International Journal for Innovation Education and Research

ONLINE ISSN: 2411-2933 PRINT - ISSN: 2411-3123

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Published Date: 8/31/2018 **Page.79-90** **Vol 6 No 08 2018**

DOI: https://doi.org/10.31686/ijier.Vol6.Iss8.1119

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Abstract

Chemistry self-efficacy is to do with desire or confidence to perform well in Chemistry and has been predominantly low among secondary school students in Kenya, and many other developing countries. The study investigated the effect of Computer Aided Instruction (CAI) on Chemistry self-efficacy of students as compared to Conventional Methods (CM). The study adopted Solomon Four- Group, Non-equivalent Control Group Design which emphasizes Quasi Experimental design. A sample of 174 Form Two secondary school Chemistry students in Tharaka Nithi County in Kenya was used. Four schools were purposively sampled and randomly assigned as either Experimental groups or Control groups. The students of the Experimental groups were taught through CAI while the Control groups were taught through Conventional methods on the topics "the structure of the atom, the periodic table and chemical families" for six weeks. Data was collected using Students' Self-efficacy Questionnaire (SSEQ) and was administered before and after exposure of intervention (CAI). Both descriptive and inferential statistics, in particular, t-test and Analysis of Variance was used to analyze the data. The study revealed that, the students taught through CAI obtained significantly higher Chemistry self-efficacy scores than the students taught through CM. Further, the study revealed that girls obtained higher Chemistry self-efficacy scores than their counterpart boys when taught through CAI. Thus, Chemistry teachers, should adopt CAI in their teaching to help in enhancing Chemistry self-efficacy of students, and by extension enhance performance in Chemistry.

Keywords: Computer aided instruction, conventional methods, Chemistry self-efficacy and gender

1. Introduction

Self-efficacy is defined as self-judgment of one's competence to successfully execute a course of action necessary to reach desired outcomes (Bandura, 1982). In Chemistry academic settings, Chemistry self-efficacy refers to students' confidence in their ability to master Chemistry concepts, tasks and activities.

Self-efficacy of students is an important aspect in learning secondary Chemistry as it directs learners to rate their confidence for attaining a specific goal in the subject (Martin, Mullis & Foy, 2008). Bandura (1993) posits that self-efficacy beliefs affect students' learning outcomes by influencing their determinations of interests, choices, efforts, perseverance, persistence and career paths. Kennedy (1996) believes that self-efficacy in science, including Chemistry may affect science learning, choice of science, amount of effort exerted, and persistence in science. Moreover, it predicts initial engagement and in turn, success leads to greater interest and engagement in that task in the future (Diane, 2003). This assertion is supported by Britner and Pajares (2006) who noted that a student with low self-efficacy in science activities, tends to avoid them and more so put less effort when faced with challenging tasks. Therefore, self-efficacy is an important aspect needed for successful learning of Chemistry, and science in general.

The low self-efficacy in learning Chemistry and science in general exists in countries across the world. In United States, for instance, the National Center for Educational Statistics, NCES (2000) reported that the number of students who took additional science courses was considerably lower than the number of students who took at least one year of science in high school.

In addition, only 60% of students took two years of high school science and the percentage dropped to 25% who took three years of science. For advanced science courses, only 6% took Advanced Placement Chemistry. Britner and Pajares (2001) suggested self-efficacy as one potential factor that influence the academic choices of students towards science. In Turkey, Guvercin (2008) reported a decrease in students' self-efficacy beliefs in science from 6th grade level to 8th grade level, in which the 6th grade students had higher levels of self-efficacy beliefs than 8th grade students. This suggested a decline in students' self-efficacy in science as the grade level increased. In Kenya too, low self-efficacy of students in learning Chemistry is a possibility. For instance, Chepkorir (2013), observed that students in Kenyan secondary schools lacked self-confidence in themselves when learning Chemistry. According to Chepkorir (2013), some students could not work out problems they considered difficult without assistance from the teacher. Lack of self-confidence by students is predetermined by low self-efficacy in their ability to carry out Chemistry academic tasks. The low self-efficacy of students, specifically in Chemistry is a concern that need to be addressed.

Additionally, gender gap in Chemistry self-efficacy has consistently been predominant in higher levels of education where the study of Chemistry is not compulsory. Some studies have revealed that from primary school level, female students have lower science self-efficacy as compared to male students (Smith & Owen, 1991; Tippins, 1991). Other research studies have suggested that gender differences in science self-efficacy is insignificant (Chen & Zimmerman, 2007; Kay & Knaack, 2008; Kenney-Benson, Pomerantz, Ryan, & Patrick, 2006). Another study by Britner and Pajares (2006), revealed that the middle school girls had higher science self-efficacy than boys. Literature review of previous study findings regarding to gender self-efficacy in science, Chemistry included, revealed inconsistencies, hence the need for further study.

1.1 Statement of the problem

Chemistry self-efficacy among secondary school students in Kenya has been given minimum attention. While the self-efficacy of students has been recognized as an important affective aspect in Chemistry education, it has received much less attention by researchers than the instructional team. Available researches on Computer Aided Instruction (CAI) have mainly focused on its use in classroom instruction for improvement of students' academic performance with less emphasis on Chemistry self-efficacy, which is one of the main driving force on performance.

1.2 Purpose of the study

The purpose of this study was to investigate effect of Computer Aided Instruction on Chemistry self-efficacy of students as compared with the use of Conventional Methods among selected secondary school students in Kenya.

1.2.1 Objectives

The study was guided by the following objectives:

(a) To investigate the effect of computer aided instruction on Chemistry self-efficacy of students as compared to Conventional Methods.

(b) To establish gender difference in Chemistry self-efficacy of students when taught using Computer Aided Instruction as compared to Conventional Methods.

1.2.2 Hypotheses

The following hypotheses guided the study and were tested at 0.05 level of significance.

$H_0$1: There is no significant difference between Chemistry self-efficacy scores of students taught using CAI and those taught in CM.

$H_0$2: There is no significant gender difference in Chemistry self-efficacy scores of students' when taught using CAI as compared to CM.

2. Literature Review

The confidence to approach learning in an independent manner which promotes the belief in one's ability to execute a given task may invariably lead to enhanced self-efficacy. Bandura (1997) mentioned that student's beliefs about their efficacy to manage academic task demands can influence them emotionally by decreasing their stress, anxiety, and depression. Studies affirms a positive link between self-efficacy and engagement to learning. For example, Zimmerman and Kitsantas (1997), found self-efficacy to be highly correlated with students' rated intrinsic interest in a motoric learning task as well as in a writing revision task. Pajares and Miller (1994) observed that learning skills acquisition enhances self-regulated learning behavior which in turn ensures motivation and confidence as a learner engages in learning tasks. Salomon (1984) also found that self- efficacy is positively related to self-rated mental efforts and achievement during students' learning from text material that was perceived as difficult. Studies have demonstrated a connection between computer-based learning and self-efficacy in elementary and higher science education. For example, Liu and Chen (2013) observed that grade 5 students from elementary school in Northern Taiwan demonstrated effectiveness in learning science when taught through computers.

Similarly, Yien, Hung, Hwang and Lin (2011) observed that computer-game-learning was more effective in enhancing the self-efficacy of students in learning nutrition course. Based on the results of existing research studies, there appears to be a relationship between self-efficacy and computer supported learning in higher and elementary science education (Liu & Chen 2013; Yien, Hung, Hwang & Lin, 2011). However, no research has yet established a firm connection between computer-aided instruction and self-efficacy of secondary school chemistry students in a developing country like Kenya.

2. Theoretical Framework

The study was based on Bandura (1986) self-efficacy theory which holds that people possess a "self-system" that enables them to exercise control over their thoughts, emotions and feelings, and actions. This

self-system is comprised of both cognitive and affective components including the ability to symbolize, learn from others, plan alternative strategies, and regulate one's own behavior and self-reflection. In Chemistry teaching, the instructional strategy play a major role in determining the students' perception of success or failure in learning outcomes. Bandura (1986) emphasized that being involved with the specific task experience is the most effective source of self-efficacy information for educational purposes. This implies that educational efforts should therefore design teaching and learning strategies that focus on improving students' self-efficacy.

2.1 Conceptual Framework

In this study, the conceptual framework was based on a mode of instructional method which included both computer aided instruction and conventional methods. The dependent variable for this study was chemistry self-efficacy of students, while the intervening variables were learner characteristics such as gender. The interactions among the independent variables, intervening variables and dependent variables that were used for the study are diagrammatically represented in Figure 1.

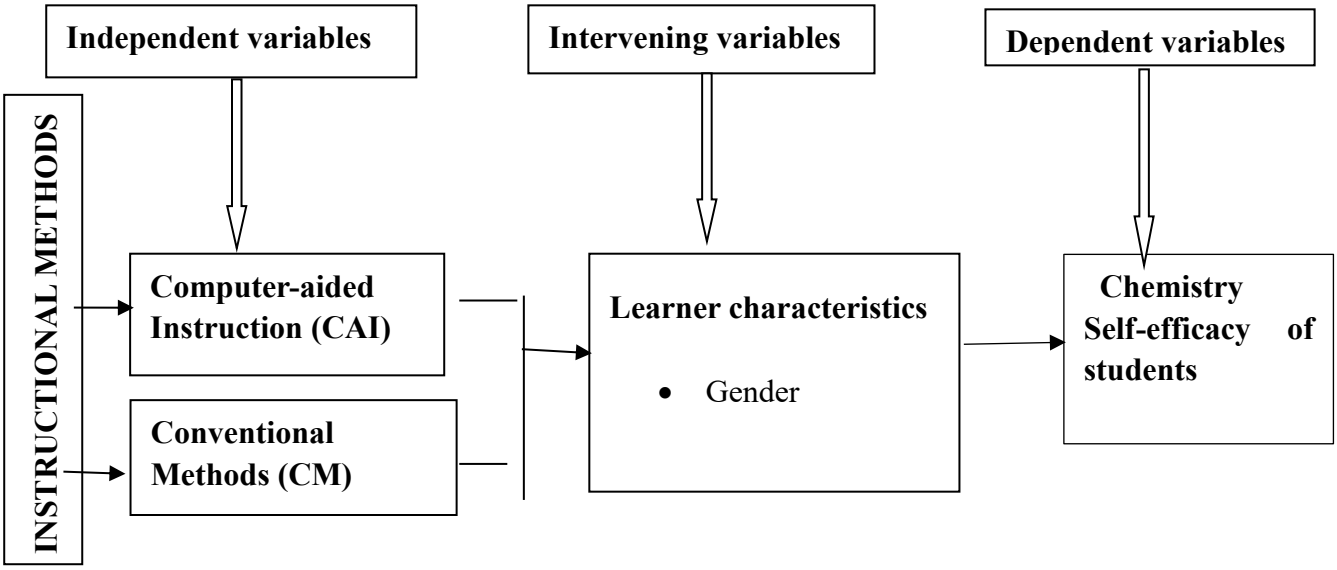

Figure 1: Conceptual framework for the study

3. Research Methodology

The study applied a Quasi-Experimental design based on Solomon Four-Group, Non-equivalent Control Group design which is widely used in education (Borg & Gall, 1989).
Quasi-experimental design involves no randomization of the subjects to the sample groups but rather it involves random assignment of intact classes to sample groups.

The Solomon-Four group design is illustrated in figure 2.

	Pretest	**Treatment**	**Posttest**
Experimental Group 1	O_1	X	O_2
		……	
Control Group 1	O_3		O_4

Experimental Group 2	X	O_5
Control Group 2		O_6

Figure 2: Solomon-Four Group Design

3.1 Participants

Four secondary schools were purposively sampled from the 15 secondary schools with computer laboratories in Tharaka Nithi County, Kenya. Purposive sampling was used in order to select schools with similar academic level as possible. Sampling involved only schools with computer laboratories because the computer was considered as the key resource that was required for Computer Aided Instruction lessons. The assignment of the four schools (groups) to either experimental or control conditions was done using simple random sampling. Random sampling gives each and every school from the target population a known and equal probability of selection (Kothari, 2004). A total of 174 Form Two Chemistry students (Group EI=45, E2=46, C1=45, C2=38) were involved. The Groups E1 and C2 comprised of boys only while Groups E2 and C1 comprised of girls only.

The Form Two students were preferred to other levels (forms) for the study because at this level, study of Chemistry is compulsory and the students were acquainted with computer skills.

3.2 Research Instrument

The Students' self-efficacy questionnaire (SSEQ) was used to measure the perceived Chemistry self-efficacy (confidence) of students. Students' self-efficacy scale was used as the pre-test and post-test. The pre-test self-efficacy scale was used to measure perceived Chemistry self-efficacy of students before the exposure of the treatment (CAI). On the other hand, the post-test self-efficacy scale was used to measure chemistry self-efficacy of students after the treatment. The items of the pre-test self-efficacy scale were re-arranged to form the post-test self-efficacy scale items. The items of the SSEQ assessed students' level of confidence (self-efficacy) in mastering Chemistry concepts, for example, generally perceived Chemistry self-efficacy of students, and the choice of Chemistry as preferred subject and career courses related to Chemistry. The SSEQ comprised of 12 items on a five- point likert scale namely; 1= strongly disagree, 2= disagree, 3= not sure, 4= agree and 5= strongly agree.

To enhance reliability of the instrument a pilot study was necessary. Piloting is important as it helps identify misunderstandings, ambiguities, and inadequate items (Wiersma, 1985). The SSEQ instrument was pilot tested using two secondary schools from the same County (Tharaka Nithi) as the major study sample. The pilot schools had similar characteristics as the sample schools. The reliability of the self-efficacy scale was estimated using Cronbach Alpha method. This is because the items of the SSEQ yields data that is not dichotomous (Borg & Gall 1989). The reliability estimate obtained for students' self-efficacy Scale (SSEQ) was 0.884. Thus, the SSEQ instrument was considered appropriate for this study.

3.3 Data Collection procedure

Installation of CAI program in the computers of the experimental schools was done first. This was followed by the training of chemistry teachers on how to use CAI program for one week. Before the exposure of the treatment, pre-test self-efficacy scale was administered by the regular Chemistry teachers to the students of the Experimental group 1 and Control group 1, which lasted for 20 minutes. It was then followed by

exposure of treatment to the students of Experimental groups who were taught using Computer Aided Instruction while the control groups were taught using conventional methods covering selected topics. These topics included; "the structure of an Atom, the Periodic Table and chemical families" for a period of six weeks. At the end of treatment period, the post-test self-efficacy scale was administered to all the four groups.

3.4 Statistical Analysis

Data analysis was done using both descriptive and inferential statistics which included; mean, standard deviation, t-test and Analysis of Variance (ANOVA). The descriptive statistics described the self-efficacy variable of the various groups while the inferential statistics tested the significance difference between the groups' means. The ANOVA test was performed to determine the difference in the mean scores of the four groups while the independent samples t-test was performed to determine the significance of the difference in the mean scores of boys' group and girls' group. This is because t-test has the power to detect difference between two means (Borg & Gall, 1989). The statistical significance was tested at $\alpha = 0.05$. The data analyzed was finally presented in tabular form and graphics such as bar graphs.

4. Results and Discussion

The results were based of the following null hypotheses;

i) There is no significant difference between Chemistry self-efficacy scores of students taught using CAI and those taught in CM.

ii) There is no significant gender difference in Chemistry self-efficacy scores of students' when taught using CAI as compared to CM.

4.1 Students' pre-treatment scores in Self-efficacy

The aim of the pre-testing the groups was to ascertain whether the students selected to participate in the experimental group and control group had comparable self-efficacy measure before they were exposed to treatment (CAI). Both experimental and control group students were exposed to a self-efficacy questionnaire (SSEQ) before the application of treatment (CAI).

Self-efficacy questionnaire contained 12 items, in which students were asked to report their confidence in learning Chemistry on a five point likert scale calibrated Strongly Disagree (SD), Disagree (D), Not Sure (NS), Agree (A) and Strongly Agree (SA). In analyzing the results, "strongly disagree" was rated as 1, "disagree" as 2, "not sure" as 3, "agree" as 4 and "strongly agree" as 5. The data obtained were analyzed using descriptive statistics and t-test and the results indicated in Table 1.

Table 1: Descriptive and Independent Sample t-test of pre- treatment scores in Self-efficacy

Variable	Group	N	Mean	Std. deviation	df	t-value	p-value
Self-efficacy	Experimental	53	37.25	5.445	107	-0.333	.740
	Control	56	37.59	5.328			

The results from table 1 show that the experimental group had 53 respondents while control group had 56 respondents. Experimental group obtained an average score of 37.25 out of 60 on CAT. For control group

the average score was 37.59. The t-test analysis revealed that the computed p-value (0.740) was greater than the set alpha value 0.05. Therefore, there was no significant difference in pre- treatment scores in self-efficacy between experimental group and control group, (t (107) = -0.333, p > 0.05. Therefore, the Experimental and Control groups were similar on self-efficacy measure, hence they were homogenous at the beginning of the study. This made the groups suitable for the study. Regarding difference in gender self-efficacy in learning Chemistry, descriptive and t- test was performed. The results of analysis were as indicated in Table 2.

Table 2: Independent Sample t-test of pre- treatment scores in Self-efficacy by Gender

Variable	Gender	N	Mean	Std. deviation	df	t-value	p-value
Self-efficacy	Female	56	37.59	5.328	107	-0.333	.740
	Male	53	37.25	5.445			

The results in table 2 show that the self-efficacy average score of male and female were 37.25 and 37.59 out of 60 respectively. Both female and male obtained relatively the same mean score. The t-test analysis showed that the computed p-value (0.740) was greater than the set alpha value (0.05). Therefore, the self-efficacy mean scores of female and male students were not significantly different, t (107) = -0.333, p > 0.05. Thus, the female and male student samples were similar before the application of the treatment.

4.2 Effect of CAI and CM on Students' Self-efficacy in learning Chemistry

The research aimed at investigating whether there was significant difference in Chemistry self-efficacy of students when taught with CAI from those taught through CM. Self-efficacy scale application was administered to the four groups after the exposure of the treatment to the experimental groups. Self-efficacy scale contained 12 items in the instrument, in which students were asked to report their confidence in learning Chemistry on a five point scale calibrated Strongly Disagree (SD), Disagree (D), Not Sure (NS), Agree (A) and Strongly Agree (SA). In analyzing the results, "strongly disagree" was rated as 1, "disagree" as 2, "not sure" as 3, "agree" as 4 and "strongly agree" as 5. The data obtained was analyzed using descriptive statistics and Analysis of Variance (ANOVA).

Table 3: Descriptive Statistics of Post Scores in Self-efficacy

group	Mean (Max =60)	N	Std. Deviation
Experimental group1	47.11	45	5.793
Control group 1	40.91	45	5.854
Experimental group 2	49.04	46	5.362
Control group 2	42.92	38	5.952

Table 3, shows that the average self-efficacy scores of experimental groups were higher than those of the control groups. This indicates that the students of experimental groups who were taught Chemistry with CAI approach were more obtained higher Chemistry self- efficacy scores than those of the control groups. To illustrate the analyzed quantitative data more clearly, graphics in form of bar graph was used as in Figure 2.

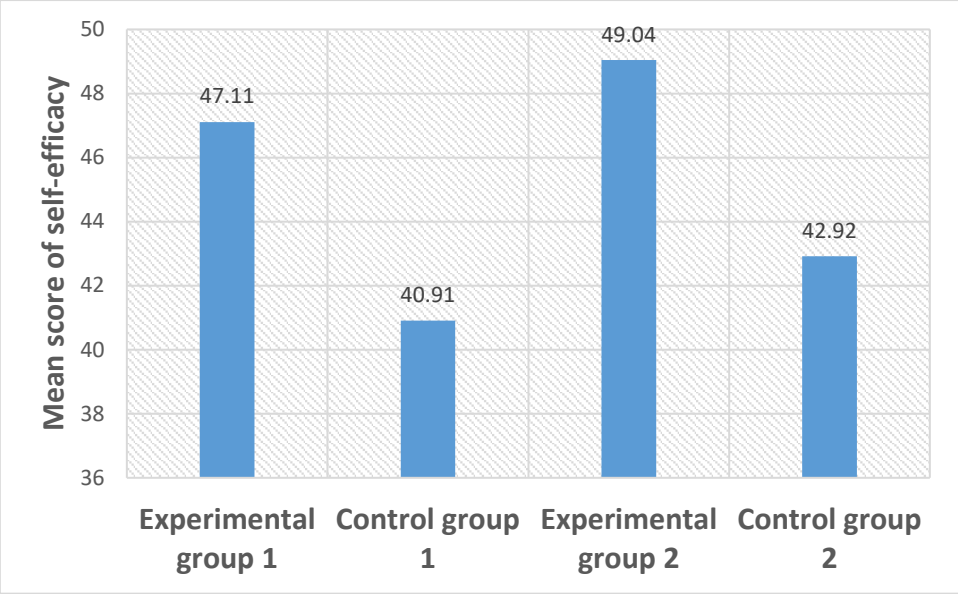

Figure 2: Chemistry self-efficacy based on Groups

Figure 2, clearly show that students taught Chemistry using computer aided instruction had higher self-efficacy than the students who were taught chemistry using conventional methods. To determine whether the groups were significantly different, One-Way ANOVA was performed. The results are indicated in Table 4.

Table 4: One-Way ANOVA of Post scores in Self-efficacy

Source of variation	Sum of Squares	df	Mean Square	F-ratio	p-value
Between Groups	1867.373	3	662.458	18.934	.000
Within Groups	5888.765	170	32.875		
Total	7456.738	173			

The results in Table 4 show that the difference in self-efficacy post-test means scores of the students between the experimental and control groups was significant, $F(3,170) = 18.93$, $p < 0.05$. This shows that the students taught with Computer Aided Instruction (CAI) achieved higher self-efficacy mean scores than the students taught with Conventional Methods (CTM). The findings of this study are in agreement with the report by Fencl and Scheel (2005) which investigated the effects of different teaching methods on the classroom climate and self-efficacy in non-majors Physics students. The results indicated that use of electronic applications had a positive correlation with increased self-efficacy in non-majors physics students. The findings further, are in agreement with findings of Liu and Chen (2013) who observed that grade 5 students from elementary school in Northern Taiwan demonstrated effectiveness in learning science when taught through computers.

Similarly, Yien, Hung, Hwang and Lin (2011), observed that computer aided learning was more effective in enhancing the self-efficacy of students in learning nutrition course than conventional methods. The findings of this study may be explained in line with the study of Zimmerman (2000); Pajares and Miller (1994) which observed that learning skills acquisition enhances self-regulated learning behaviour which in turn ensures motivation and confidence as a learner engages in learning tasks.

4.3 Chemistry Self-efficacy by Gender when taught with CAI

The research aimed at establishing whether there was significant gender difference in Chemistry self-efficacy of students when taught with CAI.

Experimental group 1 and group 2 which were taught with Computer aided instruction had 45 boys and 46 girls respectively. After the application of CAI treatment to both groups, self-efficacy questionnaire was administered to both female and male students groups. In the questionnaire, students were asked to report their confidence in learning Chemistry on a five point scale calibrated Strongly Disagree (SD), Disagree (D), Not Sure (NS), Agree (A) and Strongly Agree (SA). In analyzing the results, "strongly disagree" was rated as 1, "disagree" as 2, "not sure" as 3, "agree" as 4 and "strongly agree" as 5. Descriptive statistics were to describe the difference of self-efficacy scores between male and female students. The results are indicated as in Table 5.

Table 5: Descriptive statistics of post-test Scores in Self-efficacy by Gender

Variable	gender	N	Mean	Std. Deviation	Std. Error Mean
Self-efficacy	Male	45	47.11	6.348	1.239
	Female	46	49.04	5.362	.791

From Table 5, it is apparent that the average self-efficacy post-test scores of female students were relatively higher than those for the male students. This indicates that female students were more confident in learning chemistry concepts than male students when they were taught with CAI. In order to illustrate the male and female mean score more clearly, graphics in form of bar graph was used as in Figure 3.

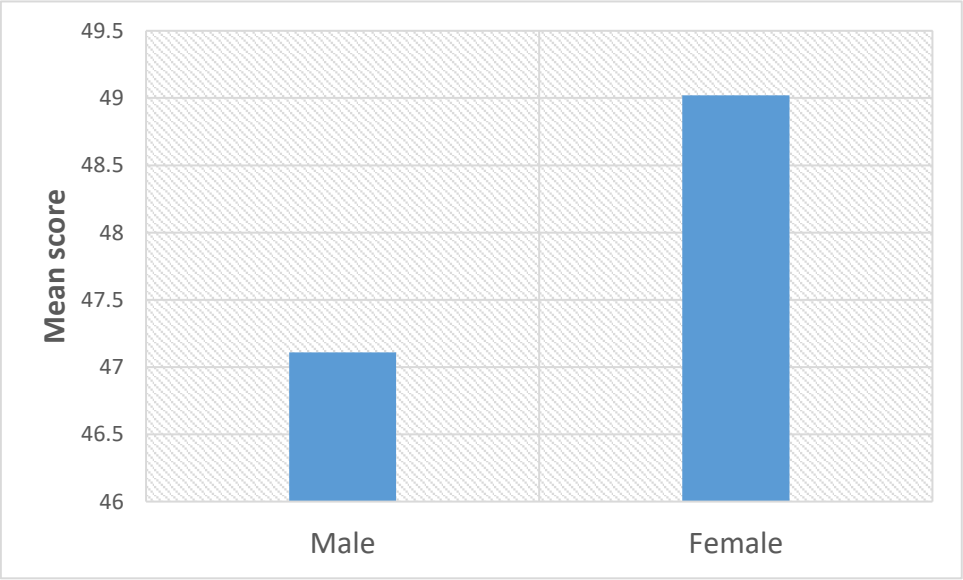

Figure 3: Chemistry self-efficacy by Gender

From figure 3, it is evident that the self-efficacy mean scores for female students was relatively higher than those of male students. In order to determine whether the difference in self-efficacy post-test scores by gender was statistically significant, an independent sample t-test was carried out. The results are shown in Table 6.

Table 6: Independent sample t-test of post-test scores in Self-efficacy by gender

Variable	Gender	N	Mean	Std. deviation	t-value	df	p-value
CAT	Male	45	47.11	6.348	-2.445	89	.016
	Female	46	49.04	5.362			

The t-test analysis results in Table 6 shows that the difference in self-efficacy post-test mean scores between male and female students was significant, ($t(89) = -2.445$, $p < 0.05$.
This revealed that on average female students obtained a different chemistry self-efficacy mean score than males students, with females having a higher mean score.

From the findings of this study, it is clear that use of computer aided instructional method enhances chemistry self-efficacy of female more than it does to the male students. The findings of the study concurs with the results of Britner and Pajares (2006), which reported that the middle school girls had higher science self-efficacy than do boys. The findings of this study found similar results, which indicate that there exists a gender difference in science self-efficacy (DeBacker & Nelson, 1999). In addition, the findings of this study agrees with the report of (AAUW, 1999) that suggested, females are more likely to take both Biology and Chemistry in high school than males. Moreover, the findings of this study finds support from Bandura's (1997) argument that gender can influence academic performance through its mediating effects on self-efficacy.

5. Conclusions

Based on the findings of this study, the following main conclusions were drawn:
The study revealed that the students who were taught Chemistry with Computer Aided Instruction obtained higher Chemistry self-efficacy mean scores than the students who were taught with Conventional Methods. Therefore, use of computer aided instruction enhances students' self-efficacy in learning Chemistry concepts more than use of conventional methods. Thus, CAI is particularly an impressive instructional technique, and worth adopting by Chemistry teachers, for it appears, self-efficacy can translate in performance.

The study further revealed that the female students obtained higher self-efficacy scores than the male students when taught with computer aided instruction. This implies that use of computer aided instruction enhances girls' self-efficacy in learning Chemistry more than it does for boys. It is apparent that use of CAI in classroom instruction can make female students more self-confident in learning Chemistry. Therefore, Chemistry teachers, more so in girls' schools should adopt CAI in their teaching in order to enhance self-efficacy of girls which has been reported to be low by many studies. This could be one way of getting girls to perform in Chemistry and possibly in other science subjects.

5.1 Recommendations

Computers are these days available in many schools. I would recommend that:
(a) Chemistry teachers should be encouraged to use Computer Aided Instruction (CAI) in their teaching so as to improve students' self-efficacy.

(b) Teacher training institutions such as colleges and universities should emphasize Computer Aided Instruction as part of their Chemistry training curriculum so as to produce teacher trainees who would be able to integrate CAI in their teaching.
(c) The government of Kenya should provide adequate ICT infrastructure and equipment, including computer hardware and software (CAI) in all schools. Availability of adequate computer aided instruction hardware and software in schools will enable the Chemistry teachers to utilize available CAI approach in the teaching and learning processes.

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