

Association between Students' Self-Efficacy and Achievement in Electrochemistry When Taught using Software-Oriented Concept Mapping

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Abstract

This study determined the association between Kenyan students' self-efficacy and their achievement in electrochemistry when taught using Software-Oriented Concept Mapping in comparison to the Conventional Instructional Approaches. The study was based on David Ausubel's Meaningful Learning Theory, and was executed via the Quasi-experimental research design, using non-randomized pretest-posttest control group model. A sample of 400 students and 10 chemistry teachers was selected by multi-stage sampling procedure, through a combination of purposive, proportionate stratified and simple random sampling techniques. The study was piloted two weeks to the actual study, in two secondary schools within Kakamega County. A close-ended questionnaire and a standardized achievement test were used to collect the study's raw data. Both research instruments were assessed for their validity using the Rasch Model, and reliability using the internal consistency alpha coefficients method. The study's null hypothesis was tested inferentially at the 0.05 alpha level of statistical significance, using Bivariate Pearson's Correlation. Findings revealed a weak but significant positive association between students' posttest self-efficacy and achievement scores [$r=.228$, $p<.001$ at $\alpha=.05$]. These findings have important instructional implications in the field of Chemistry education.

Key Words: Self-Efficacy, Achievement, Concept-Mapping, Electrochemistry

Background of the study

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 from a variety of subjects like Physics and Biology, which makes it to have a wide range of applications in different fields like Medicine, Agriculture, Biotechnology and Engineering (Masinde, Aurah and Wanjala, 2020). 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 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. Some of the reasons that have been attributed to this poor performance are; students' low self-efficacy (MoE, 2015), low motivation and negative attitude towards abstract topics (Masinde, 2020). All these factors boil down to the use of conventional instructional strategies of instruction, whose rampant use has been found ineffective, especially in abstract and difficult topics (Masinde, Aurah and Wanjala, 2020).

Previous analysis of past national Chemistry examinations has revealed that Electrochemistry is one of the topics that are regularly tested but students perform very dismally in its test items (KNEC, 2016). This means that as an abstract topic, conventional instructional strategies may not be the most effective when teaching or learning it. Research reveals that using hands-on student centered instructional approaches plays a vital role in improving learners' self-efficacy, attitude, motivation and achievement in several subjects

(Dimitrios *et al*, 2013). Students with high self-efficacy, positive attitude, high motivation and achievement in Chemistry are therefore expected to perform very well in the subject, because these are the all-important contributors of high academic achievement (Cheema and Mirza, 2013; Singh and Moono, 2015; Wilson and Kim, 2016; Masinde, Aurah and Wanjala, 2020).

Teachers of Chemistry in the country should therefore play their crucial part in addressing this problem by using such novel instructional strategies to deliver abstract content and also by encouraging their students to use similar learning strategies to carry out their private revision of all concepts that they would have been taught. This approach should no doubt have a positive impact on the previously mentioned aspects of academic performance, according to the researcher's informed projection. Perhaps Software-Oriented Concept Mapping (SOCM) could be implemented in all the abstract Chemistry topics, so as to address the pitfalls of Conventional Instructional Strategies (Masinde, Aurah and Wanjala, 2020). This study therefore determined the association between students' self-efficacy and achievement in electrochemistry when taught using SOCM and the CIS, so as to come up with recommendations that may help formulate policy measures on the best approaches of improving students' academic achievement in abstract topics like electrochemistry.

Literature Review

Research reveals that self-efficacy plays a key role in all aspects of human endeavor (Waaktar, 2013). This section brings into perspective a number of studies that involved concept mapping with respect to self-efficacy. A recent study by Wilson and Kim, (2016) investigated the effects of concept mapping on mastery goal orientation and academic self-efficacy in a collaborative learning environment. The study employed a randomized controlled pretest-posttest group research design to examine whether learning strategies such as concept mapping can help students with both reading comprehension and intrinsic motivation of wanting to master a task at a high level. A total of 42 fifth grade students at Ilshin Elementary School in South Korea participated in this study. The experimental group, which consisted of 22 participants underwent concept mapping training while the control group, which consisted of 20 participants did not. All students were required to fill out questionnaires based on mastery goals, performance goals and academic self-efficacy.

Their results, which were analyzed using one way ANOVA, indicated that concept mapping did not increase mastery goals and mastery goals had no effect on test scores. In addition, the interaction effect between academic self-efficacy and condition did not increase mastery goals and had no effect on test scores. The study further reported in their findings that,

“Students who experience anxiety will usually perform not as well because they may question their own abilities and talents. This is important because despite having the intrinsic motivation of wanting to accomplish a task, if it is hindered by anxiety then it could lead to compulsive behavior or panic attacks because of fear, especially in the form of not performing as well. In addition, Bandura (1977) research supports this claim because even though students may have high academic self-efficacy it may not increase mastery goal orientation. The reason for this is because if students are unable to observe other students to see how a task is done first, then it can create a sense of nervousness when it is their turn to perform and the full potential of reading comprehension achievement may be hindered. Students will not have a solid idea of what they need to do despite the desire of wanting to do the task”. (Page 20)

These results were attributed to the reduced number of samples that might have caused a potential source of instability considering the statistical procedure chosen. It is however worth noting that one-way ANOVA may not have been the best statistical tool to use given that the sample had been divided into only two groups. Independent samples t-test should have been used instead, as it is robust for determining significance of differences between two groups, without any chance of committing type one error (Bailey, 2008). The target population is also not stated, which makes it difficult to establish whether the sample used was sufficient to represent the population, or not. The current study addressed this issue by using a sufficient sample, basing on criteria of well-known educational research authorities. The target population was also

clearly stated for purposes of verifying whether the sample used met the threshold that has been set by various research authorities.

In Iran, a study by Khajavi and Ketabi, (2012) was done, investigating the influence of concept mapping, on reading comprehension and self-efficacy of intermediate EFL (English as a Foreign Language) students in the country. To fulfill the aims of their study, 60 participants (21 males and 39 females) were selected, whose ages ranged between 19 and 23 years. A randomized pre-test post-test control group design, with a concept mapping group and a traditional method group was employed. Prior to the treatment, both the concept mapping group and the traditional method group were administered pre-tests in reading comprehension and self-efficacy. Eight items in the Motivated Strategies for Learning Questionnaire (MSLQ), which measured self-efficacy, were applied to measure students' self-efficacy beliefs.

The duration of training was ten weeks. At the conclusion of the training, all participants again completed the MSLQ. After controlling the effects of pre-test scores, results of Analysis of Covariance (ANCOVA) revealed that students in the concept mapping group showed greater self-efficacy in reading comprehension than students in the traditional method strategy group. These findings are in agreement with another study, in the same country, by Nobahar, Tabrizi and Shanghaghi, (2013), which investigated the effect of concept mapping on Iranian intermediate EFL learners' self-efficacy and expository writing accuracy. Unlike the previous study however, the writing proficiency test, along with self-efficacy questionnaire was given to a larger sample of 180 learners. Based on the results of the writing test and self-efficacy questionnaire, 60 intermediate homogeneous participants were selected and randomly assigned to two groups of control and experimental. In the course of 22 sessions, regular class times of 15 minutes were devoted to concept mapping. In each session, participants of both groups were given a writing task besides their course book writing section.

Those in the experimental group were engaged in concept map construction after writing each task and organized their pre-writing activities such as discussion, doing exercises and reflective practices according to their constructed concept maps. A post-test of writing and a self-efficacy questionnaire were administered to all the participants, but unlike the study by Khajavi and Ketabi, paired samples t-test, together with the independent samples t-test were used to answer their research questions. Results of their study showed that concept mapping had a significant effect on self-efficacy and expository writing accuracy, just like the previously mentioned study.

Nbina and Viko, (2010) conducted a study on the effect of instruction in metacognitive self-assessment strategy on senior secondary school students' Chemistry self-efficacy. A non-equivalent control group pretest and posttest design, involving one treatment and one control group was adopted, in which a total of 192 students from Port Harcourt Education zone in Nigeria were used for the study. Instructional software was developed, validated and used for the study. A questionnaire was adopted, validated and used for data collection. Their results suggested that instruction in the metacognitive self-assessment strategy improve the students' Chemistry self-efficacy. These findings are in tandem with the previously mentioned studies.

In the USA, Chularut and DeBacker, (2004) performed a study, which investigated the influence of concept mapping on self-efficacy in students of English as a Second Language (ESL) and the effectiveness of concept mapping, used as a learning strategy with students in ESL classrooms. Seventy-nine ESL students participated in the study, which employed the randomized pretest-posttest control group research design.

Their findings revealed a statistically significant interaction of self-efficacy variables in the concept mapping group, with greater gains from pre-test to post-test than the individual study group. One question that begs from this study however is how randomization was achieved, given the static nature of classes in most countries in the world. One would also want to know whether ethical considerations were made in the course of random sampling of the participants. The current study addressed these pertinent questions by using a different research design, which it is hoped not compromise the ethical issues raised from this American study.

Ferla, Valcke, and Cai, (2009), researchers from Belgium investigated whether academic self-efficacy and academic self-concept represent two conceptually and empirically distinct psychological constructs, when studied within the same domain. A questionnaire was used to collect data on self-efficacy in Mathematics of the participants. The study was based on cognitive theories, whose findings indicated that Mathematics self-efficacy and Mathematics self-concept do indeed represent conceptually and empirically different constructs, even when studied within the same domain. Moreover, students' academic self-concept strongly influences their academic self-efficacy beliefs. Additionally, academic self-concept is a better predictor and mediator for affective-motivational variables, with academic self-efficacy being the better predictor and mediator of academic achievement.

Interestingly, these findings are in total disharmony with a similar study, which was carried out in Greece, using methodology similar to that of Ferla, Valcke, and Cai, (2009). The latter, which was carried out by Paraskeva, Bouta, and Papagianni, (2008), investigated the relationship between individual characteristics of secondary school teachers and computer self-efficacy, as well as teacher prospects with regard to modern technologies. Their second research question concerned the relationship between self-concept and computer self-efficacy, which ascertained that between the two variables there is no significant correlation. The current study tried to reconcile these two studies.

One major point of convergence in all studies reviewed so far, which focused on the influence of concept mapping on students' self-efficacy is the use of the pretest-posttest quasi-experimental research design. The present study also used this design because experts put, it does not require random sampling of participants, which would otherwise be unethical, given the static nature of classes in Kenyan secondary schools. The present will however control for pretest, which is known to compete in one way or the other, with any intervention to influence the outcome of any study.

Research Methodology

By combining qualitative and quantitative research methods, the weaknesses of one method can always be taken care of by strengths of the other. This is according to Creswell and Plano, (2011) who explained:

“A problem exists when the quantitative results are inadequate to provide explanations of outcomes, and the problem can best be understood by using qualitative data to enrich and explain the quantitative results in the words of the participants. In other words, mixed methods research helps answer questions that cannot be answered using only qualitative or quantitative methods alone. Mixed methods provide a more complete picture by noting trends and generalizations, as well as in-depth knowledge of participants' perspectives.” (Page 33)

For this reason, a mixed methods approach was used in this study to obtain both quantitative and qualitative findings. Research data were collected sequentially, because this approach demands integration of the data in one or more stages of a research process (Guest, 2013). In this regard, quantitative data were collected first, followed by qualitative data in quick succession. Quantitative data provided the study's primary findings, which were corroborated by the qualitative findings. The qualitative phase of the study was accomplished through Focus Group Interviews (FGI), which were conducted immediately after the last stage of the quantitative phase, on some of the students who participated in the study to capture their self-efficacy beliefs in Chemistry. The quantitative phase was implemented through quasi-experimental research design, using non-randomized pretest-posttest with control group being 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 variables, 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 variables, so as to establish whether or not the intervention given to students in the experimental groups made a difference. Comparison of the experimental groups versus the control groups therefore climaxed the quasi experiment.

This research design was deemed most appropriate for this study because; (i) it involves control groups, which enhance a study's internal validity, (ii) it involves pre-testing, which allows the researcher to establish beforehand whether or not the sample selected is homogenous, a crucial requirement for inferential analysis, especially when using parametric tests (DeRue, 2012). Potential threats of this research design to internal and external validity were; interaction, multiple treatment effect and maturation. These threats were however countered or minimized by; (i) random assignment of intact classes into experimental and control groups, (ii) using different schools as experimental and control groups, and (iii), administering posttest shortly after intervention.

The qualitative phase of this study was carried out after the quantitative phase as previously mentioned, whereby oral interviews were conducted on several focus groups of students who had taken part in the quantitative phase of the study, to gather information that corroborated the quantitative research findings. The 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 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.

Kakamega 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. (Source: KNBS, CDE and CDO Offices). 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, 350 was obtained as the calculated value of s, the sample size that was deemed sufficient to represent the study's population. A value equal to or greater than this should therefore have sufficed for generalizing the research findings to the entire population (Wilcox, 2010). The study used 400 students, which was even bigger than the calculated sample size value. Multi-stage sampling technique was used to arrive at the required sample. To begin with, purposive sampling as indicated in Table 1 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 kinds 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 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 one 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.

As for the qualitative phase of this study, 10 focus groups, comprising of 73 respondents in total, were involved in the interviews, one group from each of the 10 that had participated in the quantitative phase of the study. Additionally, the participants of the FGI therefore formed sub-samples of between 6 and 10 students in each focus group to represent their respective research groups. Selection of these respondents was on volunteer basis, which explains why the focus groups were of different sizes. Each FGI was moderated by one Chemistry teacher. After comprehensive literature review and consultation with several educational research experts, and guided by the research objective, the researcher developed four instruments for data collection. These included; a questionnaires, an interview guide and two achievement tests.

The Students' Self-Efficacy Questionnaire, SSEQ was a close ended questionnaire, which sought information about students' self-efficacy in the use of the two instructional strategies under investigation, Chemistry lessons, Chemistry assignments and Chemistry in general. It was adapted and modified from Aurah, (2013), who used it to measure students' self-efficacy beliefs in Biology. The instrument was

administered before and after intervention to all the sampled form four students, to collect data that was used to address the objective of this study.

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, which was administered as pre-test to all the sampled students. It 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 (Table 3) 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, like the KNEC does.

Table 3: Test Specification Grid for the SEBAT

SOURCE	COGNITIVE LEVEL			TOTAL
	LOW	MIDDLE	HIGH	
FORM 1	7	2	1	10
FORM 2	12	6	2	20
FORM 3	17	10	3	30
FORMS 1 - 3	36	18	6	60

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% (for a student who obtained maximum scores in each of the items therein) while the minimum possible score was 0% (for the student who obtained zero marks in all the 18 items therein).

The SEAT was administered as post-test to all the sampled students, to measure their 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 (Table 4) to enhance its face and content validity. Each question was allocated between 1 and 4 marks.

Table 4: Blue Print for the SEAT

CONTENT	COGNITIVE LEVEL			Total
	Low	Middle	High	
Redox reactions	4	-	-	4
Displacement reactions	-	1	-	1
The electrochemical cell	2	-	1	3
Standard electrode potentials	1	1	1	3
Calculating the E.M.F of a cell using E^{θ} values	2	1	1	4
Electrolysis	1	3	-	4
Preferential discharge of ions	4	-	-	4
Quantitative treatment of electrolysis	-	3	-	3
Fuel cells	4	-	-	4
TOTAL	18	9	3	30

As Table 4 reveals, 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. All items intended to measure achievement in electrochemistry were arranged in section I of the SEAT, which had 10 theory questions, worth 30 marks. Section II of the

same instrument was a practical question worth 25 marks, which tested the use of several experimental skills by students in the electrochemistry practical test. The skills were assessed using another instrument, which is discussed in the next section, as it collected data for a different objective.

A student's 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% (for a student who obtained maximum scores in each of the items therein) while the minimum possible score was 0% (for the student who obtained zero marks in all the 10 items therein). A series of focus group interviews were conducted one day after the quantitative aspect of this study. A total of 10 focus groups, comprising of 73 interviewees were used. This number was arrived at by selecting a sub-sample of between 6 and 10 students from each of the 10 research groups, all on a volunteer basis as earlier mentioned. A set of guiding questions were developed prior to the start of the study to guide the moderators of the FGI i.e. the interviewers.

These guiding questions were related to what participants experienced from the research and while sitting for the SEAT, their perspectives on learning of Chemistry and electrochemistry as a topic, challenges they may have faced during learning of electrochemistry and how they overcame them. The interview protocols had embedded probes to guide the interviewer. Students' responses to items in the FGI were analyzed in themes as they emerged. The qualitative data collected by this instrument were used to give more elaborate explanations to the quantitative findings made with respect to the other previously mentioned instruments.

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* 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>

This being a mixed methods study, both qualitative and quantitative data were collected. To facilitate analysis, the raw data were coded in SPSS and 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 self-efficacy and achievement in

electrochemistry, between the experimental and control groups and also to account for any differences between the ten groups under comparison.

Quantitative data were analyzed inferentially, using Bivariate Pearson’s Correlation (BPC) to test the null hypothesis respectively, at the 0.05 significance level. BPC was used for H_0 to determine the direction and strength of association between students’ self-efficacy and achievement, as measured by the SSEQ and SEAT respectively. This was because data that were collected with respect to this hypothesis were expected to meet the earlier stated assumptions of parametric tests. On top of these, it was assumed that the true association between self-efficacy and achievement was linear, as it was found to be the case while reviewing related studies (Aurah, 2013). This assumption was nevertheless assessed using scatter diagrams.

Results and Discussion

The objective of this study was to determine the association between students’ self-efficacy and achievement in electrochemistry when taught using SOCM and the CIS. Data concerning students’ self-efficacy and their achievement in electrochemistry were collected by the SSEQ and the SEAT respectively. Both instruments were administered to the sampled students as per the research design. The null hypothesis was formulated from this objective as follows;

H_0 There is no significant association between students’ self-efficacy and achievement in electrochemistry when taught using SOCM and the CIS.

This hypothesis was tested inferentially using bivariate Pearson’s correlation in order to determine the direction and strength of association between the two variables in question. Results were as presented in Table 5.

Table 5: Correlation Coefficients of Posttest Achievement vs. Self-Efficacy

VARIABLE	ACHIEVEMENT	S.E	DESCRIPTIVES	
			MEAN	S.D
ACHIEVEMENT	-	0.228*	58.59	11.90
S.E	0.228*	-	71.79	9.894

* $p < 0.001, \alpha = 0.05$

As we can see from Table 5, there was a positive but weak association between students’ post test self-efficacy and achievement scores [$r=.228, p<.001$ at $\alpha=.05$]. This is because the Pearson’s correlation coefficient obtained is closer to zero than to 1, hence the description of the association as ‘weak’. Furthermore, it can be observed from Table 5 that the sign of the correlation coefficient (r) is positive, which implies that a students’ high self-efficacy score also translates to high achievement score and vice-versa. All these revelations are contrary to the assertion of the second null hypothesis, which was consequently rejected because empirical evidence arising from data collected by the SEAT and SSEQ suggested otherwise. It can alternately be asserted that there is a weak positive association between students’ self-efficacy and their achievement in electrochemistry.

It was established that there was a weak positive association between students’ achievement and self-efficacy scores in the posttest of this study. This association was statistically significant at the 0.05 alpha level, which was contrary to the assertion of the null hypothesis of the study. The positive value of the correlation coefficient implies that a students’ high self-efficacy score would lead to a high achievement score and vice-versa.

This association, though weak, is statistically significant because the p-value associated with the calculated correlation coefficient is less than the stipulated alpha value. These findings are similar to those of Aurah, (2013), whose mixed methods study revealed that there was a significant positive association between

students' self-efficacy beliefs in Biology and their achievement in the subject. However, the association between self-efficacy beliefs in Biology was strong, unlike the findings of the present study.

Just like this study, a study by Goulao, (2014) examined the relationship between the academic self-efficacy of an adult learners group in an online learning context with their actual performance. The latter aimed at evaluating the relationship between self-concept of a group of students in online context and their academic achievement. Data were collected from 63 students of both genders, with average age of 42 years old, selected from the first years of their undergraduate studies. An adapted questionnaire was used to measure self-efficacy, whose data were analyzed using descriptive and inferential statistics. The Pearson correlation coefficient was used to determine the relationship between self-efficacy and academic performance. The result indicated that students' level of self-efficacy was high and a significant relationship existed between self-efficacy and academic achievement ($r=0.286$, at 0.05 level), which is the same result that the current study obtained.

Also in support of findings of this study are results of another study by Tenaw, (2013) which investigated the relationships between self-efficacy and achievement for second year students in the fall of 2012 in Analytical Chemistry at Debre Markos College of Teacher Education. The self-efficacy survey and an achievement test were completed by 100 students. The self-efficacy survey data were gathered by Likert scale questionnaire. By using Pearson's correlation, the relationships between self-efficacy and achievement were determined. The results indicated that a significant weak positive relationship exists between self-efficacy and achievement, which is in perfect agreement with the findings of the present study.

Using the Children's Perceived Academic Self-Efficacy subscale from The Morgan-Jinks Student Efficacy Scale (MJSES), a study similar to the present one was conducted at Springfield Middle School by Taylor, (2014), which examined the correlation between students' self-efficacy level and their self-reported academic grades in English, math, science, and social studies.

Also, the correlation between above-grade-level students' self-efficacy and their self-reported grades was compared to those of general students. The sample included 56 middle school students from a suburban area in Williamsport, Maryland. Through the use of a Chi-square test of independence, the results indicated that regardless of class level, students' self-efficacy in math and science are related to their grades in those subjects. These results seem to go in the same way as several other studies that lend support to the outcome of the present study, as they all found out a statistically significant relationship between students' academic achievement and self-efficacy (Bates and Khasawneh, 2007; Cascio, Botta and Anzaldi, 2013; Taipjutorus, Hansen and Brown, 2012).

Findings of this study are however in disagreement with those of Wilson and Kim, (2016), which investigated the effects of concept mapping on academic self-efficacy in a collaborative learning environment. Their study, which employed a randomized controlled pretest-posttest group research design to examine whether learning strategies such as concept mapping can help students with both reading comprehension and intrinsic motivation of wanting to master a task at a high level. Their results found a strong positive association between students' self-efficacy beliefs and their achievement, unlike this study where the relationship was weak.

Focus group interviews were conducted at the latter stages of this study to corroborate the findings from quantitative data. Some of the students who were interviewed expressed high levels of self-efficacy with regard to items in the SEAT administered to them as achievement posttest. Transcripts from 3 randomly selected participants from the experimental group supported these themes, as they had this to say when they were asked to comment about the SEAT, electrochemistry as a topic, and the use of SOCM to teach it:

Student X: *“All questions in that test were from what we had learnt and I think I will get quite a good score. The concept mapping software we used also made it very easy for us to relate almost all concepts we learnt in*

electrochemistry on one page!” I’m very sure I will score good marks in all the questions I attempted.”

Student Y: *“Some of the questions were tricky but not difficult in my opinion, especially because they were all from one topic of electrochemistry. Furthermore, I always drew concept maps at the back of my question paper and used them to remind myself of ideas that had slipped out of my mind....very interesting. I think I like this topic and method of tackling questions which is very timely. Generally, I think everyone will score higher marks.”*

Student Z: *“The concept maps that our teacher taught us how to draw were very helpful to me during my private study as I was able to relate several concepts learnt on a particular day, all on one big concept map, with so much ease! I was also able to connect some of the ideas I learnt in class with what I see in real life settings. A good example is the mobile phone batteries.... I now understand why they ‘die’ after a few days. As for that exam, let’s just say I enjoyed it. I don’t need to mention the grade here but I will pass for sure.”*

In the long run, the participants quoted obtained high self-efficacy scores when their completed SSEQ were retrieved and analyzed. [Student X = 86, Student Y = 84, Student Z =82]. When all the SEAT scripts were later marked and scored, those belonging to students X, Y and Z were retrieved and on observation, the achievement scores they obtained generally supported their verbal sentiments in the FGI [Student X = 23/30, student Y =27/30, Student Z =26/30].

When asked about the same subject during their turn for the FGI, most respondents in the control group were categorical about their expected scores in the SEAT, opining that most questions therein were tricky, challenging and needed cramming or good mathematical skills in order to for them to be tackled successfully. The transcripts that follow give a word-for-word account of three of the respondents.

Student P: *“You see the questions in this test were from only one topic, which was a big disadvantage for someone like me who had read widely. To be sincere though, I personally don’t like questions where you have to write stoichiometric equations, let alone balancing them, yet there were so many in this exam.”*

Student Q: *“Surely mwalimu, the questions were a bit challenging. Others looked simple at first, yet so tricky after reading again. Some of them needed someone who is good in Mathematics. There were also several questions about definition and stating..... which need cramming or revising about them daily, which may not be possible for some of us who have seven other subjects to prepare for”*

Student R: *“I can’t really say whether I will pass or fail the test we did yesterday because you know most Chemistry questions are usually very unpredictable and the test we sat for yesterday was no exception. The questions you are sure you will get right may let you down at times”. To add on that, the topic of electrochemistry is very wide, which makes it difficult for one to prepare adequately because you can never be sure from which sub-topic the questions will come from. I also did not attempt questions 6 and 9 because they were very tricky.... more or less like Mathematics....which I’m not very good at. The other questions were less difficult”*

The three respondents obtained comparatively low self-efficacy scores when their completed SSEQ were later checked out [*Student P = 51, Student Q = 48, Student R = 55*]. Incidentally, the same students had comparatively lower achievement scores when their SEAT answer sheets were later retrieved and marked [*Student P = 12/30, Student Q = 10/30, Student R = 8/30*]. The emergent theme that clearly stood out from all the ten focus group interviews, which were conducted one day after administration of the SEAT was high self-efficacy beliefs in electrochemistry among students who was taught using SOCM and low self-efficacy for their counterparts who were taught using the conventional approaches.

Conclusion

On the basis of empirical evidence arising from data that were collected in this study's quasi experiment and the subsequent focus group interviews, the conclusions made is that students' with low self-efficacy beliefs in electrochemistry might consequently fail their achievement tests if question items are only from this topic, while those with high self-efficacy beliefs might consequently obtain high achievement marks in this topical test. Therefore the higher the self-efficacy, the higher the achievement in electrochemistry, as it has been found out.

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