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Effect of experiential concept mapping teaching strategy on students' academic achievement in chemistry based on gender in Tigania West Sub County

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Abstract

In academic performance among learners, gender disparities is more evident in science and technical disciplines and thus, gender stereotyping and gender bias can be major factors in coeducational classrooms. Thus, this study sought to establish the effect of experiential concept mapping teaching strategy on students' academic achievement in chemistry based on gender in Tigania West Sub County. A quasi-experimental research design involving the Solomon Four non- corresponding regulator cluster design was utilized. It involved a target population of 1765 Form two learners from Tigania West Sub County. The sample size comprised 182 students from four sub county coeducational secondary schools, selected using simple random sampling. Simple random sampling technique was employed to allot the schools to either investigational or regulator groups. The study comprised four clusters; two investigational clusters (E1 and E2), and two regulator clusters (C1 and C2). A Chemistry Achievement Test (CAT) was administered during the pre-test and post-test in order to look into learners' achievement in chemistry. Data obtained was analyzed by use of Statistical Package for Social Science (SPSS) version 24. For descriptive statistics, percentages, frequency distributions, mean and standard deviation were used while t-test was used for inferential statistics. The statistical significance was tested at $\alpha = 0.05$. The results established that gender of learners had no significant effect on achievement in chemistry when learners are instructed using Experiential Concept Mapping teaching method. Adoption of ECM is recommended as appropriate for instructional of chemistry in secondary schools. These study results will be of great importance for reference among instructors, educational stakeholders, education policy makers, related researchers and academicians.

Keywords: Gender, academic, achievement, chemistry, learner, Tigania

1. Introduction

Gender variations in academic performance is more pronounced in science and technical related disciplines ^[1]. This is because these academic programs are traditionally believed to be exclusively male whereas arts related disciplines seem to attract majority of female learners. Additionally, according to ^[1], various factors influence dismal enrollment by female learners in science and technical oriented faculties include negative attitude by females towards science and technical subjects, inadequate attainment in these disciplines at secondary school level, public discernment towards female learners undertaking these subjects, ill-equipped laboratories, besides deficiency in career guidance programs.

Concept mapping allows visual observation of relationships and connections between multiple areas and pieces of information. Research conducted by ^[8] indicated that the acquisition of science knowledge can be greatly facilitated by the use of concept maps ^[8]. ^[8] noted that the ability to recognize connections between different pieces of information or aspects of a problem acts to facilitate problem-based learning and it favours male students as opposed to female students. Problem-based learning assists in the development of higher order thinking skills, helping male students to become independent, self-directed learners who respond appropriately to situations in a logical and reasonable manner ^[12].

^[10] found that small differences in teacher behavior combined with the organization of instruction, made up a pattern of classroom organization that appeared to favor males. For instance, competitive activities encouraged boys' learning and had a negative influence on girls' learning, while the opposite was true of cooperative learning. Since competitive activities were much more prevalent than cooperative activities, it appeared that classrooms were more often favorable to boys' learning ^[9].

The debate on gender in Africa is less intense on achievement compared with the literature and debate in the USA. The literature in Africa is mainly concentrated on analysis of gender parity in terms of enrolment, but not in terms of achievement gaps. However, the few studies

done so far seem to support the view that gender gaps in mathematics and sciences achievement exist. According to South African consortium for monitoring educational quality (SACMEQ) data for the 15 countries participating in the study ^[11], found that the set of countries where boys performed significantly better than girls in mathematics in 2000 (Tanzania, Kenya, Malawi and Mozambique) were also countries where boys performed better than girls in 2007. Furthermore ^[11], asserts that between 2000 and 2007, the directions in gender differences in mathematics achievement were consistent ^[13]. Carried out a study on comparative analysis of gender performances in biology, chemistry and physics among pre-degree students of the University of Uyo, Nigeria. A total of 83 students registered for the pre-degree program in 2013/2014 academic session comprising 56 male and 27 female students were used for the study. An ex-post facto design was used to analyze data that was already on the ground without any manipulation. From the results, it showed that there were no significant differences in the performance of male and female students in Biology, Chemistry and Physics. It was recommended based on the findings that courses such as engineering, medicine, pure sciences, computer science, physical sciences, which were exclusively meant for men, would also involve more women since pre-degree performance of male and female students in Biology, Chemistry and Physics is the same.

Several factors have been put forth on why high achieving women may not be entering in careers related to mathematics, computer science, physics engineering or information technology ^[8]. The factors include discrimination, gender-typed socialization, and self-concept of ability in these areas, and the value and interest that women put in these professions ^[4]. Found that self-concept of ability and task value in mathematics and science decline for both genders between first and twelfth grades with no real difference between girls and boys over time. By the twelfth grade, girls valued mathematics and science more than boys when controlling for self-concept of ability in mathematics. Further ^[4], argued that even though women have made great strides in the law, medical, and social science professions, very few can be found in graduate programmes or professions in Mathematics, Computer Science, Physics, Engineering, or Information Technology jobs. The interactions between using concept maps and gender can be interpreted in light of the cognitive style theory that categorizes males and females into different learning styles. According to ^[16], males are field-independent learners while females are field-dependent learners.

Studies done in Botswana by ^[5] indicated that cultural expectations of society could give rise to differences in performance between girls and boys in school subjects and that such expectations could influence occupational choices

between the two sexes” ^[5], found that about a quarter of the students of both sexes had some problems when studying with students of opposite sexes. More girls than boys laugh at the opposite sex when one fails to answer the question correctly in class. The girls accused boys of resulting to intimacy, harassment and intimidation in class. The boys complained of lack of concentration as they admired girls and kept looking at their faces ^[14] examined how the cooperative class experiment (CCE) teaching method affect students’ achievement in Chemistry in Nakuru District in Kenya. The findings revealed that there was no significant difference in gender achievement between the experimental and control groups, but girls had a slightly higher mean score than boys did.

In a related study conducted by ^[6] on gender variations in science disciplines in secondary schools in Kenya, the investigation looked into teachers’ perception or extent of likeness on gender gaps in academic performance and predominantly in science-related subjects. The study established that a majority of instructors had perceptions of girls and science that were gender stereotyped and traditional. A smaller cluster of teachers, however, had quite girl-friendly perceptions. According to ^[6], textbooks, curricula and teachers are some of the factors contributing to gender gaps in education and in particular science subjects at the moment. The factors resulted in low completion rates in secondary education such that national completion rate in Kenya in 2004 was 91.5% for boys and 87.5% percent for girls, which further led to a case scenario of low transition rate to colleges, low enrolment, retention and completion rate for girls.

2. Materials and Methods

2.1 Location of the Study Area

This study was carried out in Tigania West sub county, Meru County. The Sub County comprises of learners with varied academic potentials and different social economic origin. Additionally, Tigania West sub-county has consistently posted poor academic attainment in KCSE especially in chemistry, nevertheless there is no empirical study which has been conducted in the sub county to aid the education stakeholders have an insight to the reasons contributing to this dismal achievement in chemistry thus the need for this study.

2.2 Target Population

The study targeted all public secondary schools in Tigania West Sub County. The learners population comprised of 1765 Form two students in Tigania West Sub County as shown in Table 1. Form two students were targeted as the respondents of this study because, the main topic; the structure of the atom and the periodic table is taught at this level.

Table 1: Target Population

School type	Number of schools	Total number of students
Girls only	4	365
Boys only	3	400
Co-educational schools	20	1000
Total	27	1765

Source: Tigania West Sub County Education Office (2021)

Information on Table 1 indicates that there were 4 girls' boarding schools in Tigania West sub- county with 365 form two students, 3 boys' boarding schools with 400 form two students and 20 co-educational schools with 1000 Form two learners. The study targeted 1765 Form two learners in Tigania West sub-county.

2.3 Sample Size and Sampling Procedures

Simple random sampling method was employed in the selection 4 sub county co-educational secondary schools in Tigania West Sub County. The sampled schools were further assigned as either control group or experimental group using simple random sampling (Table 2).

Table 2: Sample Size

School type	Sample school	Total population	Number of Students		
			Experiment Group	Control Group	Total
	4	40 48	50	40	90
Sub county schools		50 44	44	48	92
Total		182	94	88	182

The learners in sampled schools were 40, 48, 50 and 44, giving rise to a total of 182 form two students (Table 2). The schools assigned as experimental groups had 50 and 44 students, while those assigned as the control groups had 40 and 48 students. Cases whereby a school comprised of more than one stream, all of them were allowed to take part in this investigational study.

2.4 Data Collection Instrument

The Chemistry achievement test (CAT) was employed in the assessment of learners' comprehension of the subject matter. The CAT also aided in quantifying learner's attainment in chemistry more particularly in the in the area of interest; the structure of the atom and the periodic table. The CAT consisted of items developed from the same topic that would be covered in the course of the investigation. The content of the test items included; the atom, the periodic table, isotopes, ion formation and the periodic table. The test was composed of a pre-test to the investigational cluster (E1) and regulator cluster (C1), prior to the start of the course and to all clusters at the end of the study period as a post test. The items were ranked with the aid of a moderated marking scheme and the scores obtained were recorded for further examination.

2.5 Data Collection Procedure

After visiting the sampled schools, the investigator trained the instructors of chemistry on how to utilize ECM. CAT (pre-test) was administered to experimental cluster (E1) and regulator group (C1) followed by three weeks integration of ECM approach to the investigational clusters E1 and E2. The conventional instruction approach was subjected to regulator clusters (C1 & C2). A post-test CAT was then administered to all the regulator and investigational clusters in order to collect the required data.

2.6 Data Analysis

The data gathered was coded and prepared for analysis. Descriptive statistics (mean and standard Deviation) and inferential statistics (t-test) were employed in the analysis the gathered data. This was aided by the use of the Statistical Package for Social Sciences (SPSS) version 24. The analyzed data was then presented using tables and graphs.

3. Results

3.1 Respondents' Demographic Information

The findings on the gender of the respondents was presented as shown in Table 3.

Table 3: Gender of the respondents.

Gender	Control groups		Experimental groups		Total	
	F	%	F	%	F	%
Male	39	44.32	50	53.19	89	48.90
Female	49	55.68	44	46.81	93	51.10
Total	88	100	94	100	182	100

Results on Table 3 indicates that 55.68% of the respondents under control group were female, and 44.32% of the respondents were of the male gender while, 53.19% of the respondents on experimental group were of the male gender while 46.81% of the respondents comprised of the females. This implies that more girls than boys were in the control groups. Experimental groups had 50 boys and 44 girls and that the overall percentage of girls involved in the study was 51.10% and that of boys was 48.9%. Information in Table 4 shows the groups involved in the study and number of students in each groups.

Table 4: Sample Size Stratification

Group	Experimental and control	Number of students
C1	Control	40
C2	Control	48
E1	Experiment	50
E2	Experiment	44
Total		182

Information on Table 4 indicates that control group (C1) had 40 students, control group (C2) had 48. Experimental Group (E1) had 50 students and experimental group (E2) had 44 students.

3.2 Pre-test Results

A pre-test on Chemistry Achievement Test (CAT) was administered to regulator cluster (C1) and investigational cluster (E1). Administration of CAT was to ensure the groups used in the study were homogeneous before administration of the ECM teaching strategy. The CAT was marked out of 30. Table 5 indicates t-test results of pre-test tallies on CAT.

Table 5: t-test Results of Pre-test Scores on CAT

Group	N	Mean	SD	SE	Df	t-value	p-value
C1	40	6.03	4.154	0.657	90	0.284	0.777
E1	52	5.77	4.368	0.606			

Significance level= 0.05

The findings on Table 5 indicate that the pre-test average for learners in regulator cluster (C1) had a higher mean score (M=6.03, SD = 4.154) than that of students in investigational cluster (E1) (M=5.77, SD=4.368). To test for homogeneity of the groups, t-test was conducted in order to determine if there was statistically significant difference in pre-test means scores. The results $t(90) = 0.284, p = 0.777$ shows that the two groups had no statistical significant differences and therefore had similar characteristics before the ECM teaching strategy was administered. Therefore, the clusters were considerably appropriate for this investigational study.

3.3 Effect of Experiential Concept Mapping Teaching Strategy on students’ academic achievement in chemistry based on gender

Post-test CAT scores for both male and female students in E1 and E2 groups were analyzed in order to determine the effects of student academic achievement in chemistry based on gender when taught using Experiential Concept Mapping teaching strategy. The results in Table 6 indicates that the mean score for girls (15.2500) was higher than that of boys (13.3333). To establish whether the difference among the mean score of the two gender were significant, t-test was done. Table 6 provides information on t-test results of post-test scores on CAT based on gender.

Table 6: T- test Results of Post-test Scores on CAT based on Gender.

Gender	N	Mean	SD	SE	df	t-value	p-value
Male	54	13.3333	7.61082	1.03570	92	-1.318	0.191
Female	40	15.2500	5.98609	.94648			

Significance level = 0.05

Results in table 6 indicate that, $t(92) = -1.318, p = 0.191$, since p value is greater than 0.05, it is an indication that there was no statistically significant difference between the CAT post-test scores for male and female students taught using ECM teaching strategy. Therefore, null hypothesis (H_{03}), which states that there is no statistical significant difference in students’ academic achievement in chemistry based on gender when taught using Experiential Concept Mapping teaching strategy is accepted. The results of this study indicate that ECM resulted in higher achievement in chemistry in both gender. This may have led to meaningful understanding of concepts in chemistry arising from enhanced activities in ECM. Enhanced achievement in tasks as learners engaged in construction of concept maps may have increased their confidence and attainment of knowledge construction skills in Chemistry.

4. Discussion

The findings of the current study are consistent with previous studies by [7]. In their study on effects of Cooperative Concept Mapping (CCM) teaching approach on motivation of students in biology in Gucha District Kenya, reported significantly higher motivation among students exposed to CCM than those taught using conventional

teaching methods. Their findings further indicate that there is no statistically significant gender difference in motivation towards the learning of biology among secondary school students exposed to CCM. Therefore, ECM teaching strategy is not gender biased and improves the academic achievement for both male and female students.

Similarly [15], agreed that the use of Experiential Concept Mapping teaching strategy improves achievement in learning for both male and female students, in their study on effects of experiential cooperative concept mapping instruction approach on secondary school students’ achievement in physics in Nyeri County, Kenya. The results indicated that the impact of concept mapping instruction is positive and effective than conventional learning. The achievement of male and female students who were taught using concept mapping was evidenced by significant statistical difference. The researchers confirmed that cooperative concept learning is not gender discriminatory. Instructional strategies that are result oriented and student centered such as cooperative concept mapping strategy should be generally adopted during instruction irrespective of gender.

However, the results of the current study differed with a study carried out by [1] on gender differences in students’ achievement in chemistry in secondary schools of Kakamega District, Kenya. The study showed that gender was strongly associated with chemistry achievement. As a result, boys’ schools performed better than girls schools. The study also showed that boys had a stronger affinity and interest towards chemistry.

[2], carried out a study on the effect of using concept maps as study tools on achievement in Chemistry in a private coeducational high school in Lebanon a study which contrasts with the current one. Participants of the study were 60 tenth-grade students, who were randomly divided into two groups: experimental and control. Results showed that there were significant differences favoring the experimental group, for scores on the knowledge level questions. Moreover, there were gender-achievement interactions at the knowledge and comprehension level questions, favoring female students and achievement level achievement interactions favoring low achievers. In addition, there were significant correlations between students’ scores on high level questions and total concept map scores.

Findings of the current study are in contrast with the findings of [3]. They investigated the effect of concept mapping on academic achievement of 7th grade students’ general science. Their quasi experimental research involved 167 students, selected from two single sex schools. Results showed that the male and female students taught through concept mapping performed better than the students who were taught through traditional teaching methods. However male students taught through concept mapping performed significantly better than the female students.

5. Conclusion

Gender does not affect student’s achievement when ECM is used to teach chemistry to both boys and girls. This means that ECM teaching strategy is effective in improving the academic achievement of all students irrespective of gender.

6. Recommendations

Teachers should embrace use of ECM instructional strategy when teaching students because it has a potential of

reducing the gender performance disparities in national exams, especially in chemistry. Use of concept maps engages students in constructing and altering knowledge structures.

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