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EFFICACY OF EXPERIENTIAL CONCEPT MAPPING TEACHING AND LEARNING STRATEGY ON STUDENTS ACHIEVEMENT IN PHYSICS IN SECONDARY SCHOOL IN MAARA SUB-COUNTY, KENYA

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ABSTRACT
The fundamental challenge facing the teaching and learning of physics as a science in Kenya secondary schools is how to enhance students' conceptual understanding as well as affective characteristics associated with teaching and learning process. The challenge is clearly depicted by low academic achievement both at school level and national level. Application of new teaching strategies that will improve students' achievement in Physics should be used. One of these teaching strategies is experiential concept mapping. The purpose of the study was to investigate the efficacity of using experiential concept mapping teaching and learning strategy on students' achievement in Physics in secondary schools. The target population of the study was 8430 Physics students in Maara Sub County. Accessible population was 3137 form one students, from purposively sampled co-educational secondary schools in Maara sub-county. Solomon's Four Group Non–Equivalent Control Group Design was used in the study. Based on the design, four co-educational schools forming the sample size of 182 form one students, were randomly sampled. Data was collected by use of Physics Students Achievement Test (PSAT). Validity of the instruments was ascertained by supervisors and experts in the field of study. Reliability of the instrument was computed using Cronbach Alpha formula. Reliability coefficient of 0.783 for PSAT was obtained and the instrument was deemed reliable. The experimental groups were taught using experiential concept mapping teaching and learning strategy while the control groups were taught using conventional methods of teaching. Results were analyzed using descriptive statistics (mean, standard deviation and percentages) and inferential statistics (ANOVA, and t-test). Hypothesis was tested at α=0.05 level of significance. The results showed a statistically significant difference between students' achievement when exposed to experiential concept mapping teaching and learning strategy and students who were taught using conventional teaching methods. The study concluded that experiential concept mapping strategy positively influences students' achievement in Physics. Therefore, Physics teachers are recommended to incorporate the experiential concept mapping strategy in teaching.

Key Words: *Achievement, Physics Subject, Experiential Concept Mapping, Conventional Methods*

Introduction

The world is increasingly dependent on Physics knowledge, fueled by breakthroughs in Physics research. Socio-economic and technological transformation requires the basic principles of Physics education that are taught in Secondary School level as it prepares learners for scientific and technological vocations. Munishi, (2006) observed that careers in Physics have contributed to socio-economic and technological transformation particularly in this era of information, communication and technology as evidenced in development trends in Kenya. In spite of this importance, there is increased students' apathy to Physics as a science subject. Students view science particularly Physics as uninteresting and uninspiring (Smithers & Robinson, 2006). Kenyan students have been noted to perform poorly generally in sciences (Changeiywo, 2000). Students' achievement in Physics has been poor. Performance in Physics has been below 50% for the years 2010 -2019 in Kenya. For the year 2019, the mean score in Physics was 32.59%. The poor achievement has caused deep concern especially for Physics oriented courses for nations that are geared towards high technology and industrialization.

Student achievement will increase when quality instruction is used to teach instructional standards. A teacher influences the quality of instruction, set expectations for learning and measure the level of understanding (Cleaves, 2005). A good teacher will use strategies, that gains student attention to support the learning process (Broggy & Mc Clelland, 2008). The ultimate goal for any teacher is to improve the ability level and prepare students for adulthood. Previous studies have identified reasons contributing to low achievement in Physics. Smithers & Robinson (2006) observed that the study of Physics in secondary schools and universities is in declining trend as teenagers perceive it to be too difficult. Another reason identified is that the teaching method used may not be interesting thereby resulting in more students dropping Physics in upper secondary schools (Gunasingham, 2009; Changeiywo et al., 2011).

The teacher needs to utilize strategies which utilize instructional teaching methods that involve students in doing and thinking of applications of what they are learning (Wachanga, 2005). Teaching need to be participatory where all the domains of the student are engaged in learning, therefore there is need to adapt the latest instructional strategies that are capable of maintaining the interest of the learners and helping them to understand the concept (Wachanga, 2005). The main teaching goal is to help students understand the main concept in a subject rather than memorization isolated facts (Santrock, 2004). Research findings in science education by Kalkanis, (2002) and Vlachos, (2004), revealed that active learning has many positive outcomes. According to Wachanga (2005), active learning enhances motivation, improves classroom performance, increase inquisitiveness and facilitates retention of materials. Active learning also enhances development of critical thinking skills, promotes the personal relevance and applicability of course materials, as well as improves overall attitude towards learning.

Experiential concept mapping is a graphical tool or conceptual diagram that depicts the suggested relationship between concepts where learners are actively involved in constructing concept maps. A concept map is an example of graphic organizer. Concept maps are used to help students organize and represent knowledge of a subject (Novak & Gowin, 1984; Novak, 1990; Eggen et al, 2006). Concept maps begins with a main idea that branches out to show how that main idea can be broken down to specific topics (Novak, et al, 2000). Some benefits of concept mapping are; helping students investigate and generate new ideas, encouraging students to discover new concepts as well as propositions that connect them, enables students to more clearly communicate ideas, thoughts and information, helping students relate new concepts with older concepts and enabling students to gain enhanced knowledge of any topic as well as evaluate the information (Novak, et al, 2000). Despite the benefits of experiential concept mapping teaching and learning strategy, research in this in relation to secondary school physics is limited.

Concepts represents the major portion of school curriculum, and much of teacher effort are geared at teaching concepts. According to Novak et al, (2000), concepts are mental structures that categorizes sets of objects, ideas or events. Concepts are components of cognition that help to simplify and summarizes information. Concepts also help in remembering and making learning more effective. Akinyemi, (2010) argues that a lot of present-day school curriculum is outdated in its delivery. Present day curriculum involves rote learning that makes the learners passive recipient of knowledge thus depriving them an all-round growth and development of their capabilities and talents. Experiential concept mapping is regarded as an active learning activity where students are guided in constructing concept maps in the presence of the materials they are learning. concept maps reinforce student's assimilation of knowledge among other educational applications. The present study therefore investigated the effectiveness of experiential concept mapping teaching and learning strategy on achievement in Physics by secondary school students in Maara sub-county, Kenya.

Study Objective

The overall objective of the study was to investigate the efficacy of experiential concept mapping teaching and learning strategy (ECMTLS) on learners' achievement in physics in secondary school in Maara sub-county, Kenya.

Hypothesis

The following null hypotheses guided the study.

H_{01}: There is no statistically significant difference in student's physics achievement between those who are taught through Experiential Concept Mapping Teaching and Learning Strategy and those taught using Conventional Teaching Methods.

Methodology

Research Design

The study design was a quasi-experimental research design and in particular Solomon Four Group design. Solomon's Four Non- Equivalent Control Group Design was used since the subjects were already constituted and classes once constituted exist intact and the researcher works with existing streams (Nachmias & Nachmias, 2004). Solomon's Four Non-Equivalent Control Group Design was used since it enables the researcher to control and measure the main effects of testing. Solomon's Four Non- Equivalent Control Group Design is also considered rigorous for quantitative studies since it involves two control groups as compared to other experimental designs (Borg & Gall, 1996; Cook & Campbell, 1979). Solomon's Four Non-Equivalent Control Group Design makes it possible to evaluate the main effect as well as the reactive effects of testing, history and maturation (Fraenkel & Wallen, 2009). It also allows the researcher to exert complete control over the variables and to check that the pre-test will not influence results (Shuttleworth, 2009).

The Solomon's four non-equivalent group design is as presented as shown.

Group		Pre-test	Treatment	Post-test
Experimental group	E1	O1	X	O2
Control group	C1	O3	-	O4
Experimental group	E2	-	X	O5
Control group	C2	-	-	O6

Source: Shuttleworth (2009)

O1 and O3 were the pretests while O2, O4, O5 and O6 were the posttests. X was the treatment where students were taught using ECMTLS in the topic of electrostatics in physics. E1 was the experimental group which received pretest, treatment and post-test. C1 was the true control group that received the pretest followed by the control conditions and finally post-test. E2 is the experimental group two that received treatment followed by post-test. C2 received posttest only. C1 and C2 were taught using CTM.

Data Collection and Analysis

The study was carried out in Maara Sub-county, Kenya. The accessible population was the 3137 form one physics students from purposively selected coeducational schools. A total of 182 form one students participated in the study. Physics students achievement test (PSAT) was used to collect data. PSAT was constructed from Kenya National Examination Council (KNEC) past papers which were modified to make them suitable for the study. The test items constructed were based on the topic electrostatics 1. PSAT comprised of 11 items with a maximum score of 40 marks testing on the first three levels of cognitive domain, namely knowledge, comprehension, and application.

To estimate the reliability of PSAT, a pilot study was carried out in the neighbouring Meru south sub-county. Reliability coefficient of the PSAT was computed using Cronbach alpha formula. The instrument had reliability coefficient of 0.783. Thus, the instrument was reliable since according to Fraenkel and Wallen (2009), reliability coefficient of 0.70 and above could be considered suitable to show the reliability of the instrument. The physics teachers in experimental groups were trained on the development and use of experiential concept mapping teaching and learning strategy. Students from experimental groups E1 and E2 were taught using experiential concept mapping teaching and learning strategy (ECMTLS) while those in control groups C1 and C2 were taught by use of conventional teaching methods (CTM). The topic of instruction was electrostatics 1. Before commencement of the study PSAT was administered to E1 and C1 as pretest.

Treatment and data collection took five weeks. The post test was administered as a continuous assessment test to all the four groups at the end of the teaching period. Students' pretest and posttest results were scored to get data for analysis. Data was analyzed using both descriptive and inferential statistics.

Results and Discussions

The study sought to investigate the effectiveness of experiential concept mapping teaching and learning strategy on achievement in physics by learners in secondary school. In order to assess students' knowledge in physics prior to treatment analysis of student pretest scores in PSAT was carried out. The mean and standard deviation of pretest mean scores for experimental group E1 and control group CI are presented in Table 1.

Table 1: Pretest Means Scores on PSAT

Group	N	Mean	Standard deviation
E1	48	19.84	9.768
C1	45	18.83	8.198

Key

E1-Experimental group with pretest and posttest

C1-Control group with pretest and posttest

Results in Table 1 show the mean and standard deviation for Experimental group (E1) was 19.84, and 9.768 respectively. On the other hand, control group (C1) had 18.73, and 8.198 as values of, mean and standard deviation respectively. From the results of analysis, it was evident that the experimental group (E1) pretest data had a slightly higher mean values as compared to the control group (C1) pretest data (19.84 and 18.73 respectively). A t-test was performed to determine whether there was any significant difference in the mean scores for the groups E1 and C1. Results are presented in Table 2.

Table 2: The t- test of Pretest Scores on PSAT based on Groups E1and C1

Variable	Group	N	Mean	S.D	df	t-value	p-value
PSAT	E1	48	19.84	9.768	91.00	1.01	.313
	C1	45	18.73	8.001			

*P>0.05

Key

E1-Experimental group with pretest and posttest

C1-control group with pretest and posttest

The results on Table 2 shows that the $t_{(91.)}$=1.01, P=0.313, P> 0.05. This implies that the two PSAT pretest mean sores for E1 and C1 were not statistically different. The level of achievement prior to administration of teaching strategy, for both experimental group and control group were similar. Thus, the experimental group and control groups were equivalent and suitable for the study.

Posttest PSAT scores were also generated. Table 3 shows PSAT scores for students in E1 and C1.

Table 3: Posttest Scores for E1 and C1

Group	N	Mean	Standard deviation
E1	48	38.76	13.256
C1	45	27.07	8.001

Key

E1-Experimental group with pretest and posttest

C1-control group with pretest and posttest

Information on Table 3 indicates the values of sum, mean and standard deviation for experimental group (E1) and control group (C1) posttest values. Experimental group (E1) posttest data had 48, 38.76, and 13.256 as values of sum, mean and standard deviation respectively. On the other hand, control group (C1) posttest data had 45, 27.07, and 8.001 as values of sum, mean and standard deviation respectively. From the results of analysis, it was evident that the experimental posttest data had a higher mean values as opposed to the control posttest data. This implies that the group that was taught using ECMTLS had higher mean than the control group that was taught using CTM implying that ECMTLS when used improves learners' achievement. The findings are in line with those of Keraro *et al* (2007). The findings revealed that secondary school students exposed to cooperative concept mapping teaching approach performed better in biology than their counterparts taught using the traditional teaching methods.

A comparison was done on students' improvement from pretest to posttest. Data on Table 4 shows the means scores and mean gain obtained by students in experimental group E1 and control group C1 in the PSAT.

Table 4: Mean Gain obtained by Students in E1 and C1 in PSAT

Group	E1	C1
N	48	45
Posttest mean score	38.76	27.07
Pretest mean scores	19.84	18.73
Mean gain	18.92	8.34

Key
E1-Experimental group with pretest and posttest
C1-control group with pretest and posttest

The results in the Table 4 shows that the posttest mean scores for experimental group E1 and control group C1 were 38.76 and 27.07 respectively while the pretest mean scores for experimental group E1 and control group C1 were 19.84 and 18.73 respectively. The mean gain for experimental group E1 and control group C1 were 18.92 and 8.34 respectively. This means that E1 had a higher mean gain than C1. Thus, the experimental group had increased scores to a greater degree than the control group. This implies that when ECMTLS is used, it improves students' achievement in physics and the gain in scores can help to close the gap in learners' performance both in school and national level.

The interaction between pretest and posttest in PSAT for students in experimental group E1 and control group C1 is represented in the Figure 1.

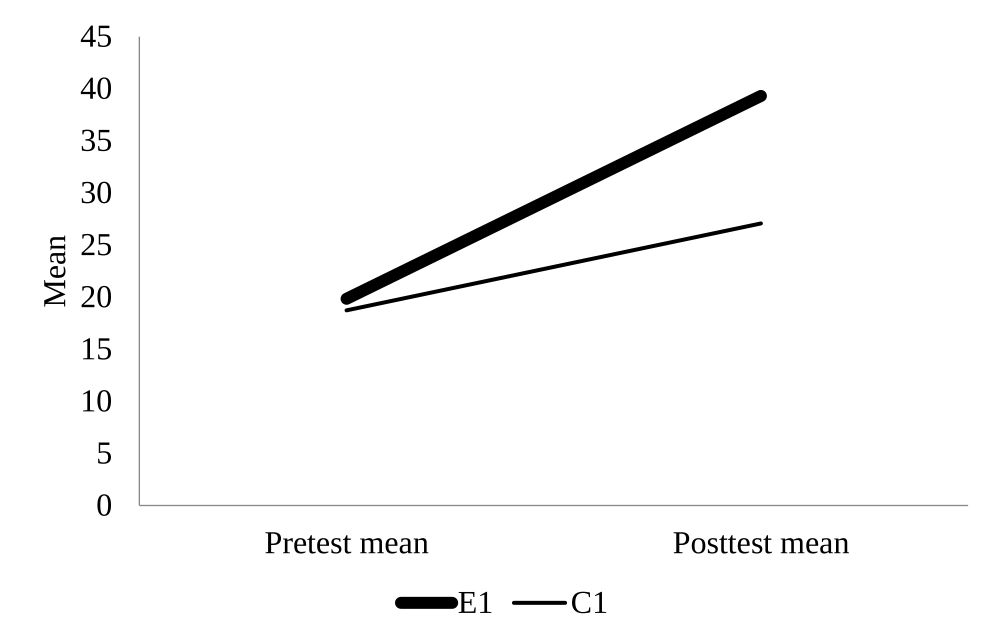

Figure 1: Student Achievement in Pretest and Posttest in PSAT of Experimental and Control Group

Information on Figure 1 shows achievement line for means of students in experimental group E1 and control group C1 for PSAT. The difference between the mean scores of students in experimental group E1 and control group C1 for PSAT is shown by the slope of the achievement line. The mean scores of students in experimental group E1 started slightly above the mean scores of the control group C1 in pretest while in the posttests the mean score of the experimental group E1 was far much above that of the control group C1. The slope of the experimental group (E1) achievement line is greater than the slope of achievement line of control group (C1). This suggests that the progress in the experimental group E1 was significantly higher than the progress of the control group C1 in the PSAT. This implies that ECMTLS widens the achievement gap between students in experimental group E1 and control group C1.

The posttest mean scores obtained in the study groups when students were exposed to experiential concept mapping teaching and learning strategy in experimental groups and to conventional teaching methods in control groups are shown in Table 5.

Table 5: Mean Scores in PSAT Posttest for Experimental Groups and Control Groups

Group	N	Mean	Standard deviation
C2	46	13.67	6.537
C1	45	27.07	8.001
E2	43	38.78	12.452
E1	48	39.38	13.531

Key

E1- experimental group with pretest and posttest after treatment

C1- control group with pretest and posttest

E2- experimental group with posttest after treatment

C2- control group with posttest

The information on Table 5 reveals that the control group (C2) had a sum, mean and standard deviation values of 46, 13.67 and 6.537 respectively. Control group (C1) on the other hand had 45, 27.07 and 8.001 as values of sum, mean and standard deviation respectively. The experimental group (E2) data had 43, 38.78, and 12.452 as values of sum, mean and standard deviation respectively while experimental group (E1) had sum, mean and standard deviation values of 48, 39.38 and 13.531 respectively. Comparing the achievement between experimental groups and control groups, the experimental groups that were instructed using ECMTLS had higher mean scores as compared to control groups that were instructed using CTM.

To determine if there was a significant difference in the means of the four groups, ANOVA test was run. The result are shown in Table 6.

Table 6: Analysis of variance (ANOVA) on Posttest Mean score

group	Sum of Squares	df	Mean Square	F	Sig.
Between groups	19325.40	3	6441.80	58.45	.000
Within groups	19617.17	178	110.21		
Total	38942.57	181			

Results in Table 6 revealed that the PSAT mean scores for the experimental and control groups were statistically significant $F(3,178) = 58.45$, $p= 0.00$, $P < 0.05$. Therefore, the null hypothesis that there is no statistically significant difference in student's Physics achievement scores between those who are taught through Experiential Concept Mapping Teaching and Learning Strategy and those taught using Conventional Teaching Methods was rejected. Thus, there was statistically significant difference in student's Physics achievement scores between those who are taught through ECMTLS and those taught using CTM. The higher posttest mean scores for the experimental groups was due to the use of ECMTLS.

The results agree with the finding of Wambugu, et al. (2011) who investigated effect of experiential cooperative concept mapping instructional approach on students' achievement in Physics. The study findings are also in agreement with the findings of a study conducted by Muraya and Kimamo, (2011) on the Effect of Cooperative Learning Approach on Mean Achievement Scores in Biology. There was significant difference in Students mean achievement when taught using Cooperative Learning Approach as opposed to those instructed using regular teaching approach.

Conclusion and Recommendation

Based on the results of the study, significant differences were found between the means of groups taught using experiential Concept Mapping Teaching and learning strategy (ECMTLS) and those taught using conventional methods of teaching (CTM). The study showed that ECMTLS was very beneficial in promoting students' achievement in Physics subject. Students' academic performance improved when students were instructed using ECMTLS. Thus, ECMTLS is an effective teaching and learning strategy. Physics teachers should be encouraged to adopt ECMTLS in the teaching and learning of physics in order to improve students' academic achievement.

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