EFFECTS OF COMPUTER-BASED SIMULATIONS TEACHING APPROACH ON CHEMISTRY SELF-CONCEPT AMONG HIGH SCHOOL STUDENTS IN KENYA

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ABSTRACT

The role of Chemistry education is to help in the development of scientific attitude in the learner. The students' performance in Chemistry at the national examinations in Kenya has remained poor, despite the importance attached to the subject. Many factors influence this performance, one being learners' chemistry self-concept. Computer-Based Instruction may help address the problem of student's negative chemistry self-concept as most educational institutions take learning online due to COVID -19 pandemic. In an attempt to address this, this study aimed at finding out the effects of Computer-Based Simulations (CBS) on students' chemistry self-concept. The study involved quasi-experimental research using Solomon Four Non- Equivalent Control Group Design. Sample size was 175 students. Instrument of data collection was Chemistry Self-Concept Questionnaire (CSCQ). Results revealed that there is statistically significant difference in the chemistry self-concept of students taught through CBS and those taught through Regular Teaching Methods (RTM). Students taught through CBS acquired a higher level of chemistry self-concept than those taught through RTM.

KEYWORDS

Chemistry, Science, Computer-based Learning, Gender and Chemistry self-concept

1. INTRODUCTION

Chemistry is a branch of science that studies the composition and properties of matter and the changes it undergoes. Chemistry is far more than a collection of facts and a body of knowledge. It's all about matter, which is anything that has mass and occupies space. Chemistry is sometimes called the central science because it bridges other natural sciences, including physics, geology and biology. According to Jegede (2007), it is a core subject for medical science, textile science, printing technology and chemical technology. Therefore, the essence of appropriate conception of concepts related to Chemistry is of a very great significance because the subject is very important to science and technology. Okere (1996) cites it as an important subject in choice of career in university.

Applications of chemical science have contributed significantly to the advancement of human civilization. With a growing understanding and ability to manipulate chemical molecules, the chemist has all along been considered as a societal problem solver. They have brought many positive contributions to mankind such as; discovery of drugs and medicines to fight diseases, pesticides and herbicides for increased crop production. Chemistry has liberated mankind from

superstition, magic, religion, mythology, astrology, philosophy, magic, spirituality, folklore and others. This is as a result of Chemistry being able to explain most of the natural occurrences and phenomena. Examples of such occurrences that earlier appeared mystical are like thunderstorms, lightning, burning among many others. Chemistry has also greatly contributed to environmental conservation to mention but a few.

However chemistry has had a number of negative contributions such as the depletion of the stratospheric ozone layer by chlorofluorocarbons chemicals (CFCs). This has meant increased ultraviolet rays reaching the earth with serious consequences such as increase in skin cancer. CFCs are used in refrigerants, propellants in aerosol cans, hospital sterilisers, industrial solvents, and foam blowing agents. There has also been the problem of bioaccumulation of chlorinated organic pesticides in the food chain has brought about serious and deadly health complications to humans and animals.

Despite the importance attached to Chemistry, students' performance in the subject at the national examinations in many countries has remained poor. According to Trends in International Mathematics and Science Study ([TIMSS], 2011) 56 countries and other education systems administered TIMSS at grade eight. Less than half of the countries which participated had an average scale score of below 500. Scores on the TIMSS mathematics and science tests range from 0-1000. Both tests have an average scale score of 500, with a standard deviation of 100. Morocco, Indonesia, Lebanon and Ghana participated in the TIMSS 2011 but their scale scores were below average. According to Ogunniyi (2001) the overall performance of school Chemistry in developing countries is generally weak. The poor performance in Chemistry is very disturbing and if not checked, may jeopardize the placement chances of students in tertiary institutions, not only in chemistry education but also in other chemistry related disciplines. This has serious implications for Nigeria economy, security and manpower development (Gambari, et al, 2017).

In Kenya despite the importance attached to Chemistry, the students' examination results in the subject in Kenya Certificate of Secondary Education (KCSE) have remained poor (KNEC, 2013). Kenya National Examinations Council (KNEC) Report 2014 also showed continued decline in performance in Chemistry and its pass rates in KCSE examinations is the lowest compared to that of Biology and Physics (Keter, 2018). In addition, the mean score in percentage was higher for boys than that of girls. The poor performance in Chemistry has raised an outcry from parents. A major factor that may contribute to such a situation is the learners' chemistry self-concept which could be tied to the teaching approaches used by the subject teachers.

Teaching approach refers to all the steps, processes, and set procedures that a teacher uses when presenting the contents of the lesson (Maundu, Sambili & Muthwii, 1998). In order to make students learn Chemistry effectively the teacher has to adopt the right method of teaching. In selecting the right method in a given situation the teacher has to be familiar with different methods of teaching and the nature of the subject (Kumar, Krishna & Rao, 2004). There are two main approaches in teaching namely; Expository (transmission) and Discovery (heuristic) teaching approaches (Mondoh, 2005).

We live in an era of rapidly developing technology due to the widespread use of computer science and information technology, which have entered almost all areas of life. In the field of education, emerging technologies provide opportunities for enhancing and improving the learning and education process (Meccawy, 2017). As society becomes increasingly global and experiential, research suggests that students can benefit from alternative learning environments that extend beyond the classroom (Murugan & Kamisah, 2018).

Computer-Assisted Instruction (CAI) is one that has been lauded as able to teach concepts that

are either difficult or dangerous (Allesi & Trollip, 2001). CAI programmes are categorized into drills and practice, simulations or hypermedia. Computer-Based Simulations (CBS) is able to present certain dynamic and complex concepts that are extremely difficult to explain using words, equations or class experiments. CBS with animated colour and graphic images is capable of presenting the dynamic nature of the process of electrolysis through a multi-sensory approach that lacks in the regular methods. The process of electrolysis may therefore greatly benefit from the use of computer-assisted instruction because the process does manifest itself visibly. Also, the use of computer-based simulations may save some money by reduction on cost of experimental work. If regular teaching methods are used in teaching science subjects, students understand the subject at knowledge level and they usually memorize the science concepts without understanding the real meaning. As a result they do not conceptualize the science concepts well as intended (Wesi, 2011). Such factors influence student's attitude, cognitive development and achievement in science and science education. It is known that it is not easy to eliminate misconceptions by just employing regular instructional methods. One of the ways to overcome this problem is to try to develop and use computer-assisted instruction. CBS plays an important role in contemporary teaching and learning of science concepts (Chang, 2009). Computers can be used as a supplementary tool in order to achieve educational goals. It is reported that student abilities and skills are affected positively by use of computers (Bayraktar, 2000). It is also stated that the use of computers makes students feel confident and helps them to discover interactions among the components of a complex system (Ramjus, 1990). In addition most of the knowledge related to natural phenomenon is available in computers, hence students can be able to visualize the physical phenomena in a three dimensional form (Shamai, 2001). If CBS materials are developed and implemented in an effective way, student's achievement and affinity increases in science lessons (Lee, 2001). Integration of computers in chemistry classrooms can provide an effective learning environment for students to enhance their chemistry skills by engaging them with "real world" conditions to make the abstract concepts concrete and clear. In this way students can have a meaningful and retentive learning and they will be much more ready for their future education life such as university education or their professional life.

All the changes taking place in the teaching and learning process demand a new learning environment to effectively harness the power of ICT to improve learning. ICT has the potential to transform the nature of education: where, when, how and the way learning takes place (Witfelt, 2000). The CBS environment provides a platform to apply the knowledge in a given situation and their interactions results in the discovery of new knowledge that will help cognitive domain development and the accumulation of knowledge (Shamai, 2001). ICT provides powerful tools to support the shift from teacher centred to learner centred paradigm and new roles of teacher, learner, curricula and new media (Holbrook, 2011).

Before the onset of the COVID-19 pandemics, Kenya had a well-structured system of education. The primary and Secondary school calendar ran from January to December. The terms comprised of three months of fully learning and a month in-between for breaks. The syllabi were structured to be covered in nine months at most. During the one-month break, both teachers and learners would seize the opportunity to rest and refresh before getting back to another engaging three months (Gathuru & Mwenyeri, 2021). However, on March 15, 2020, the Kenyan government abruptly closed all schools and colleges nationwide in response to the first positive test of Covid-19. This led to throwing into disarray learning programmes countrywide. The closure of institutions affected learners and teachers (Gathuru & Mwenyeri, 2021). Government of Kenya provided remote teaching support using the internet and television and encouraged academic institutions to adapt teaching material to create a more accessible online learning environment. This plan targeted both vulnerable students and teachers and aimed to capitalize on existing radio infrastructure to enhance the possibility of community-based learning. Online teaching and learning was not well established in both public and private school in Kenya before the COVID-

19 pandemic. At the onset of this pandemic many Kenyan schools took teaching and learning online to prevent learning lose. It is this introduction of this online teaching and learning in Kenyan schools that provoked this study.

This study investigated the effects of computer-based simulations teaching approach on chemistry self-concept by gender among secondary school students in Nakuru Sub-county, Kenya.

2. OBJECTIVES OF THE STUDY

The following were the specific objectives of this study:

a) To compare the self-concept towards Chemistry between students taught through CBS and those taught through RTM.
b) To find out whether there is a gender difference in self-concept towards Chemistry of students who are taught through CBS teaching approach.

3. HYPOTHESES

In this study, the following null hypotheses were tested;

H_o1: There is no statistically significant difference in secondary school students' self-concept in Chemistry between those taught through CBS and those taught through RTM.
H_o2: There is no statistically significant difference in the students' self- concept in Chemistry between male and female students who are taught through CBS teaching approach.

4. METHOD

4.1. Research Design

The study involved quasi-experimental research in which the researcher used Solomon Four Non-Equivalent Control Group Design. The design is considered rigorous enough for experimental and quasi-experimental studies. The secondary school classes once constituted exist as intact groups and school authorities do not allow such classes to be broken up and reconstituted. The research design may be represented in Figure 1;

E1	O_1	X	O_2
C1	O_3	_	O_4
E2	_	X	O_5
C 2	_	_	O_6

Figure 1. Solomon Four Non-Equivalent Control Group Research Design

Key
O_1 and O_3 are pre-tests
O_2, O_4, O_5, and O_6 are post- tests
X is the treatment where students learn through CBS
Experimental Groups E1 and E2
Control Groups C1 and C2
Non-equivalent control groups…….

4.2. Sample and Sampling Procedure

A total of 175 students participated in the study. Purposive sampling was used to select participating schools. The unit of sampling was the schools rather than individual learners because secondary schools operate as intact groups. Each school provided the Form Two class to participate in the study. Simple random sampling was used to select the stream for purposes of data analysis if the school had more than one stream for a Form Two class. According to the Ministry of Education regulations, the average number of students in Kenyan secondary school classes is 45, so both the experimental and control groups were made of an average class size of 45 each.

4.3. Instrumentation

Two instruments were used namely;

- Chemistry Self- Concept Questionnaire (CSCQ)
- CBS Module

4.3.1. Chemistry Self- Concept Questionnaire (CSCQ)

The CSCQ contained 20 Five- point Likert- type scale items designed to measure Form Two students' self-concept towards Chemistry. Students were asked to indicate whether they strongly agree (SA), agree (A), undecided (U), disagree (D), strongly disagree (SD) with each item in the questionnaire. The items in the questionnaire were closed-ended questions and were measured on a 5-point Likert scale. The highest score in the scale is (5) while the lowest is (1) per item. For questions with a positive stem, strongly agree (SA) scored highest (5) while strongly disagree (SD) scored lowest (1). For questions with a negative stem, strongly agree scored lowest (1) while strongly disagree scored highest (5). The maximum score was 100 while the minimum score was 20.

4.3.2. CBS Module

The Computer-Based Simulation Module was developed by the researcher with the assistance of computer experts. The Module consisted of 16 lessons taught over a period of four weeks. Experimental Groups 1 and 2 and chemistry teachers were inducted for one week on basic computer operational skills to enable them to have easy navigation of the courseware. The developed simulation module was given to two computer education experts and three high school teachers knowledgeable in chemistry education to assess general design, format and sequencing of events, language level and subject content. Before being exposed to the CBS module the students were instructed on what to do and each one issued with a manual by the teacher. Students were allowed to go through the CBS module with the least help.

4.4. Data Analysis And Interpretation

Data was analysed using inferential statistics; to test for differences between the control and experimental groups. Data was analysed using analysis of variance (ANOVA) and analysis of covariance (ANCOVA). ANOVA was used to determine if the control and experimental groups differ significantly among themselves on treatment. ANCOVA was used to level out differences among the groups. To test for differences between the pre-test mean scores for Experimental Group E1 and the Control Group C1, t–test was used. A t-test was also used to test on gender differences in achievement and self-concept. To make reliable inferences from the data, all statistical tests were tested for significance at alpha level at 0.05.

Analysis of the pre-test CSCQ scores was done and the results obtained. Table 1 shows the independent samples t-test of the pre-test scores for CSCQ for Experimental Group1 and Control Group.

Table 1. Independent Samples t-test of the Pre-test Mean Scores on CSCQ

Levene's Test for Equality of Variance		t-test for equality of means						
Varia-ble	Equal Variances	F	Sig.	t	df	Sig (2-tailed)	Mean Difference	Std Error Differen ce
CSCQ	assumed	.106	.690	-.559	84	.578	-1.069	1.913
	Equal Variances Not assumed			-.559	82	.578	-1.069	1.913

df = 84, t-critical = 1.984, $p<0.05$

The results in Table 1 showed that the mean score for Experimental Group 1 and Control Group 1 on CSCQ are not statistically significantly different since t(84)= -.559, $p>0.05$.This means that the groups used in the study exhibited comparable characteristics. The groups were therefore regarded as suitable for the study.

Analysis of the pre-test CSCQ scores for Experimental Group 1 by gender was done and the results obtained. Table 2 shows the independent samples t-test of the pre-test scores for CSCQ.

Table 2. Independent Samples t-test of the Pre-test Mean Scores on CSCQ Based on Gender for Experimental Group 1.

Levene's Test for Equality of Variance				t-test for equality of means				
Variable	Equal Variances	F	Sig.	t	df	Sig (2-tailed)	Mean Difference	Std Error
CSCQ	assumed	.106	.746	.040	41	.968	.099	Difference
	Equal Variances			.040	41	.968	.099	2.497
	Not assumed							2.497

df = 41, t-critical = 2.00, p<0.05

The results in Table 2 shows that the mean scores of female and male students are not statically significantly different since t(41)= .040, p> 0.05.This means that the groups used in the studyexhibited comparable characteristics.

Pre-tests were administered to evaluate self-concept towards Chemistry. After the pre-test, students in the experimental groups were taught using CBS teaching approach while the control groups were taught using the conventional teaching methods. The use of a pre-test enabled the researcher to evaluate the similarity of the treatment and control groups prior to treatment.

The results indicate that there was no significant difference in the post-test mean scores between Experimental Groups 1 and 2 and Control Groups 1and 2. The post-test results in this study did not indicate any interaction between the pre-test and the instructional intervention. If the pre-test provided a practice effect it would result in higher post-test performance by groups receiving the pre-test. A comparison of the post-test results of the four Groups does not indicate that the pre-test provided a practice effect.

4.5. Effect of CBS on Students' Self-Concept in Chemistry

To determine the effects of CBS teaching approach on students' self-concept in Chemistry, CSCQ mean scores were analysed using ANOVA and ANCOVA. This was to test hypothesis one, H_o1 which stated that there is no statistically significant difference in self- concept of students who are taught Chemistry through CBS and those who are not exposed to it. The post-test mean scores were analysed. Table 3 shows the CSCQ post-test scores of the students in the four groups.

Table 3. CSCQ Post-test Mean Scores obtained by the Students in the Four Groups

Group	**N**	**Mean**	**Std Deviation**
Experimental Group 1	43	80.50	8.08
Control Group 1	43	72.60	10.85
Experimental Group 2	44	79.98	11.99
Control Group 2	45	73.07	10.80
Total	175	76.50	11.08

The mean scores for Experimental Groups 1 and 2, which received treatment were higher than the mean scores of the Control Groups, suggesting that CBS had a positive effect on students'

chemistry self-concept. Though Experimental Group 2 was not pre-tested, the students in this group obtained more or less the same mean score as compared to the students' in Experimental Group 1. This would suggest that the pre-test exercise did not have any effect on the students' chemistry self-concept thereby reinforcing the fact that CBS contributed to the enhanced chemistry self-concept. To establish whether the mean scores were statistically significantly different, analysis of one way variance (ANOVA) was carried out and the results are shown on Table 4.

Table 4. Analysis of Variance (ANOVA) of the post-test scores on the CSCQ

	Sum of Squares	**df**	**Means of Squares**	**F**	**P-value**
Between Groups	2367.40	3	789.13	7.104	0.000
Within Groups	18996.34	171	111.09		
Total	21363.74	174			

F-critical= 2.60; df = (3, 171); $p<0.05$

Table 4 shows the difference between and within groups is statistically significant $F(3,171) = 7.104$, $p<0.05$. In order to establish that there was significant difference between means, it was important to carry out further tests on the various combinations of means to find out where the difference occurred. The tests were done using Bonferroni post-hoc analysis. Table 5 shows the post-hoc comparisons of the post-test CSCQ mean scores for the four groups.

Table 5. Post-Hoc Comparisons of the Post-test of CSCQ Mean Scores for the Four Groups

(I) Group	(J) Group	Mean Differences (I-J)	Std Error	Sig. (a)
E1	C1	7.9707	2.273	.005
	E2	.41808	2.260	1.000
	C2	7.3286	2.247	.008
C1	E1	-7.7907	2.273	.005
	E2	-7.3726*	2.260	.008
	C2	-.46202	2.247	1.000
E2	E1	-.41808	2.260	1.000
	C1	7.3726*	2.260	.008
	C2	6.9106*	2.235	.014
C2	E1	-7.3286*	2.247	.008
	C1	.46202	2.247	1.000
	E2	-6.9106*	2.235	.014

*The mean difference is significant at the 0.05 level.

The results in Table 5 indicate that there is statistically significant difference in the students' chemistry self-concept between Experimental Group 1 and Control Group 1 and 2, and between Experimental Group 2 and Control Group 1 and 2. However, the mean scores of both Experimental Groups 1 and 2, Control Groups 1 and 2 were not significantly different. The Experimental Groups did not display any significant difference in chemistry self-concept probably because they were exposed to CBS. Therefore, it is reasonable to suggest that exposure of students to CBS enhanced their chemistry self-concept as compared to students in the control groups. Since this study involved non-equivalent control groups, it was necessary to confirm the results by performing analysis of covariance (ANCOVA). Table 6 shows the adjusted CSCQ post-test mean scores for the four groups.

Table 6. Adjusted CSCQ Post-test Mean Scores for ANCOVA with KCPE Scores as Covariates

Groups	**N**	**Actual Mean**	**Adjusted Mean**
Experimental Group 1	43	80.40	80.40[a]
Control Group 1	43	72.60	72.59[a]
Experimental Group 2	44	79.98	79.97[a]
Control Group	45	73.07	73.08[a]

[a] Covariates appearing in the model are evaluated at the following: KCPE marks 279.5314.

The mean scores of Experimental Groups 1and 2 were very comparable and much higher than the mean scores of Control 1 and 2. This may be construed to mean that the experimental groups that were exposed to CBS had better chemistry self- concept than the control groups which were not treated. Since the Experimental Group 2 and Control Group2 were not pre-tested the possible explanation for greater chemistry self-concept exhibited by the students in Experimental Group 2 was due to exposure to CBS.

The results of the adjusted means enabled an analysis of covariance to be done and the results are shown in Table 7.

Table 7. Analysis of Covariance (ANCOVA) of the Post-test Scores on the CSCQ

Dependent variable: Chemistry Self-concept

Source	Type III Sum of Squares	df	Mean Squares	F	Sig.	Partial Eta Squared
Corrected Model	2368.55[a]	4	592.14	5.299	.000	.111
Intercept	8491.986	1	8491.986	76.000	.000	.309
KCPE	1.151	1	1.151	.010	.919	.000
Groups	2363.429	3	787.810	7.051	.000	.111
Error	18995.184	170	111.736			
Total	1045278.00	175				
Corrected Total	21363.737	174				

a. R squared = .111 (Adjusted R squared = .090)

The findings of ANCOVA showed significant difference between the groups, F (3,170) = 7.051, $p<0.05$. To establish where the differences were located, a Post-hoc pair-wise comparisons based on ANCOVA were carried out and the results shown in Table 8.

Table 8. ANCOVA Pair-wise Comparison on CSCQ Mean Scores

(I) Group	(J) Group	Mean Differences (I-J)	Std Error	Sig. (a)
E1	C1	7.804□	2.283	.001
	E2	.038	2.275	.848
	C2	7.326□	2.252	.001
C1	E1	-7.804□	2.283	.001
	E2	-7.365□	2.268	.001
	C2	-.477	2.259	.833

E2	E1	-.438	2.275	.848
	C1	7.365*	2.268	.001
	C2	6.888*	2.252	.003
C2	E1	-7.326*	2.254	.003
	C1	.477	2.259	.833
	E2	-6.888*	2.252	.003

*The mean difference is significant at the 0.05 level

The results in Table 8 suggest that there was a statistically significant difference between Experimental Group 1 and Control Groups 1 and 2, Experimental Group 2 and Control Groups 1 and 2. However, the experimental groups showed no significant difference between them. The same trend was observed with the control groups. From the results it may be interpreted that the students in experimental groups were more motivated and got interested in Chemistry after treatment than students in the control groups. This implies that CBS teaching approach enhanced students' chemistry concept. Therefore hypothesis H_o2, which stated that there is no statistically significant difference in self-concept of students who are taught Chemistry through CBS and those who are not exposed to it, is rejected. A comparison of the CSCQ pre-test and post-test means scores was carried out and the results obtained are shown in Table 9.

Table 9. Pre-test and Post-test Mean Scores of Experimental Group 1 and Control Group 1

	Experimental Group1 N=43	Control Group 1 N=43
Pre-test Mean	56.86	57.93
Post-test Mean	80.40	72.60

The results of the comparison between Experimental Group1 and Control Group1 pre-test and post-test of CSCQ shows that the mean scores were comparable before the treatment as shown in Table 9. However, after the treatment it was observed that the mean scores of CSCQ in the post-test were different .This means that the CBS teaching approach resulted into a higher positive self-concept towards Chemistry than RTM did.

The results of ANOVA and ANCOVA for CSCQ post-test mean scores indicate that CBS had an effect on students' self-concept towards Chemistry. This implies that CBS resulted to a higher positive self-concept towards Chemistry.

The results of the pre-test showed that there was no significant difference in the means of the two groups. These results implied that the level of students' self-concept in the two groups were similar before exposure to the intervention. The results of the post-test mean scores for the four groups were different. The results of the study indicated that CBS resulted in higher scores on students' self-concept in Chemistry. The findings are in agreement with the earlier findings supporting capability of computer-based instructional programs to promote positive attitude and motivation. The findings indicate that the CBS teaching approach enhanced students' chemistry self-concept. There is considerable evidence to support the contention that positive academic self-concept contributes to academic achievement. Martin, Klein and Sullivan (2007) showed that those who used computer program performed significantly better and had consistently more positive attitude. Solso (2011) supports the effectiveness of computer based simulation learning techniques in improving students' self-concept in a study conducted in North Carolina for science students. Motivation is an attitude that is used in conjunction with self-concept, or the way one thinks about oneself to perform a task successfully. It is clear that the results are in agreement

with the earlier findings showing that the use of computers promotes positive students' attitude and motivation (Kiboss, 1997, 2002). People with positive self-concept will act in ways that will help them to outperform others, meet or surpass some standard of excellence, or do something unique. A research by Aasma-tuz (2010) in Pakistan showed that there is a relationship between academic and non-academic measures on students' self-concept. The study also revealed that self-concept measures were positively correlated to academic outcomes. Johnson and Johnson (1989) reported that cooperative group work benefits students in improving their self-concept. According to Wekesa (2003), CBI has the potential to improve students' retention and interest. Serin (2011) showed that computer-based instruction positively affected the attitude of the students toward science. He also found out that CBI motivates students to learn better by providing them with the immediate feedback and reinforcement and by creating an exciting and interesting game-like atmosphere.

All students are influenced by the need to achieve to a certain degree. Those students, who hold a high desire of success, work hard to achieve (Pullmann & Allik, 2008). Kithaka (2004) on a project in Kenya for SMASSE argued that there is too much theoretical teaching of sciences. The CBS teaching approach is one approach that can help direct the teaching-learning process to move away from the theoretical approaches and recognize the learners' important contribution to learning through active involvement. Parkinson (1994) points out that teachers must ensure that they make science as interesting and stimulating as possible.

The findings of this study established the role played by CBS in the students' perceptions on the image of Chemistry in secondary schools. The results showed that CBS had a positive effect on self-concept of students towards chemistry learning. The CSCQ scores indicate that CBS helped in improving the students' level of self-concept to learn Chemistry irrespective of their academic ability. Achievement in Chemistry influences students' self-concept and the students' self-confidence in a subject is an important factor that is likely to determine their success. Thus CBS teaching approach can influence the development of self-concept in Chemistry. According to Centre for Mathematics, Science and Technology Education in Africa ([CEMASTEA],2019), CBS activities helps to enhance learner's critical thinking and problem solving skills, The learners become objective, inquisitive, reflective, flexible, analytical, observant, skeptical, curious and a decision maker.

4.6. Effect of CBS on Gender Differences in Chemistry Self-concept

Hypothesis two, H_O 2 sought to find out whether there was a statistically significant gender difference in self-concept towards Chemistry between students exposed to CBS teaching approach. Table 10 shows the t-test of the post-test mean scores for experimental groups with regard to gender.

Table 10. Independent Samples t-test of the Post-test Scores on CSCQ Based on Gender

Levene's Test for Equality of Variance	t-test for equality of means

Variable	Equal Variances assumed	F	Sig.	t	df	Sig (2-tailed)	Mean Difference	Std Error Difference
CSCQ		.501	.481	.021	85	.983	.04726	2.21472
	Equal Variances Not assumed			.022	83	.983	.04726	2.18795

df= 85, t-critical= 1.984, $p<0.05$

The results in Table 10 shows that there was no significant difference in the means of the two groups since t (85) = .021, $p>0.05$. There was no significant gender difference in self-concept towards Chemistry. Consequently, H_O4 was accepted. Table 11 shows the adjusted post-test scores of CSCQ based on Gender using KCPE as covariate with Experimental Groups 1 and 2.

Table 11. Adjusted Post-test Mean Scores of CSCQ Based on Gender for Experimental Groups 1 and 2

Gender	**N**	**Actual Mean**	**Adjusted Mean**	**Std error**
Female	38	80.21	80.217[a]	1.675
Male	49	80.16	80.158[a]	1.474

a. Covariates appearing in the model are evaluated using KCPE Marks =280.3448

The mean score for female students was higher than the male students on CSCQ. The adjusted mean scores of female and male students compared closely with the actual mean scores. Table 12 shows the analysis of covariance of the post-test CSCQ mean scores of male and female students in Experimental groups1 and 2.

Table 12. ANCOVA of the Post-test CSCQ Mean Scores Based on Gender for Experimental Groups

Source	**Type III Sum of Squares**	**df**	**Mean Squares**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	.528[a]	2	.264	.002	.998	.000
Intercept	4436.308	1	4436.308	41.765	.000	.332
KCPE	.480	1	.480	.005	.947	.000
Gender	.074	1	.074	.001	.949	.000
Error	8922.530	84	106.22			
Total	568286.00	87				
Corrected Total	8923.058	86				

The results showed that there is still no statistically significant difference between the mean scores of the male and that of the female students who were exposed to CBS, F(1, 84) = .001, $p>0.05$. This therefore, means that there was no gender difference in self-concept towards Chemistry between students taught using CBS. Therefore, H_02 was accepted.

The post-test mean scores of the CSCQ indicates that the difference between male and female students was not statistically significant. The results from ANCOVA showed that there was no gender difference in self-concept between female and male students taught using CBS. The null hypothesis (Ho2) was therefore accepted at 0.05 significance level.

Researches focused on gender studies have indicated that the self-concept towards science education differ between males and females. A declining interest in Chemistry and the under-representation of females in the chemical science was found (Banya, 2005). Positive self-concept towards Chemistry, the influence of role models and knowledge about the usefulness of Chemistry affect the decision of young female students about the study of chemistry (Banya, 2005). Despite the studies done, and the recommendations made, the attitudes of young female students towards science and Chemistry are still more positive (Sullivan, 2009).

Research studies on sex differences in academic self-concept show conflicting pattern of findings. Aronson (2002) notes that gender differences in verbal ability are negligible but differences in quantitative skills show that girls' computational skills are better at all ages and boys do better in mathematics conceptual word problems. The findings by Aronson (2002) are in agreement with the present findings where girls were motivated to improve their self-concept scores toward Chemistry. Sullivan (2009) argued that boys have higher self-concepts in mathematics and science than the girls. Previous research indicates that even the males and females score equally well on standardized tests of mathematics ability, the males hold higher self-concept of science ability and science value than females do, and males select more difficult mathematics course than the females do (Simpkins, Davis-Kean, & Eccles, 2006). Other studies show that there is no significant difference between boys and girls on chemistry self-concept (Yusuf, 2010). Proko, Tuncer and Chuda (2007) posit that teacher characteristics have a significant role on students' attitude towards Chemistry. Perhaps this would explain the gender differences noted in this study since in CBS teaching approach the teacher is only a facilitator. Therefore, all learners should be given equal opportunity, the same level of motivation and encouragement irrespective of gender.

In conclusion, the use of CBS brought about a change in the teachers' role from that of a provider of information to that of a facilitator in the teaching/ learning process. Teachers may resolve the use of CBS that emphasizes interactive student learning to teach difficult topics like electrolysis. Also their self- concept improved and this means therefore that there is a likelihood of chemistry performance rising above average.

5. SUMMARY OF MAJOR FINDINGS

The following are the major findings of the study:

i. There is statistically significant difference in self-concept of students who are taught Chemistry through CBS teaching approach and that of those who follow conventional teaching methods.
ii. There is no statistically significant difference in Chemistry self- concept between boys and girls taught through CBS teaching approach.

6. CONCLUSIONS

The findings of this study established the role played by the CBS in the students' perceptions on the image of Chemistry in secondary schools. The CSCQ scores indicate that CBS helped in improving the students' level of self-concept to learn Chemistry irrespective of their academic ability. Achievement in Chemistry influences students' self-concept and the students' self-confidence is an important factor that is likely to determine their success. The results revealed that there is no significant gender difference between boys and girls self-concept in Chemistry. Therefore all learners should be given equal opportunity, the same level of motivation and encouragement irrespective of gender. On the basis of the findings of this study, the researcher

made a number of conclusions in relation to the two hypotheses of the study. These conclusions include:

i. Students who are taught Chemistry through CBS acquire a higher level of self-concept in Chemistry than those taught through RTM. Research has shown a significant but weak correlation between academic self-concept and academic achievement. Even with the weak correlation as education goes online during this period of COVID-19 and use of CBS teaching approach can go a long way in increasing academic achievement. Therefore this CBS teaching approach is highly recommended as educational instituted take learning online during this COVI-19 pandemic period and the post pandemic period.
ii. CBS teaching approach does not influence Chemistry self-concept of the girls and boys differently. Since the influence of CBS is not gender dependent then it can be used with apprehensions that one of the gender will be disadvantaged. This CBS approach is recommended for high school and other levels of education.

REFERENCES

[1] Aasma-tuz, Z. (2010). Relationship between self-concept and academic achievement of female Bachelor Degree students in Pakistan. Unpublished Doctoral Thesis. University of Arid Agriculture, Rawalpindi.
[2] Alessi, S.M. &Trollip, S.R. (2001). Multimedia for learning: methods and development Boston, MA: Ally & Bacon.
[3] Aronson, J. (2002). Improving Academic Achievement. California USA: Academic Press
[4] CEMASTEA, (2019). Monitoring and Evaluation Report. Unpublished.
[5] Chang, C. Y. (2009). Comparing the impacts of a problem based computer assisted instruction and the directive –interactive teaching method on student science achievement. Journal of Science Education and Technology, 10(2), 2001
[6] Gambari, I. A., Obielodan, O. O. &Kawu, H. (2017), Effects of virtual laboratory on achievement levels and gender of secondary school chemistry students in individualized and collaborative settings in minna, Nigeria. Online Journal of New Horizons in Education –Vol 7 No 1 2017.
[7] Gathuru, G., & Mwenyeri, M. (2021). The Impact of Covid-19 on Education in Kenya [Education]. Institute of Economic Affairs.
[8] Holbrook, J. (2011). Enhancing Scientific and Technology Literacy (STL): A major focus for science teaching at school. Journal of Science Teachers Association. Nigeria. 46(1). 9-34.
[9] Jegede, S. A. (2007). Students' anxiety towards the learning of Chemistry in some Nigerian secondary schools: Educational Research and Review volume 2 (7) pp 193-197.
[10] Johnson, D.W. & Johnson, R. T. (1989). Cooperation and competition: Theory and research. Edina, MN: Interaction Book Company.
[11] Kenya National Examinations Council, (2013). The Year 2012 Kenya Certificate of Secondary Education (KCSE) Examination Report, Nairobi: KNEC
[12] Keter, J. K. (2018). Effect of computer based cooperative mastery learning on secondary school students' skills acquisition, motivation and achievement in Chemistry practicals in Bomet County, Kenya. Unpublished PhD Thesis, Egerton University. Njoro, Kenya.
[13] Kiboss, J. K. (2002). Impact of a computer –based physics instruction program on pupils' Understanding of measurement concepts and methods associated with school science. Journal of Science Education and Technology, 11(2), 193-198.
[14] Kiboss, J.K. (1997). Relative effects of computer based instruction in physics on students'attitudes, motivation and understanding about measurement and perceptions of classroom environment. Unpublished PhD Thesis, University of the Western Cape
[15] Kithaka, J. N. (2004). Attitudes towards mathematics and science. Paper Presented During SMASSE Project Cycle One, Nairobi, April 2004.
[16] Kumar, K. S., Krishna, K. R & Rao, D. B. (2004). Methods of Teaching Chemistry: India Discovery Publishing House. Certificate of Secondary Education: Examination Report.
[17] Lee, S. C. (2001). Development of instructional strategy of computer application software forgroup instruction. Computers &Education, 37,1-9.

[18] Martin, F., Klein, D. J. & Sullivan, H. (2007). The impact of instructional elements in Computer-based instruction. British Journal of Educational Technology, 38 (4), 623 636.
[19] Maundu, J. N., Sambili, H. J. & Muthwii, S. M. (1998). Biology Education: A methodology approach. Nakuru AMU Press.
[20] Meccawy, M. (2017).Raising a Programmer: Teaching Saudi Children how to Code.Int. J. Educ. Technol.4 (2), 56-65.
[21] https://educationaltechnology.net/ijet/index.php/ijet/article/view/25
[22] Mondoh, O. H. (2005). Methods of Teaching Mathematics. A Handbook for Teachers and Students. Egerton University Press.
[23] Murugan, M.R. & Kamisah, O. (2018).The Effectiveness of Virtual Laboratory Compared to Physical Laboratory in the Mastery of Science Process Skills for Chemistry Experiments. Problem of Education in the 21st Century.vol 76, no 4 2018.
[24] Okere, M. I. O. (1996). Physics Education: A Textbook of Methods for Physics Teachers. Egerton University Njoro; Education materials centre.
[25] Ogunniyi, B. M. (2001). Effects of Science and Technology on Traditional Beliefs and Cultures. Bellville, SA: SSME, University of Western Cape.
[26] Parkinson, J. (1994). The Effective Teaching of Secondary Science. New York: Addison Wesley Longmann Inc.
[27] Prokop, P., Tuncer, G. & Chuda, J. (2007). Slovakian students' attitudes towards biology. Eurasia Journal of Mathematics, Science and Technology Education, 3 (4), 287-295.
[28] Pullimann, H. & Allik, J. (2008). Relations of academic and general self-esteem to school achievement. Personality and Individual Differences, 45, 559-564.
[29] Ramjus, H (1990) Intervention Strategies to Improve Self-esteem of Achievers in High School Science Class
[30] Serin, O. (2011). The effects of the computer-based instruction on the achievement and problem solving skills of the science and technology students. The Turkish Online Journal of Educational Technology. 10 (1), 183-201.
[31] Shamai, S. (2001). Elementary school students' attitudes towards science and their course of studies in high school. Adolescence. 31(123), 677-689.
[32] Simpkins, S.D., Davis-Kean, P.E. & Eccles, J.S. (2006). Math and science motivation: A longitudinal examination of the links between choices and belief. Development Psychology, 42, 70-83.
[33] Solso, R.L. (2011). Information Processing and Cognition: The Loyola Symposium.New York Wilej.
[34] Sullivan, A. (2009). Academic gender and single sex schooling. British Educational Research Journal, 35 (2) 259-288.
[35] TIMSS. (2011). International Results in Mathematics and Science Study. TIMSS & PIRLS International Study Centre, Chestnut Hill, MA, USA.
[36] Wekesa, E. (2003). Effects of a computer-based instruction module on students' achievement, perception of the classroom environment and attitude towards school Biology in Nakuru District, Kenya. Unpublished masters' thesis, Egerton University, Njoro, Kenya.
[37] Wesi, R. P. (2011). Conceptual Difficulties Associated with Energy. Unpublished doctoral Dissertation. Potchefstroom (South Africa). Potchefstroom University.
[38] Witfelt, C. (2000). Educational multimedia and teachers' needs for new competencies to use educational multimedia. Education Media International, 37(4), 235-241.
[39] Yusuf, A. (2010). The effect of cooperative instructional strategy on students' performance in junior secondary school social studies in Ilorin, Nigeria. Nigeria Journal of Social Studies, 8 (1 & 2), 23-36.

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