week had four lessons, one double lesson of 80 minutes and two single lessons of 40 minutes each. During the lessons, teachers taught using the Concept mapping and Vee mapping strategies in about equal proportions. The control groups were taught using the conventional approach. After the treatment, the researcher with the help of regular teachers administered the post-test.

Data Collection

The researcher began the study after pilot-testing the research instruments. The first step was to induct two teachers for the experimental groups (I and III) on the use of Concept and Vee mapping strategy in teaching. After the induction, BAT was administered as a pre-test to groups I and II. The two teachers for experimental groups used the CVMS to teach their students (group I and III) while those of control groups II and IV used conventional teaching methods. For treatment groups, teachers begun by first introducing the concept mapping to students. The final instructional sequence used with experimental groups I and III was (1) "Learning how to learn" activities; (2) Concept mapping, introduce examples and explain principles behind concept mapping with subsequent practice in conjunction with regular Biological science activities; and (3) Introduction to Vee mapping, usually after class work, with an experiment that lent itself to Vee mapping (teachers illustrated Vee mapping with subsequent practice by students). The use of Concept mapping and Vee mapping continued from the beginning to the end of the topic. Students in all the four groups were then subjected to BAT as a post-test. The researchers then scored the tests. This generated quantitative data.

Data Analysis

This study generated Quantitative data, which was analyzed with the help of the Statistical Package for Social Sciences (SPSS) version 11.5. T-test was used to test for different groups and between genders of the students. Analysis of Variance (ANOVA) was used to test for differences in post-test between the four groups under study. ANOVA was preferred over Analysis of Covariance (ANCOVA) since the study did not have an appropriate covariate. In conducting both the ANOVA and t-tests the predetermined 0.05

significance (probability) level was used in order to reject or accept the null hypotheses, which postulated equality or non-significant differences between groups.

Results of the Pre-test

The Solomon Four Group Design used in this study enabled the researcher to have two groups sit for the pre-test. Group 1 and 2 sat for the pre-test BAT. As recommended by Gall, Borg and Gall (1996) this was necessary because it enabled the researcher to:-

- Assess the effects of pre-test relative to no pre-test.
- Assess if there was an interaction between the pre-test and the treatment conditions.
- Assess the similarity of the groups before administration of the treatment

Performance in BAT Pre-test between experimental and control groups

To assess the similarity of experimental and control groups, a BAT pre-test was administered to form two students in groups 1&2 prior to the experiment. The pre-test contained 30 items that sought to test students’ mastery or understanding of the topic respiration, which was the focus of this study. The pre-test scores were then expressed as a percentage. 100 marks. Group 1 and group 2 schools were used as experimental and control groups respectively. The mean scores for each group were compared using an independent sample t-test statistic to establish if there were any statistical differences in their performance. Table 5 shows the t-test results.

Table 1: Independent samples t-test of the pre-test mean scores on BAT

Group	Mean	Std. Dev.	T-value	P-value
1	6.94	5.04	-0.937	0.352(ns)
2	8.40	7.13		

Group 1, N = 32; Group 2, N = 30
 ns= not significant at P< 0.05 level; Std. Dev = Standard deviation

An examination of the results in Table 1 shows that the mean scores for groups 1 and 2 on pre-test BAT are not statistically different. The T-value of 0.919 has a significant level (p-value) of 0.362, which is much greater than the acceptable 0.05 level. The implication is that the two groups are homogenous in their learning ability.

Performance in pre-test BAT between boys and girls

A comparison was made on the pre-test BAT scores for boys and girls for group 1 and group 2 schools which had been subjected to the pre-test. In this test the two groups were combined and their means established based on gender. The gender based pre-test means scores were then compared using an independent sample t-test to establish whether there were any differences in the performance. Table 6 shows the results of the pre-test BAT scores.

Effects of CVMS on Students’ Achievement in Biology

Students of group one and three were taught the topic respiration using the CVMS developed by the researcher hence constitute the experimental groups. On the other hand, students of group two comprising four schools were taught

using the conventional teaching approaches and thus constituted the control groups. The intervention took 4 weeks after which a post-test BAT was administered. The BAT was scored and the final score expressed as a percentage. The mean scores achieved by students in the four respective groups are presented in Table 7.

Table 2: BAT post-test mean score obtained by the students in the four groups

Group	N	Mean score	Std. Dev.
1	32	38.44	11.61
2	30	31.03	9.73
3	44	49.66	20.83
4	38	24.89	11.58
Total	144	36.66	18.91

Results in Table 2 shows that group 3 had the highest post-test mean score at 49.66 followed by group 1 with a mean score of 38.44. Groups 2 and 4, which were control, groups had lower mean scores at 31.03 and 24.89 respectively. The scores achieved by students in the four groups were then analysed, using one-way Analysis of Variance (ANOVA), to determine the relative effects of CVMS teaching approach on students’ achievement. This was to test hypothesis H₀1 of the study, which sought to find out whether there was any statistically significant difference in achievement between students exposed to CVMS teaching approach and those exposed to conventional methods. The results of the one-way Analysis of Variance (ANOVA), based on those means are shown in Table 2.

Table 3: Analysis of Variance (ANOVA) of the post-test scores

	Sum of squares	df	Mean square	F	p-value
Between groups	13744.69	3	4,581.56	21.37	0.000
Within Groups	30010.31	140	214.36		
Total	43755.00	143			

Results in Table 3 reveals that there exists a statistically significant difference in the mean scores across the four groups since the p-value of 0.00 is less than the acceptable value of 0.05. In other words, some groups achieved significantly higher scores in post-test BAT than other groups. After establishing that there was a statistically significant difference between the means, F (3, 140) = 21.37, P < 0.05, it was necessary to carry out further tests to find out where the differences existed. There are several post-hoc tests that could be used depending on the comparison of interest. The Least Significant Difference (LSD), Post hoc test was used for the mean separations with each separate comparison tested at 0.05 (Moore & MC Cabe, 1989). Table 4 shows the results of the LSD post-hoc comparisons.

Table 4: LSD Post Hoc Comparisons of the Post-test of BAT means of the four groups

	1	2	3	4
1	-	7.40*	-11.22*	13.54*
2	-7.40*	-	-18.63*	6.14
3	11.22*	18.63*	-	24.76*
4	-13.54*	-6.14	-24.76*	-

* The mean difference is significant at p<0.05

Results in Table 4 show that the mean difference between group 1 and groups 2, 3 and 4 was statistically significant. Group 1 achieved a higher mean score compared to groups 2 and 4. However, it achieved a lower mean score compared to group 3. Group 1 and 3 showed statistically significant difference in their means regardless of being experimental groups. This could be attributed by other factors besides the treatment. The mean score for group 2 students was also found to be statistically different from groups 1 and 3. Group 2 students achieved a lower mean score compared to groups 1 and 3. However, group 2 achieved a higher but non-significant mean score compared to group 4. The mean difference between group 3 and groups 1, 2 and 4 was statistically significant at an alpha level of 0.05 whereby group 3 achieved a higher mean score than the three groups. The mean difference between group 4 and groups 1, 2, and 3 was -13.54, -6.14 and -24.76 respectively. This means that group 4 achieved the lowest mean score compared to the three groups. Results also show that the mean difference between group 4 and groups 1 and 3 was statistically significant. However, the mean difference between group 4 and 2 was not statistically significant. Comparing the performance in post-test BAT between experimental groups and control groups, an independent sample t-test was employed. This was done by categorizing the 4 groups into 2 groups of experimental (group 1 and 3) and control (group 2 and 4) then running the t-test whose results are shown in Table 5.

Table 5: Independent sample t-test on post-test BAT between experimental and control groups

Group	N	Mean	Std. Deviation	T	df	p-value
Experimental	76	44.93	18.24	6.81	142	0.00
Control	68	27.60	19.80			

Results in Table 5 show significant difference in the mean scores of the two groups where the experimental group achieved significantly higher scores as compared to the control groups. The results therefore imply that the treatment, CVMS teaching strategy was effective and led to better achievement by students than the conventional teaching approaches. A comparison of the students' scores in the pre-test and post-test BAT was carried out to establish the mean gain in scores after the treatment. Table 6 shows the mean gain in scores over the pre-test.

Table 6: Comparison of the mean scores and mean gain obtained by students in the BAT

	Group 1 (N = 32)	Group 2 (N = 30)	Overall (N = 62)
Pre-test mean	6.94	8.40	7.65
Post-test mean	38.44	31.03	36.75
Mean gain	+31.50	+22.67	+29.10

The pre-test and post-test mean scores reveal that both groups gained significantly from the teaching. However, group 1 whose students were taught using the CVMS had by far, a higher mean gain than group 2 whose students were taught using the conventional approach. This strengthens the position that the CVMS resulted in higher achievement than the control condition.

A Summary of the Results for Hypothesis:H₀1

- (i) The pre-test BAT did not affect the students in the learning of the content. If this were not the case, the students who did pre-test would have different results from others who did not do the pre-test. This therefore made the pre-test suitable for the study.
- (ii) The BAT pre-test did not interact significantly with the treatment conditions. If this was not the case, the groups, which sat for the pre-test would have obtained different results from those that did not take it (Call, Borg & Gall, 1996).
- (iii) The use of CVMS resulted in higher students' achievements than the conventional teaching methods since experimental groups obtained significantly higher scores compared to control groups, as was shown by the independent sample t-test statistics.
- (iv) Hypothesis H₀1, which stated that there is no statistically significant difference in achievement in Biology between learners who are taught using the Concept & Vee Mapping Strategies and those, taught using the conventional methods is thus rejected.

A SUMMARY OF THE RESULTS FOR HYPOTHESIS:

- (v) The pre-test BAT did not affect the students in the learning of the content. If this was not the case, the students who did pre-test would have different results from others who did not do the pre-test. This therefore made the pre-test suitable for the study.
- (vi) The BAT pre-test did not interact significantly with the treatment conditions. If this was not the case, the groups, which sat for the pre-test would have obtained different results from those that, did not take it (Call, Borg & Gall, 1996).
- (vii) The use of CVMS resulted in higher students' achievements than the conventional teaching methods since experimental groups obtained significantly higher scores compared to control groups, as was shown by the independent sample t-test statistics.
- (viii) Hypothesis H₀1, which stated that there is no statistically significant difference in achievement in Biology between learners who are taught using the Concept and Vee Mapping Strategies and those taught using the conventional methods is thus rejected.

DISCUSSION OF THE RESULTS

The results have shown that students who were taught using CVMS achieved significantly higher scores in the BAT than those who were taught by conventional teaching approaches. The experimental group also achieved a higher mean gain in the post-test over the pre-test. The positive effect of CVMS teaching strategy is attributed to the fact that the overall framework of the concepts being learned is made explicit and this ensures careful sequencing of the material in order to promote meaningful learning. The students can also attribute higher achievement to its effectiveness in revealing patterns of understanding and misunderstanding. CVMS also make students to understand the general worldview and philosophy guiding the inquiry and the beliefs about the nature of knowledge being sought. It gives students the awareness of relevant concepts and theories, data recording and transforming procedures as well as knowledge and value

claims that derive from the inquiry (as in laboratory experiment exercises). Previous work by Kinchin and Ian (2000), though focussing only on use of concept mapping in biology teaching, found similar results and concluded that concept mapping leads to meaningful learning. Conversely, Novak and Gowin (1990) and Okebukola (1992) concluded that the positive effect of concept mapping was attributed to its being interactive, creative and visual. Similar results were also found by Orora, Wachanga and Keraro (2007) who investigated the effect of Cooperative Concept Mapping approach on students achievement in Biology.

Effects of CVMS on the Achievement of Boys and Girls

Hypothesis three (Ho3) stated that there is no statistically significant gender difference in achievement when learners are taught using Concept and Vee mapping teaching strategy. To test this hypothesis, post test BAT scores of experimental groups 1 and 3 were used in the analysis. The experimental groups had a total of 41 male students and 35 female students. The post-test BAT scores for the boys and girls involved are presented in Figure 3.

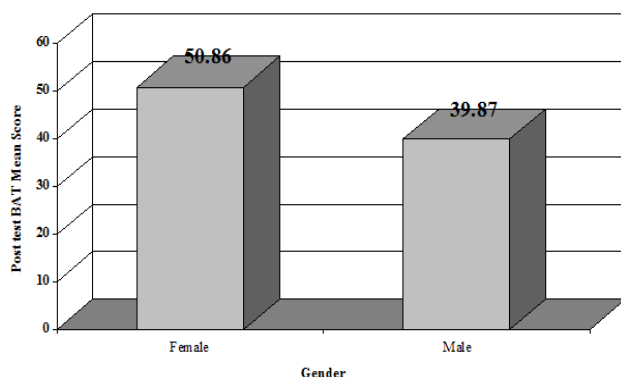


Figure 2

Difference in Post-test BAT Mean Scores

The results in Figure 3 show that female students scored higher than male students. The mean scores were 50.86 for female students and 39.87 for the male students. The difference in the means is approximately 11 scores. In order to test Hypothesis Ho3 that sought to establish whether there is a statistically significant difference between the achievement of boys and girls who were taught using the CVMS, an independent sample t-test was carried out. The t-test results are shown in Table 7.

Table 7: Independent sample t-test results of the post-test BAT Scores of boys and girls exposed to CVMS

Gender	N	Mean	Std. Deviation	T	df	p-value
Male	41	39.87	16.68	-2.71	74	0.01
Female	35	50.86	18.59			

As shown in Table 16, the P-value is 0.01, which is less than the acceptable alpha of 0.05. This means the difference in the BAT post-test mean scores of boys and girls taught using CVMS was statistically significant. The implication is that CVMS leads to higher achievement in biology among girls than boys. Hypothesis Ho3, which stated that there is no statistically significant gender difference in achievement in

biology when taught using Concept and Vee Mapping teaching strategy was thus rejected. The findings of this study have shown that there was a statistically significant difference in post-test BAT means scores between boys and girls who were taught using CVMS. Girls taught using the strategy achieved significantly higher scores than the boys. According to Collins (1985), girls utilize their right side of the brain more, which emphasizes Rhyme, Rhythm, pictures and imagination. This is contrasted to boys who mostly use their left hemispheres, which emphasize words, Logic, Mathematics, numbers and sequence. The CVMS would have probably enhanced learning for girls more than boys because of their pictorial or graphic nature. Therefore the disparity between girls’ and boys’ achievement at KCSE Biology examination can be addressed by using the Concept Mapping and Vee Mapping Strategies.

Implication of the Study

The use of CVMS teaching strategy led to better achievement in biology compared to the conventional teaching methods. This was attributed to the active role that students play in the learning process. The results of this study also indicates that Female students taught using CVMS teaching strategy had higher mean scores in Biology Achievement Test (BAT) compare to boys. The approach therefore should be used in teaching biology at secondary school level since girls have been performing dismally in science at national examination compared to boys. Education inspectorate in its efforts to make biology teachers more effective should encourage them use this method. Teacher training institutions should incorporate the CVMS concepts in their training curriculum in order to produce teachers who can use the new approach.

Conclusions

The following conclusion has been reached from this study:-

- The CVMS teaching approach enhances students learning in biology than the conventions teaching methods
- The CVMS teaching approach makes girls to do better than when they are taught using conventions methods implying that it could make girls perform equally as boys in biology.

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