EFFECTS OF EXPERIENTIAL CONCEPT MAPPING TEACHING STRATEGY ON STUDENTS' ACHIEVEMENT IN CHEMISTRY IN IMENTI SOUTH DISTRICT, KENYA

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ABSTRACT:

The aim of this study was to investigate how the Experiential Concept Mapping (ECM) teaching strategy affects secondary school students' achievement in Chemistry. Solomon Four- Group, Non-equivalent Control Group Design was used. The participants were 179 Form Two students from four classes enrolled in day co-educational district secondary schools. Two classes were randomly chosen as Experimental groups and the other two were Control groups. Experimental groups were taught through (ECM) teaching strategy while Control groups were taught through the Regular Teaching Methods (RTM).The study was conducted in four weeks and the material covered was Structure of the Atom and Periodic Table from Form Two syllabus. The students were pre-tested and post-tested using a Chemistry Achievement Test (CAT). The study showed that ECM resulted in higher students' achievement in chemistry more than regular teaching methods. Gender had no significant effect on students' achievement when ECM is used. Thus, chemistry teachers should incorporate the ECM in their teaching**.**

KEY WORDS: Experiential Concept Mapping teaching strategy, Students' Achievement Chemistry, Regular Teaching Methods.

INRODUCTION:

Research has shown that poor performance in sciences is largely due to the use of conventional teaching methods (Johnson & Johnson, 1991; Wachanga & Mwangi, 2004). These teaching approaches are mainly expository in nature hence makes learners to be passive recipients rather than active participants in the construction of knowledge (Tsuma, 1998). When students are not actively involved in learning, their knowledge of science is often characterized by lack of coherence and majority of them engage essentially in rote learning. These problems are quite serious in Chemistry, which is widely perceived as a difficult subject because of its specialized language, mathematical and abstract conceptual nature and amount of content to be learned (Moore, 1989).The prevailing teaching practices do not actively involve students in the learning process and seem to deprive them from taking charge of their learning (Boujaode & Attieh, 2008).

Improving educational quality requires placing learners in active rather than passive roles. Knowledge that empowers and increases the learner's self-confidence is that which results from the coming together of individual actions, feelings and conscious thoughts (Novak, 1998).Thus

the goal of education should be to develop educational experiences that facilitate meaningful learning and that reduce the need for rote learning. An important teaching goal is to help students understand the main concepts in a subject rather than just memorizing isolated facts. Concepts represent a major portion of school curriculum, and much of teachers efforts are directed at teaching them (Klausmeier, 1992). Individuals think in terms of concepts (Schaefer, 1979). Concepts are mental structures that categorize sets of objects, events or ideas (Eggen, 2001). They are elements of cognition that help to simplify and summarize information. Concepts also aid the process of remembering, making it more efficient. When students group objects to form a concept they can remember the concept, and then retrieve the concepts' characteristics.

Concept mapping is a teaching and learning strategy that enables learners to organize concepts and their relationships a hierarchical manner from the most general, most inclusive concepts to most specific, least inclusive concepts (Novak, Gowin & Johansen, 1984). The main concept is located at the top of the map followed by concepts subordinate to it. The concepts are highlighted in circles or boxes and are connected by suitable linking lines with words that characterize the relationship between them. Experiential learning refers to learning and development that are achieved through personally determined experience and involvement (Thompson, 2008). Lessons in experiential learning are arranged so that every student participates completely in the learning process and has control over its nature and direction (Rogers & Freiberg, 1994). Experiential Concept Mapping (ECM) teaching strategy is a composite of experiential learning and concept mapping teaching strategies. In this approach, students are directly involved in constructing experiential concept maps as a learning activity. ECM is expected to help students enhance learning of science concepts by promoting meaningful learning.

PURPOSE OF STUDY:

The study sought to investigate the effects of Experiential Concept Mapping (ECM) teaching strategy on Students' achievement in Chemistry.

OBJECTIVES OF THE STUDY:

In order to achieve the purpose of the study, the following objectives were stated:

1. To compare the achievement of students who are taught through ECM with that of those who are taught through RTM.
2. To determine whether students' achievement is affected by gender, when they are taught through ECM.

NULL HYPOTHESES:

H_O1: There is no statistically significant difference in students' chemistry achievement scores between those who are taught through ECM and those who are taught through RTM.H_O2: There is no statistically significant difference in chemistry achievement scores between boys and girls who are taught through ECM.

CONCEPTUAL FRAMEWORK:

The conceptual framework used in this study was based on the constructivist theory of learning. This theory holds that, learning is active processes where students are actively involved in construction of meaning rather than having a teacher serve as a dispenser of facts and lower level cognitive information (Duit & Treagust, 1998). The study was based on the assumption that a teaching method that involves students in experiential concept mapping is more likely to lead to meaningful learning as compared to regular teaching methods.

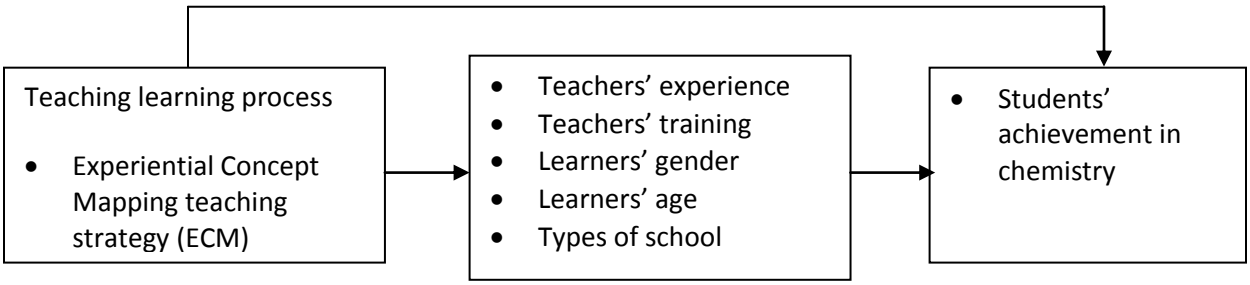

Figure 1.Conceptual Framework for effects of ECM Teaching Strategy on students' achievement Teachers' experience and training were controlled by involving trained teachers who had three of more years of experience. Learners' age was controlled by involving Form 2 students who have similar age. The type of school was controlled by involving district co-educational schools only.

RESEARCH METHODOLOGY:

The researchers used Solomon Four-Group, Non-equivalent Control Group Design. This design is rigorous enough for experimental and quasi-experimental studies (Borg & Gall, 1989). The design involved a random assignment of intact classes to four groups. This is because the school authorities do not allow such classes to be broken up and reconstructed for purposes of research. This design controlled all major threats to internal validity except those associated with history and maturation (Cook & Campbell, 1979). The design is illustrated in Figure 2.

Group 1	O_1	X	O_2
Group 2	O_3		O_4
Group 3		X	O_5
Group 4			O_6

Figure 2: Solomon-Four Group, Non-Equivalent Control Group Design.

Group I was the Experimental group which received the pre-test (O_1), the treatment (X) and the post-test (O_2). Group 2 was the Control group which received pre-test and a post-test but no treatment. Group 3 was the experimental group which received the treatment (X) and post-test but no pre-test. Group 4 was the Control group which received post-test only. Four schools were purposively sampled from Imenti South District. This was done in order to select schools with similar characteristics as they should be as equivalent as possible. The assignment of the groups to either Experimental or Control groups was done through simple random sampling. Where the school had more than one stream, all the streams were involved in the study but only one was sampled randomly for data analysis. Participants in this study were 179 Form Two chemistry students. Group 1 (n=40), Group 2 (n=51), Group 3 (n=34) and Group 4 (n=54). According to Mugenda and Mugenda, (2003) at least 30 cases per group are required for experimental studies. Chemistry Achievement Test (CAT) was developed on the topic of Structure of the Atom and Periodic Table from Form 2 Chemistry syllabus and was used as a pre-test and a post-test to assess students' achievement in chemistry.CAT had10 items with scores ranging between 1 to 3. It had Cronbach's Alpha reliability coefficient of 0.71. The items tested knowledge, comprehension and application levels of learning. According to Fraenkel and Wallen (1990), an $\alpha \geq 0.7$ is considered suitable to make possible group inferences that are accurate enough. Before administration, the CAT was pilot tested in two secondary schools from a neighbouring district that had similar characteristics as sample schools. Chemistry teachers of the Experimental groups were trained on Experiential Concept Mapping for 4 days. This enabled them to master the skills of using ECM as a teaching strategy. After this period, a CAT pre-test was administered to Experimental Group I and Control Group 2. This was followed by the exposure of Experimental groups 1 and 3 to the treatment which took four weeks. Students constructed experiential concept maps and the teachers checked and guided them during each lesson. Students in Control Groups 2 and 4 were taught through regular methods. At the end of treatment period, CAT post-test was administered to all the four groups by the chemistry teachers from sampled schools and supervised by the researchers. The Analysis of Covariance (ANCOVA) was carried out when analysing the differences in the mean scores in the post-test. A t-test was performed to detect the differences between two group means. This is because of its power to detect differences between two means (Borg & Gall, 1989).The statistical significance was tested at $\alpha = 0.05$.

RESULTS:

Pre-test

Group 1 and Group 2 students were exposed to pre-test before the start of treatment. The aim of the pre-test was to ascertain whether the students selected to participate in this study had comparable characteristics. Table 1 shows the mean scores of the two groups

Table 1:Means of Pre-test Scores on CAT for Groups 1 and 2

Group	Number of participants (N)	Mean score	Maximum Score
Experimental 1	40	16.00	30
Control 2	51	15.41	30

The pre-test CAT mean scores of Group 1(16.00) were slightly higher than that of Group 2 (15.41) (Table 1).

A t-test for independent samples was conducted to establish whether the two mean scores were statistically different.

Table 2: Independent Sample t-test of Pre-test Scores on CAT

Variable	Group	N	Mean	Std. dev	df	t-value	p-value
CAT	1	40	16.00	2.562	89	0.903	0.369(ns)
	2	51	15.41	3.645			

ns: non significant at $p>0.05$

Pre-test CAT mean scores of both groups 1 and 2 were not significantly different at 0.05 alpha level ($t(89) = 0.903$, $p>0.05$) (Table 2). Thus the groups were similar on CAT measure, implying that the two groups had comparable characteristics, hence homogenous. This made them suitable for the study. A similar test was carried out based on gender and the results are shown in tables 3 and 4.

Table 3: Means of Pre-test Scores on CAT based on Gender

Gender	Number of participants (N)	Mean score	Maximum Score
Male	42	15.60	30
Female	49	15.73	30

The results in Table 3 show that the CAT mean score of male (15.60) and that of female (15.73) were similar. Thus, there was no gender difference. A t-test was conducted to investigate whether the two groups were statistically different on CAT pre-test mean scores based on gender.

Table 4: Independent Sample t-test of Pre-test scores on CAT based on Gender

Variable	Gender	N	Mean	Std.dev	df	t-value	p-value
CAT	M	42	15.60	3.272	89	-0.204	0.839 ns)
	F	49	15.73	3.101			

ns: non significant mean differences at $p>0.05$ level

The t-test analysis (Table 4) shows that the computed p-value was greater than the set alpha value (0.05). Therefore the pre-test mean scores of boys and girls were not statistically significant different at 0.05 alpha level ($t(89) = -0.204$, $p>0.05$.Thus, boys and girls entry levels were similar.

Effect of ECM on Students Chemistry Achievement:

All the groups took the post-test CAT. One-way ANOVA and ANCOVA were conducted on students' post-test CAT scores to investigate the effect of ECM on students' chemistry achievement (H_O1). Table 5 show the CAT post-test mean scores while Table 6 is ANOVA of post-test CAT mean scores.

Table 5:CAT Post-test Mean Scores obtained by the Four Groups

Group	N	Mean	Maximum score	Std.dev
Experimental 1	40	20.15	30	4.15
Control 2	51	15.85	30	4.31
Experimental 3	34	18.94	30	3.66
Control 4	54	16.80	30	3.66

The Post-test mean scores of Groups I and 3 (20.15 and 18.94) were relatively higher than that of the Groups 2 and 4 (15.85 and 16.80). This shows that the experimental groups performed better than control groups in the CAT. In order to determine whether the difference in the CAT post-test mean scores was statistically significant a One-Way ANOVA was performed.

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

Source of variation	Sum of squares	Df	Mean square	F-ratio	p-value
Between groups	508.700	3	169.57	10.77*	0.000(s)
Within groups	2755.781	175	15.75		
Total	3264.480	178			

The result in Table 6 reveals that the computed p-value (0.000) was less than the set alpha value 0.05. Therefore the differences in CAT Post-test mean scores among the four groups were statistically significant $F(3,175) = 10.77$, $p<0.05$. Table 7 shows the mean scores for CAT post-test scores for ANCOVA with Kenya Certificate of Primary Education(KCPE) mark as a covariate.

Table 7:Adjusted CAT Post-test Mean Scores for ANCOVA with KCPE Mark as Covariate

Group	1	2	3	4
N	40	51	34	54
Mean Score	20.22	15.83	18.78	16.73

The results in Table 7 show that adjusted mean scores are similar to the CAT post-test mean scores based on ANOVA.Thus the four groups had similar characteristics on CAT post-test scores.

Table 8: ANCOVA of the Post-test Mean Scores on the CAT

Source of variation	Sum of squares	Df	Mean square	F-ratio	p-value
KCPE	13813590.8	1	13813590.75	3491.37	0.000(s)
GROUP	129843.214	3	43281.071	10.94	0.000
Error	692385.620	175			

ANCOVA test confirmed that the differences between the means were significant at 0.05 alpha level $F(3,175) = 10.94$, $p<0.05$. In order to establish how the groups differed, a Least Significant Difference (LSD) Post hoc comparison was conducted. The LSD test showed that the CAT mean scores for Groups 1 and 2, 1 and 4, 2 and 3 and 3 and 4 were significantly different while Groups, 1 and 3, and 2 and 4 were not significantly different. Therefore, H_O1 was rejected.

Effect of Gender on students' Chemistry Achievement :

The study aimed at finding out how ECM affects the achievement of boys and girls in chemistry. An independent samples t- test was carried out in order to test H_O2

Table 9: Independent Sample t-test of Post-test Scores on CAT based on Gender

Variable	Gender	N	Mean	Max score	Std.dev	df	t-value	p-value
CAT	M	36	19.97	30	4.23	72	1.87	0.066(ns)
	F	38	18.18	30	3.98			

The results in Table 9 indicate that the male students had a mean score of 19.97 while that of female students was 18.18 were similar. However, boys attained slightly higher mean score than girls. The computed p-value was greater than the set alpha value 0.05.Therefore the post-test mean scores of boys and girls were not statistically different at 0.05 alpha level, t (72) = 1.870, p >0.05. Thus, H_O2 was accepted.

DISCUSSION OF THE RESULTS:

The findings in this study show that the CAT pre-test scores did not interact significantly with the treatment conditions. This is because the groups which were exposed to the pre-test did not score higher than those not exposed to it. Greater scores by Group 1 and 2 than Group 3 and 4 could have been the results, if the pre-test provided a practice effect. If two Experimental groups (1 & 3) are similar to each other in post-test as opposed to the two Control groups (2 & 4), then the researchers are in a position to attribute the difference to the treatment. Thus, the higher scores by Experimental Groups 1 and 3 are as the result of ECM treatment and not the pre-testing effects. Thus the pre-test is suitable for the study.

Effect of ECM on Students' Achievement in Chemistry:

Students taught through ECM teaching strategy performed better in CAT than those taught through the RTM. The Experimental groups 1 and 3 obtained significantly higher mean scores than Control groups 2 and 4. This implies that the ECM method enhances students' achievement more than the RTM. Experiential concept maps help students organize information, foster metacognition and engage students in building their knowledge structures (Boujaode& Attieh, 2008).The findings of the study are in agreement with Ausubel's (1963) description of meaningful learning as the establishment of non- arbitrary relation among concepts in the learners' minds. Moreover, it highlights the importance of chemistry instruction that emphasizes identifying key concepts and stresses on teaching concepts and their relationships (Novak, 1998). However, the finding of this study disagrees with Stensvold and Wilson (1992) studies that investigated the effects of students' construction of concept mapping in high school chemistry laboratories on their comprehension of chemical concepts. No differences were found between the experimental and control groups. Another study conducted by Nicoll, Francisco and Nakhleh (2001) on the effects construction of concept maps on freshmen chemistry students' achievement and ability to link concepts, showed positive results for both variables. A study conducted by Boujaode and Attieh (2008) on tenth-grade students that examined the effect of using concept maps as study tools on achievement in chemistry showed no significant differences on the achievement total scores , but there were significant differences favoring the experimental group for scores on the knowledge level questions. This supports the findings of the present study.

Effect of Gender on Achievement in Chemistry when ECM is used:

There was no significant difference in Chemistry achievement between boys and girls exposed to ECM teaching strategy. This implies that the ECM method eliminates the gender disparity in chemistry achievement. Analysis of results (KNEC, 2009) indicates that the performance of girls is poorer than that of boys in Chemistry at KenyaCertificate of Secondary Education (KCSE) examination. However, in this study the achievement of boys and girls was the same. These results do not support Eshiwani's (1982) studies, that girl under achieve in science and Mathematics at secondary level. Similarly, the Forum of African Women Educationists FAWE (1997) indicates that Science achievement for girls in Kenya was lower than for boys partly due to their attitudes towards Science and discouragement by the teachers. However, the results are in agreement with Klainin and Fensham (1987) reports that Thai girls perform at least as well as boys in Physics and Chemistry.

CONCLUSIONS:

ECM teaching strategy results in higher students' chemistry achievement than the Regular Teaching Methods (RTM). Gender does not affect student's chemistry achievement when ECM is used. Both boys and girls taught using ECM attained similar scores. Therefore, chemistry teachers should use ECM in their teaching in order to improve students achievement in chemistry. Teacher training colleges and universities should make ECM part of their training curriculum.

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