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EFFECT OF SOFTWARE-ORIENTED CONCEPT MAPPING ON KENYAN STUDENTS' ACHIEVEMENT IN ELECTROCHEMISTRY

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ABSTRACT

This study investigated the effect of using Software-Oriented Concept Mapping on students' achievement in electrochemistry among secondary school students in Kakamega County, Kenya. It was grounded on David Ausubel's Meaningful Learning Theory. The quasi-experimental research design, using non-randomized pretest-posttest control group model, was adopted to implement the study. Target population was 4,000 form four students and 30 Chemistry teachers from secondary schools in Kakamega County, which offer computer studies. A sample of 400 students and 10 teachers was selected by multi-stage sampling procedure, through a combination of purposive, proportionate stratified and simple random sampling techniques. The dependent variable was academic achievement, while the independent variable was instructional strategy at two levels; Software-Oriented Concept Mapping and the Conventional Instructional Strategies. The study was piloted one week to the actual study in one secondary school within Kakamega County. Data were collected using two achievement tests, the Students' Entry Behavior Achievement Test (SEBAT) as pretest and the Students' Electrochemistry Achievement Test (SEAT) as posttest. Both research instruments were validated using the Rasch Model, while their reliability was assessed using data from the pilot study, via the internal consistency alpha coefficients method. The percentage validity scores awarded were 85 for the SEBAT and 81 for the SEAT. The reliability coefficients were 0.805 for the SEBAT and 0.877 for the SEAT. Both measures therefore surpassed the minimum thresholds for validity and reliability as set by various research experts in educational research. There was one null hypothesis, which was tested using One-Way Analysis of Variance, whose outcome showed that the difference in mean score between the experimental and control groups was significant in favor of the former.

KEYWORDS: Software Oriented Concept Mapping, Electrochemistry, Achievement

INTRODUCTION

One of the roles of science education in the world is to develop in learners a sense of curiosity, which will help them understand how and why phenomena happen. Chemistry education specifically aims at inculcating in students a positive attitude towards appreciating the usefulness and relevance of scientific work in the world today (Iftekhar, 2013). In Kenya, Chemistry education aims at providing knowledge that prepares learners for further study, vocations and to appreciate their environment (KICD, 2002). Chemistry can be viewed as a 'bridge' because it incorporates knowledge acquired

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from a variety of subjects like Physics & Biology, and has a wide range of applications in different fields like Medicine, Agriculture, Biotechnology and Engineering (Iftekhar, 2013; Masinde, Wanjala and Michieka, 2015). A lot of emphasis is therefore placed on the application of the knowledge of Chemistry, in order to solve environmental and other issues that currently affect the Kenyan society.
In developing countries, the major problem facing Chemistry education is inadequate allocation of funds towards promoting quality teaching. In India for instance, the prime minister, Dr. Mammohan Singh announced in the 99th Indian Science Congress that his government would double the allocation of funds towards science education by the year 2017 (Iftekhar, 2013), which has already happened (Padma, 2015). In Kenya however, the biggest problem currently lies in the consistently low achievement by students in the subject, in the annual Kenya Certificate of Secondary Education (KCSE) examinations. Biology, which is viewed as a subject of relatively similar difficulty level and students' enrolment has always outshined Chemistry in KCSE, as attested by the compiled results, shown in Table 1.

Table 1: National Mean Scores of Biology and Chemistry from 2011 to 2015

YEAR	2011	2012	2013	2014	2015
Biology	52.65	55.54	57.01	56.98	56.72
Chemistry	43.55	45.65	41.65	51.95	50.01

Source: KNEC

As Table 1 reveals, in no single year has Chemistry performed better than Biology for the last five years. This situation has attracted concern from different quarters in the Kenyan education sector, all seeking to know the reason. One of the reasons that have been attributed to this poor performance is teachers' use of the conventional instructional strategies, as they are mainly teacher centered (MoE, 2015). Not all topics in the Chemistry curriculum are a problem to the Kenyan child in secondary school however. A question-by-question analysis of previous national Chemistry examinations has revealed that topics which are abstract are performed much more dismally than those that are not. Electrochemistry is one such topic, which is very frequently tested, yet students perform very poorly in its test items (KNEC, 2016). Table 2 gives a breakdown of the number of marks allocated to questions from this topic in past KCSE examinations.

Table 2: Weighting of Electrochemistry in Past KCSE Theory Papers

YEAR	WEIGHTAGE (MARKS ALLOCATED)		
	PAPER 1	PAPER 2	TOTAL
2016	8	5	13
2015	6	8	14
2014	5	6	11
2013	3	9	12
2012	4	7	11

Source: KCSE Chemistry past papers

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Data provided in Table 2 proves that electrochemistry is indeed a key topic in Chemistry, whose importance is underscored by the fact that it is allocated such a relatively high number of marks, and is tested every year in KCSE papers 233/1 and 233/2. Being an abstract topic, conventional instructional strategies are obviously not the most effective when teaching or learning it. The worry however is that many teachers still use them in this topic, probably because they are convenient in the sense that when used, a lot of content is covered within a very short period of time (Dimitrios, Labros, Kakkos, Koutiva and Koustelios, 2013).

Concept Mapping, when used as an instructional strategy alongside other conventional strategies, has been found to be very effective in improving learners' self-efficacy, motivation, attitude, experimental skills and achievement of students in many different subjects, or so are findings from empirical studies (Riga, 2015; Wambugu, Changeiywo and Ndiritu, 2014; Wilson and Kim, 2016; Zadeh, Gandomani, Delaram and Yekta, 2015). So what is Concept Mapping? This is a graphical way of representing and structuring knowledge by use of a concept map (Novak, 2010a). A typical concept map represents relationships between ideas, images or words, just like a sentence diagram represents its grammar, a road map shows location of highways and towns, and a circuit diagram represents the workings of electrical appliances (Moreno, Jelenchick and Christiakis, 2013). In every concept map, ideas and information in circles and boxes are connected using labeled arrows, in a downward branching hierarchical structure. The relationships between concepts are expressed using linking phrases on top of the arrows, also in a downward-branching and hierarchical structure (Moreno et al, 2013). Concept maps have proven to be effective for stimulating generation of ideas, aiding creative thought, brainstorming and communicating complex ideas (Novak, 2010b). Concept maps are mostly drawn using paper and pencil, but with recent advances in technology, there are computer programmes that can also be used to do this. When the latter is done, the current study termed it "Software-Oriented Concept Mapping".

Software-Oriented Concept Mapping (SOCM) is considered superior to other forms of concept mapping in the sense that being an interactive computer-based approach, it stimulates creative thinking skills, improves communication skills, and at the same time keeping the learner up-to-date with their computer skills, which are much needed on the job market in the 'digital' world of today (Riga, 2015). Implementation of SOCM in Kenya could therefore provide a timely intervention to the inappropriate and insufficient ways through which students have been learning electrochemistry and other abstract topics. This study was grounded in the Meaningful Learning Theory (MLT). The theory, which was advanced by Ausubel (2000), contrasts meaningful learning from rote learning. Ausubel (2000) posits that to learn meaningfully, students must relate new knowledge, concepts and propositions to what they already know (Novak, 2011). He proposed the notion of an advance organizer, as a way to help learners link their ideas with new material or concepts. The MLT also suggests that new concepts to be learnt must be incorporated into more inclusive concepts or ideas. These more inclusive concepts or ideas are referred to as "advance organizers", which could be in

the form of verbal phrases, or graphic representations (Ausubel, 2000). Concept maps, as were used in the present study, fall in the latter category.

It is no secret that of all the science subjects offered at secondary school level in the current Kenyan education system, Chemistry is the worst performed, if the analyses of previous KCSE results provided by KNEC are anything to go by. The subject has always ranked poorly in KCSE for the last five consecutive years, especially when compared to Biology, which has a similar students' enrollment. Reasons leading to this predicament are well documented and among them are students' low self-efficacy, low motivation and negative attitude towards abstract topics. The widespread use of and overreliance on Conventional Instructional Strategies in abstract topics has only made matters worse. Electrochemistry is one such topic, which is frequently tested in KCSE, with high weightage given to its question items in the theory papers. Unfortunately, the Conventional Instructional Strategies, which have been criticized for being mainly teacher-centered, continue to be used to teach it. This therefore means our students will continue to perform poorly in the subject, unless research about more effective student-centered and metacognitive instructional strategies is done is the country and its recommendations adopted.

Software-Oriented Concept Mapping is one good example of a student-centered instructional strategy, which incorporates technology to promote creativity in the way learners think about, visualize and relate different concepts in a topic or subject. Elsewhere, this strategy has been found to impact positively on several aspects of students' academic achievement but unfortunately, research about its use in the Kenyan context is scanty at the moment and hence this study couldn't be timelier. In fact, there is no study known to the researcher so far, about its application anywhere in Kakamega County. It is on these premises that the current study was carried out. The study's objective was to determine whether there is a difference in achievement between students who are taught electrochemistry using SOCM and those taught via the CIS.

REVIEW OF RELATED LITERATURE

Cheemaa and Mirza, (2013) investigated the effect of concept mapping on academic achievement of 7th grade students in the subject of general science. Their quasi experimental research was based on a 2x2 factorial research design, involving 167 students, selected from two single sex schools. Major objectives of the study were to; (i) find out the effect of concept mapping as a learning strategy on the academic achievement of students (ii) study the differential effect of concept mapping on academic achievement of male and female students (iii) to find out the interaction effect of concept mapping as a learning strategy and gender on students' academic achievement. The researchers developed their own achievement tests and administered them to students before and after intervention. During the treatment, which lasted five months, the experimental group was trained to develop concept maps for three weeks. Subsequently students developed concept maps of general science content individually, shared them in groups and were compared by teacher with scientifically accepted concept maps for possible correction and improvement. Data on gain achievement scores

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were analyzed through two-way ANOVA. 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. One serious issue that was of concern to the researcher of the current study is the duration of the study, which was a whooping five months! This time frame might have been rather too long, which could have given maturation a chance to negatively affect internal validity of the study in question. The current study rectified this by limiting the teaching of electrochemistry to a maximum duration of three weeks, as stipulated by the syllabus.

In Lebanon, a study was done by Boujaoude and Attieh, (2008), on the effect of using concept maps as study tools on achievement in Chemistry. Their objectives were to: (1) examine whether or not the construction of concept maps by students improves their achievement and ability to solve higher order questions in Chemistry, (2) investigate the differential effect of the treatment by gender and achievement level, and (3) explore the relationships between performance on concept maps and Chemistry achievement. Participants of this study were 60 tenth-grade students, who were randomly divided into two groups: - experimental and control. The study spanned six weeks, in a class that met five times a week. The material covered was acid-base titration and equilibrium in weak acids. The students were pre- and post-tested using a teacher-constructed Chemistry test. Results showed that while there were no significant differences on the achievement total score, 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. Finally, there were significant correlations between students' scores on high level questions and total concept map scores. This study informed the current one in the sense that achievement was chosen as one of the dependent variables investigated.

Elsewhere, a Nigerian study by Otor, (2013) focused on the effects of concept mapping strategy on students' achievement in difficult Chemistry concepts. It also examined the differential effect on the achievement of male and female Chemistry students. Two research questions and two hypotheses were formulated to guide the research. His study used a quasi-experimental pretest-posttest group research design. Data were collected from 1,357 Chemistry students, using a stratified random sampling procedure, from two schools in two local government Areas of Benue State of Nigeria. One instrument for data collection was developed by the researcher and validated by experts - the Chemistry Achievement Test, on Structure of Matter and Energy Changes. The research questions were answered using mean and standard deviation scores, while the hypotheses were tested at the 0.05 significance level, using ANCOVA. Students taught using concept mapping strategy achieved higher and significantly better scores than those taught using conventional metacognitive methods. There was also a better performance in favor of female students as compared to their male counterparts using this method.

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A more recent study by Singh and Moono (2015), investigated the effect of using concept maps on Zambian students' achievement in selected Chemistry topics at tertiary level. Three groups were used in this study, one control and two experimental. The pretest-posttest true experimental research design was adopted, using 39 first year students at Mafulira College of Education. All the groups were randomly assigned into their respective groups, each with 13 students. Treatment lasted four weeks using the topic "atomic structure" and chemical bonding. Whereas the control group used traditional methods of instruction, experimental group 1 used the concept map method while experimental group 2 used both methods. One-way ANOVA at the 0.05 alpha level was conducted to analyze the pretest and post test scores. Results revealed no significant differences in the pretest mean scores but significant ones in the post test. Post hoc comparisons indicated that both experimental groups were similar, but different from the control group. These findings supported the study's alternative hypothesis that when students are taught using both traditional and concept mapping approaches, they achieve the best scores. It is on the basis of these findings that the current study used a combination of both traditional and concept mapping strategies, so as to achieve the hypothesized outcomes in the experimental groups of the present study and hopefully solve the problem that necessitated the study.

MATERIALS AND METHODS

The study was implemented using the quasi experimental research design, using non-randomized pretest-posttest with control group as a model. This research design was implemented by assigning the sample into two treatment groups; one experimental and one control. Both groups were pre-tested, after which the experimental group received intervention as the control group maintained status quo. Intervention entailed the use of SOCM by Chemistry teachers assigned to experimental groups for teaching the whole topic of electrochemistry. It also included students' use of the concept maps drawn on their own or with the help from their teachers, to revise electrochemistry during their private study sessions. While this was happening, students in the control groups were also taught the same topic of electrochemistry, albeit using the Conventional Instructional Strategies (CIS). Both treatment groups were thereafter post-tested. Pre-test served the purpose of establishing whether or not the sampled students had the same entry behavior in terms of the study's dependent variable, without which a study is deemed to lack internal validity (George and Mallery, 2003). Posttest on the other hand was used to compare the treatment groups, with respect to the study's dependent variable, so as to establish whether or not the intervention given to students in the experimental groups was effective. Comparison of the experimental groups versus the control groups therefore climaxed the quasi experiment. Threats of this research design to internal and external validity of this study were; interaction, multiple treatment effect and maturation. These threats were however countered or minimized by; (i) random selection of intact classes, (ii) using different schools as experimental and control groups, and (iii), administering posttest shortly after intervention.

This study was carried out in Kakamega County, Kenya. This region was opted for by the researcher, reason being that of all counties in western Kenya, the county stood out as the one with the highest

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number of schools that offer computer studies, and consequently had the highest computer-student ratio, which in turn provided a wide range of sampling options. Results of this study therefore have high external validity. Kakamega County is situated in western Kenya. Kakamega town is the headquarters of this county, which is bordered by; Busia, Bungoma, Siaya, Vihiga, Nandi, Uasin gishu and Trans Nzoia counties. It occupies a geographical area of 3,050.3 km2 and has a large population of 1,660,651 persons, the second highest in Kenya. The county has 12 sub-counties namely; Likuyani, Lugari, Matete, Kakamega North, Kakamega East, Kakamega South, Kakamega Central, Kwisero, Butere, Mumias, Matungu and Navakholo. The county has 411 secondary schools, 282 of which are mixed, 73 girls' and 56 boys' schools. The secondary school population is 113, 202 students and 3,620 teachers, which is a teacher-student ratio of 1:31. The secondary school enrolment rate is 69%, while the dropout rate stands at 9.5 %. Most schools in this region perform dismally in Chemistry during national examinations as revealed by previous KCSE analysis reports. Out of the 411 secondary schools in Kakamega County, the study targeted the 4,000 form four students in all the secondary schools that offer computer studies as an examinable subject and had computer laboratories. Only form four students were targeted in this study, because the topic of interest, which was Electrochemistry, is taught at this level in the current syllabus.

The sample size of this study was determined using the formula of Krejcie and Morgan, Taking 4000, which is the study's target population, as the value of N in the formula, 400 was obtained as the calculated value of s, the sample size that was deemed sufficient to represent the study's population. The study therefore used 400 students as respondents. Multi-stage sampling technique was used to arrive at the required sample. To begin with, purposive sampling was used to select from the accessible population only schools that offer computer studies or those with computer laboratories. This was because the intervention of this study vis-à-vis SOCM, needed computers as an instructional media resource, which compelled the researcher to purposively select these kind of schools, as they were the only ones in the research location which were equipped with sufficient computers for proper implementation of SOCM. From the resulting list of schools, purposive sampling was also used to select only schools whose average mean score in KCSE for the last three years was between 5 and 7 points, in an attempt to ensure fair competition and the need for a sample with similar entry behavior. Heterogeneity of participating schools being a mandatory requirement for achieving the fifth objective of this study, this range was deemed most appropriate, as it has been found through research to be the most heterogeneous (Wasike, 2013). Thereafter, proportionate stratified random sampling was used to select schools of each type needed i.e. co-educational, boys' only and girl's only, to ensure fair representation, because school type was one of the factors under investigation. Six mixed schools, two girls' schools and two boys' schools were proportionately selected for this study. Each school type was therefore fairly represented using this selection criterion. Simple Random Sampling (SRS) was used to select the specific schools to be used. To select the students for participating in the study, SRS was further used to select only one of the form four streams in the case of schools with multiple form four streams. For schools with only one form four stream, the entire stream participated in the study. SRS was executed using the balloting

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technique, whereby different random numerals were assigned to all schools that were earmarked for participating in the study via the previously mentioned selection criteria. The numerals were written on separate small pieces of paper of same size and color. Each of the papers was then folded to conceal the numbers and placed in 3 different bags, one for mixed schools, another for girls' schools and the other for boys' schools. All the bags were then closed and thoroughly shaken to mix up their contents. Since only 10 schools were required, a blindfolded person was asked to pick 10 pieces of paper from the bags as required i.e. 6 from the mixed schools' bag, 2 from the girls' schools bag and 3 from the boys' schools bag. Picking of the pieces of paper was done one at a time without replacement. Schools corresponding to the numbers on the papers that were fished out of the bags were eventually used for the study. The same technique was used to select one form four stream to be used in the study, in the case of schools with multiple form four streams. This technique ensured that all eligible schools and students had an equal chance of being selected to participate in this study. To take care of interaction, which is a known potential threat to internal validity of a study (Pearl, 2015), different schools were used as experimental and control groups. The 10 intact streams of form four students selected as earlier described were randomly assigned into two treatment groups and labeled SOCM-1, SOCM-2, SOCM-3, SOCM-4, SOCM-5, CIS-1, CIS-2, CIS-3, CIS-4 and CIS-5. Those with the prefix "SOCM" made up the experimental group while those with the prefix "CIS" formed the control group. These prefixes were used deliberately and strategically so, for ease of identification of each research group by type of treatment it received. This was because SOCM and CIS as used in this document are acronyms for "Software-Oriented Concept Mapping" and "Conventional Instructional Strategies" respectively, which were the two treatments that were under scrutiny. Purposive sampling technique was finally used to select all the respective Chemistry teachers that were teaching the selected form four students in the selected schools just before this study took off. This was an effort to avoid any timetable issues as a result of random sampling of the teachers, which in turn could have made some schools reluctant to participate in the study. The smallest research group had 35 students, while the biggest had 44 students, each group with one Chemistry teacher.

Raw data were collected using two achievement tests; The Students' Entry Behavior Achievement Test (SEBAT) as pretest and the Students' electrochemistry achievement Test (SEAT) as posttest. Just as its name suggests, the purpose of the SEBAT was to determine students' entry behavior in Chemistry, so as to ascertain their homogeneity. The SEBAT was a one-hour achievement test of 60 marks, and had 18 items that were developed by the researcher by constructing questions that cut across the Chemistry curricula of forms 1, 2 and 3, using a blue print to enhance its face and content validity. All items therein were set in line with the specific instructional objectives outlined in the KICD syllabuses. The items cut across all six levels of the Bloom's cognitive domain of objectives and spread out in ratio 6:3:1 for Low level (knowledge and comprehension), Middle level (application and analysis) and High level (synthesis and evaluation) respectively. A students' score in the SEBAT was determined by converting his or her total marks to percentage. The maximum

possible achievement score in the SEBAT was therefore 100% while the minimum possible score was 0%.

The SEAT on the other hand was used to measure students' understanding of concepts taught in the topic of Electrochemistry. It was a one hour achievement test, worth 30 marks, whose items were all short answer, set by the researcher using a blue print to enhance its face and content validity. Each question was allocated between 1 and 4 marks. All question items in the SEAT covered the six levels of the Bloom's cognitive domain of objectives, and were weighted using the KNEC's criteria of low level (knowledge and comprehension) as the majority, followed by middle level (application and analysis), then high level (synthesis and evaluation) as the minority, in ratio 6:3:1 respectively. A students' score in the SEAT was determined also by converting their total marks to percentage. The maximum possible achievement score in the SEAT was therefore 100% while the minimum possible score was 0%.

The two instruments were validated using the Rasch model, whereby three experienced KNEC examiners of KCSE papers 233/1 and 233/2 were given a rating scale and asked to critique them. Comments from the experts were used by the researcher to modify the instruments, so as to make them more ideal and accurate for data collection in the actual study. A validity score of 85% was obtained for the SEBAT and 81% for the SEAT, both therefore minimum recommended score of 60% for educational researches as recommended by Kahn and Best, (1998). These scores implied that the instruments had a strong ability to measure what they purported to measure. Reliability of the instruments was assessed before the actual study, using data from the pilot study. This was done via the internal consistency reliability analysis, using Cronbach's alpha coefficients. This method helped in determining each instrument's inter-item correlation on the basis of a correlation matrix for all items in the instruments, and also the corrected item-total correlation, including alpha coefficients that would have been obtained on deleting an item altogether from the instrument. This kind of analysis helped the researcher to detect items that needed modification or removal from the instrument (Peters, 2014). A coefficient of 0.805 was obtained for the SEBAT and 0.877 for the SEAT, which implied that both instruments were of good scholastic quality and if used again under the same research conditions, they would produce a similar outcome.

Two of the softwares that were used by students in experimental groups of this study were adopted while one was developed by the researcher, with help from a qualified software engineer. The developed software was christened "MACOMASO", an acronym for "Masinde's Concept Mapping Software". It was original, interactive computer instructional software, named after the researcher, and was designed for use on Windows XP, Windows Vista, Windows 7.0 and Windows 8.1 operating systems. The software was supplied with a user's manual, which had step-by-step instructions in simple English language, which explained how to construct, save, edit and print concept maps, using desktop or laptop computers. Other complimentary softwares namely Inspiration 9.0 and Smart Ideas 5.0 were used alongside MACOMASO, so as to expose the students

to a variety of concept map construction skills. The software are different in terms of outlook, ease of use, number and type of drawing tools within the programme, though they all function basing on the same principle. After exposure to the three types of concept mapping softwares, students were eventually able to select and use their favorite software since there was variety. It is worth noting that Inspiration 9.0 and Smart Ideas 5.0 were 'richer' in concept map construction features as compared to MACOMASO, because development of the latter was limited by time and financial constraints. Inspiration software exists in several versions namely; Inspiration, Kidspiration and Webspiration. According to their product catalogue, they all contain diagram views that make it easy for students to create concept maps. Students are able to add new concepts and links as they fit. They all come with examples, templates and lesson plans to show how concept mapping and the use of other graphic organizers can easily be integrated into the curriculum to enhance learning, comprehension and writing skills. Free trial versions of this software are downloadable from the internet at http://www.inspiration.com/freetrial/index.cfm. According to the manufacturer's description, Smart Ideas software on the other hand "brings the power of visual learning into the classroom". Students can better understand and analyze complex ideas by building multilevel concept maps. Multilevel maps take students through concepts one level at a time, for greater clarity and easily converting into a multipage website for everyone to share. Free trial versions of this software is downloadable from the internet at http://www.smartideas.com

Data were analyzed descriptively to generate frequencies, percentages, means and standard deviations. These descriptive measures were used to supplement inferential tests by giving explanations that delineated the proportional amount of achievement in electrochemistry, between the experimental and control groups. One-way ANOVA was used to test HO1 because data collected by this study's achievement tests were expected to meet assumptions of this test, which are; (i) there should be more than two groups, categorized basing only on one factor - this study had ten groups, categorized basing only on the type of treatment they received, (ii) Data should be normally distributed. This was expected to be the case since intact classes were assigned randomly into experimental and control groups. Nevertheless, the Shapiro-Wilk test was used to assess this assumption beforehand. (iii) Data should be continuous. The SEAT was an achievement test, whose possible scores ranged on a continuous ratio scale of 0 to 100. Absolute zero in the SEAT therefore meant absence of the variable, (iv) the groups should not be related - this assumption was already taken care of by the research design, as it entailed the use of intact classes. This meant there was no chance of a participant belonging to more than one treatment group i.e. being in experimental as well as control groups (iv) the groups should have equal variances. This assumption was assessed using Levene's test of homogeneity of variances.

RESULTS AND DISCUSSION

Several descriptive measures were computed on data that were collected by the research instruments, with the intention of establishing trends and patterns that would give explanations to some of the observations made in the analysis of quantitative data. Students' pretest achievement scores as

measured by the SEBAT and SEAT were analyzed descriptively to generate Means and Standard Deviations (S.D) and the outcome was as presented in Table 3.

Table 3: Means and Std. Deviations of the Pretest and posttest achievement

Group	Statistic	Pretest (SEBAT)	Posttest (SEAT)
Experimental (N=200)	Mean	39.51	58.87
	S.D	9.116	11.08
Control (N=200)	Mean	40.23	50.31
	S.D	9.576	11.15
Whole sample (N=400)	Mean	39.87	54.59
	S.D	9.344	11.90

Table 3 reveals that students in both treatment groups obtained relatively similar achievement mean scores in the pretest [mean (experimental) =39.51, S.D=9.116, Mean (Control)=40.23, S.D=9.576]. In the posttest however, superior mean scores were recorded by the experimental group as Table 3 clearly indicates [Mean (experimental)=58.87, S.D=11.08, Mean (control)=50.31, S.D=11.15]. It can be deduced from Table 3 that the experimental group had a higher achievement mean gain [Mean gain (experimental)=19.36, Mean gain (control)=10.08]. Notably, both groups had a positive deviation in achievement mean score, which was attributed to the fact that the posttest was narrower in scope, covering only one topic, unlike the pretest which covered 15 topics from forms one up to three. The objective of this study was to determine whether there is a difference in achievement between students taught electrochemistry using SOCM and those taught via the CIS. A null hypothesis was formulated from this objective as follows:

Ho1: There is no difference in achievement between students who are taught electrochemistry using SOCM and those taught via the CIS

This hypothesis was tested statistically by performing one-way ANOVA on students' pretest and posttest achievement scores, at 0.05 alpha level and the results were as presented in Table 4.

Table 4: One-Way ANOVA on Students' Achievement Scores

SOURCE	TEST	D.F	F	P
Between Groups	Pre test	9	0.419	0.925
	Post test	9	6.852	0.000
Within Groups	Pre test	390	-	-
	Post test	390	-	-
Total	Pre test	399	-	-
	Post test	399	-	-

Table 4 reveals that there was a significant difference in the posttest achievement scores between the ten groups under comparison [F (9, 390)=6.852, p<.001 at α=.05]. This is because the p-value

obtained is less than 0.05, the stipulated alpha. To find out the specific groups that accounted for this significant F-value, Tukey's post-hoc Least Significant Difference (LSD) tests were carried out. These follow-up tests revealed that all experimental groups produced non-significant p-values when compared against each other and so was the case when control groups were compared against each other. However, significant p-values were obtained when all the experimental groups were compared against all the control groups. This implied that the experimental groups had significantly higher mean scores in the posttest achievement test than the control groups. Table 4 further reveals that in the pretest, there was no significant difference in mean score between the 10 groups under investigation [F (9, 390)=.419, p=.925 at α=.05]. This was because the p-value was greater than 0.05, the stipulated alpha level. For these reasons, the null hypothesis of this study was rejected because empirical evidence that arose from data collected with respect to the study's objective suggested the contrary assertion. It can alternately be asserted that there is a significant difference in achievement between students who are taught electrochemistry using SOCM and those who are taught using the CIS in favor of the former. It was established that the use of SOCM in teaching and learning of electrochemistry had a significant positive impact on students' achievement in the topic than when the CIS were used. This was because students in all the experimental groups of this study were taught electrochemistry using SOCM and obtained significantly higher scores than their counterparts in all the control groups, who were taught the same topic using the CIS, which was not the case prior to the study because a similar comparison in the pretest achievement test scores showed that all the groups had statically the same achievement entry behavior. This difference in achievement scores obtained in the SEAT was therefore attributed by the researcher to the treatment that the experimental groups received after the quasi experiment.

These findings are in agreement with those of Cheema and Mirza, (2013), whose study reveal that the use of concept mapping in general science was superior to the conventional methods of instruction with respect to students' academic achievement. This was because their quasi-experimental study revealed that students who learnt via concept mapping obtained significantly higher achievement scores than those who were taught via the traditional teaching methods, as was done in the control groups of this study. Concept mapping as an instructional strategy was also used to teach Chemistry, in a study by Singh and Moono, (2015), which involved 118 girls (59 in the experimental group and 59 in the control group). The control group was exposed conventional methods (lectures and discussion) while the experimental group was exposed to concept mapping, both for 25 days. However unlike the present study, Singh and Moono, (2015) used the mixed group intelligence test to collect data, which was analyzed using t-test. Their results revealed that achievement in Chemistry of the girls taught by concept mapping was significantly more as compared to those taught by the traditional lectures and discussion, which is in perfect agreement with the outcome of this study. Findings of this study are also in unison with those of a studies by Wilson and Kim, (2016); Boujaode and Attieh, (2008); Chee and Wong, (1996) and Otor, (2013). All these studies focused on the effect of concept mapping as the main intervention, on students' achievement in different subjects, using methodologies similar to those applied in the present study.

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They all established that students who were taught using concept maps obtained higher grades in respective topics and subjects as compared to those who were taught the same content by way of the conventional instructional approaches.

CONCLUSION

On the basis of data collected in this study's quasi experiment and the empirical evidence provided by the subsequent statistical data analyses, it is hereby concluded that the use of concept mapping software to teach the abstract form four topic of electrochemistry significantly improves students' achievement in the topic when compared to the use conventional instructional approaches. The positive effect of concept mapping is attributed to the fact that it was a hands-on experience for all the learners, who were all able to visualize all abstract concepts therein. Teachers of Chemistry in Kenya should therefore incorporate concept maps in their daily teaching, so as to solve the current performance crisis that has befallen Chemistry education in Kenya for the last five years.

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