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Influence of Science Process Skills Teaching Approach on Secondary School Students' Achievement in Chemistry in Kisii South Sub-County, Kenya

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Abstract: *This study focused on the influence of Science Process Skills Teaching Approach (SPSTA) on secondary school students' achievement in Chemistry. The science process skills selected for the study include experimenting, observation and classification. The study sought to find out whether the achievement of students who are taught through SPSTA is statistically different from that of students who are taught using the regular teaching (RT) methods in Chemistry. The achievement of the boys and the girls who are taught using SPSTA in Chemistry was compared. The study employed quasi-experimental research design. The sampling frame consisted of County co-educational schools of Kisii South Sub-County. Simple random sampling techniques were used to select four schools for the study. Two schools formed the experimental groups and another two schools formed the control groups. A sample of 366 students in the four schools was selected. SPSTA was used to teach the experimental group while the control group was taught using the regular teaching (RT) methods. All groups were taught the chemistry content 'Salts'. Chemistry Achievement Test (CAT) was used for data collection. Data was analyzed using one-way ANOVA, ANCOVA and t-test. Hypotheses were accepted at $\alpha = .05$. Results of the study show that SPSTA improved students' achievement in chemistry. The boys and girls exposed to SPSTA performed equally well in Chemistry. The researcher concludes that SPSTA is suitable to use for teaching boys and girls in Chemistry, hence teachers should be encouraged to use SPSTA for teaching Chemistry to improve the students' achievement.*

Keywords: *Science Process Skills Teaching Approach (SPSTA), Regular Teaching (RT) Methods, achievement in Chemistry, performance according to gender, science process skills*

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1. Introduction

Chemistry knowledge is important in day to day life including among others: - cooking, medicine, cleaning and environmental issues. Despite its usefulness, students' performance in it has been low, especially in the Kenya Certificate of Secondary Education (KCSE). This could be addressed by considering the teaching method, since students' achievement is among other factors greatly determined by the teaching method used. According to Ketpichainarong (2010), science process skills teaching approach improves students' performance for example in solving problems, reflecting on their work, drawing conclusions and generating prediction , qualities necessary for a high achieving student. The rationale for the science process skills teaching approach has strong support from constructivist psychology where the teacher applies procedures so that: - (i) there is a primary emphasis on hands-on, problem centered approach and (ii) the focus lies with learning and applying appropriate investigational or analytical strategies. The approach is essentially reflective and judgmental with respect to investigations (Khan& Zafar, 2011)

In Science process skills instructional approach learners integrate skills, knowledge and attitudes to develop a better understanding of scientific concepts. Teachers focus on teaching science skills by encouraging learners through scientific investigation to produce and use scientific information to perform scientific research and solve problems (Atkamis & Ergin, 2008). Studies have shown that Science process skills teaching approach positively influences the learners achievement in science subjects (Nyakan, 2008; Abungu, 2014). SPSTA is a practical approach to teaching Chemistry where the teacher identifies a specific scientific skill and uses it to teach the learners. The learners will then apply this knowledge in solving problems of familiar situations; this limits the practice of lower level skills in blooms taxonomy (Dillon, 2008). Emphasis on processes-instruction help students to differentiate between observation evidence and inference evidence, the students then learn to test inferences experimentally and to see the applicability of their ideas as a result, the engagement and interest of students is promoted as well as a range of skills, science knowledge and conceptual understanding is developed (Millar,2009). This study was based on experimental approach to teaching which incorporated science process skills of observing, classifying and experimenting; this approach to teaching was referred to as science process skills teaching approach (SPSTA) and it was used to establish its influence on secondary school students' achievement in chemistry. SPSTA had not been fully explored in Chemistry teaching in Kenya, yet the Kenya Certificate of Secondary Education (KCSE) report show that the performance in Chemistry is low in table 1.

Table 1: National Students' Performance in KCSE Chemistry Examination

Year	paper	candidature	Maximum score	Mean score	Standard deviation
2016	1		80	19.15	14.85
	2		80	14.66	12.85
	3		40	13.63	6.31
	overall	566,836	200	47.42	34.01
2017	1		80	17.03	14.67
	2		80	17.97	14.32
	3		40	14.1	6.11
	overall	606,515	200	48.09	32.87
2018	1		80	19.36	14.57
	2		80	16.96	14.17
	3		40	14.44	6.45
	Overall	656,163	200	53.76	33.45
2019	1		80	20.00	14.98
	2		80	18.00	13.07
	3		40	13.00	6.07
	overall	691,802	200	52.17	32.71

Source: KNEC KCSE essential statistics (2019)

Objectives of the Study

The study was guided by the following objectives:-

(i) To find out whether there is a statistically significant difference in the achievement of students who are taught through SPSTA and that of students who are taught using the regular teaching (RT) methods in Chemistry.

(ii) To establish whether the achievement of the boys and the girls who are taught using SPSTA is statistically significantly different in chemistry.

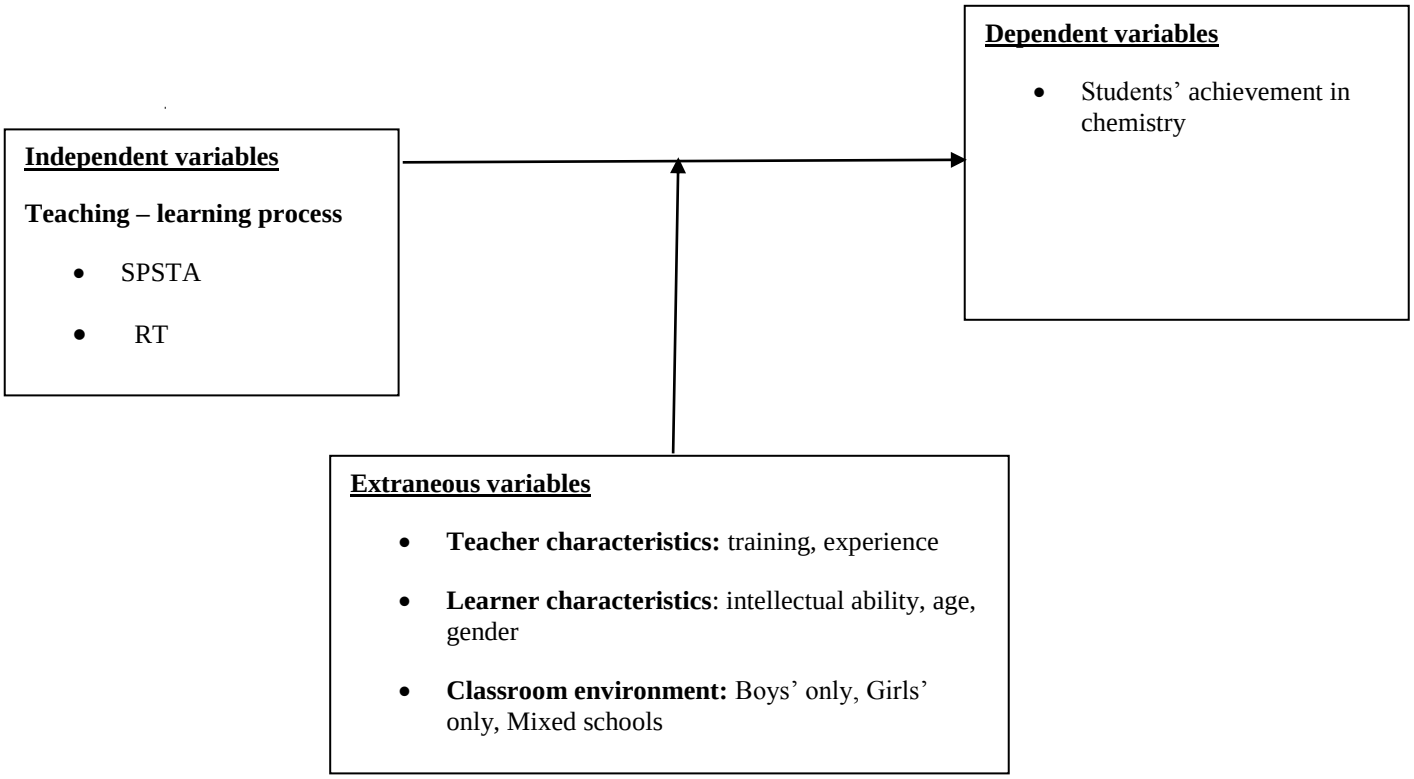
Hypotheses for the Study

$H_0$1: There is no statistically significant difference between the achievement of students who are taught using SPSTA and those who are taught using RT methods in Chemistry.

$H_0$2: There is no statistically significant difference in achievement between boys and girls who are taught through SPSTA in Chemistry.

Conceptual Framework for the Study

Figure 1 shows the relationship of variables for determining the influence of SPSTA on secondary school students' achievement in chemistry



The conceptual framework for this study was based on systems approach which holds that the teaching and learning process has inputs and outputs and to achieve good results, then the input must have suitable materials put in using the best methods (Joyce & Weil, 1986). In this study, the content 'salts' was taught using SPSTA for the experimental group and regular teaching methods for the control group. The achievement of learners in both the experimental and the control groups was compared at the end of the study. Learning outcomes are however influenced by various factors. These include among others learner characteristics, classroom environment and teacher characteristics. These were the extraneous variables in this study. Teacher training determine the teaching approach a teacher uses and how effective the teacher will use the approach .The learners' intellectual ability determines how they learn. In this study, teacher characteristics were controlled by using trained chemistry teachers with a teaching experience in the secondary school chemistry curriculum of at least five years. The learners' intellectual ability was controlled by using Form Two students of schools with similar characteristics which admit students of approximately similar intellectual ability. The learner's age was controlled by using Form two students who are approximately of the same age. Both boys and girls were used for the study to control the influence of student's gender on the study. The effect of classroom environment was controlled by using mixed schools only.

2. Literature Review

Science process skills teaching approach

According to Brunk and Towns (2009), science process skills (SPS) are transferable skills that are applicable to many sciences and that reflect the behavior of scientists. They further explain that they are the skills that facilitate learning in physical sciences, ensure active student participation, and have students develop the sense of undertaking responsibility in their own learning. It also increases permanence of learning among students and have them acquire research ways and methods, which enables them to think and behave like scientists. For this reason, it is an important method in teaching sciences. Equally SPS are the building blocks of critical thinking and inquiry in science (Yager & Akcay, 2010). Therefore learning science lessons through science process skills teaching approach requires using science skills for teaching. Having science process skills, acquired at the same time, means preparing future scientists, having

scientific literacy acquired is enabling students to use science information in daily life (Cepril & Cil, 2009). Science process skills teaching approach can be a highly effective teaching method that helps students in the understanding of concepts and use of science process skills (Yager & Akcay, 2010)

In Kenya, the secondary school curriculum has had a long history of practical based approach to teaching science. The 8.4.4 secondary school science syllabus places emphasis on practical work (Kenya Institute of Education, 2002). The need for students to engage in science process skills is clearly stated in the objectives of teaching Chemistry in secondary school syllabus, which is what is also emphasized in Strengthening of Mathematics and Science Education (SMASE) programs (Changeiywo, 2000). The secondary schools annual science and engineering fare puts emphasis on students' projects in schools. This initiative is intended to enable students acquire science process skills. The instructional methods adopted in science lessons are intended to promote problem solving activities, project work and use of local materials.

The Kenya Vision 2030 also proposes application of science and technology to raise productivity and accelerate economic development, which is intended to enable Kenya join the newly industrializing countries (GOK, 2008).According to CEMASTEA, 2015 SPSTA in secondary schools in Kenya is intended to facilitate the acquisition of skills and application of scientific knowledge necessary for the economic take-off in the 21st century. Further the argument is that the activities under this framework focus on a wide range of skills and processes and attest to the importance of experimental work in the secondary schools science. Hence if all the secondary schools take up the challenge seriously then most of the graduates will be equipped with process skills necessary for technological development of this nation.

Science Process Skills Teaching Approach and Chemistry Practicals

The House of Commons Science Technology Committee (UK, 2002) argues that the quality of school science practicals and laboratory work are key concerns since they play a big role in improving students' performance in science. According to Ottander and Grelson, 2006; laboratory work should encourage the development of analytical and critical thinking skills and interest in science. Good quality Chemistry practicals can be supportive to learning and will help students in developing understanding of Chemistry skills and concepts (Dillon, 2008). According to Abraham and Millar (2008), teaching of science should involve the learner experiencing the basic and integrated science process skills. Chemistry being a science is not left out and Science process skills teaching approach helps the learner to experience the science process skills. When teaching chemistry using practicals, the teacher should incorporate science process skills teaching approach as this will enable the teacher to ensure that learners develop all abilities during learning in order to improve performance in Chemistry

Gender and Performance

Gender strongly predicts human conduct and gender differences influence academic performance according to many researchers and educationists (Ssempala, 2005). Studies have shown that in most cases boys outperformed girls in science (Kakinda, 2007); Burns (1987) and Tamir (1982) reported similar findings in New Zealand, Israel and Nigeria respectively. Anderson (1987) too reported that in America, there were too few women in science, engineering and technology; these findings can be attributed to the preferred learning styles for boys and girls according to Heffler (2001) and Tindall & Hamil (2003); male and female have different learning preferences with women preferring hands-on learning experiences and men taking an analytical approach in learning; thinking logically and rationally. Findings by Trumper (2006) showed that boys and girls of the same age tend to have different attitudes to similar teaching styles.

Permanent European Resource Centre for Informal Learning (PENCIL) pilot projects report that educational programmes can be designed which are attractive for both boys and girls (Cuomo, et al. 2007), Kolb & Kolb (2005) recommend that learning experiences of men and women alike should be enhanced to allow students to construct knowledge and encourage experiential learning and self authorship. Heffler (2001) identify four learning styles classification determined by where an individual's score falls on two continuums:- the active experimentation-reflective observation and the concrete experience –abstract conceptualization dimensions. These learning styles include accommodator learning, assimilator learning, converger learning and diverger learning. A teacher should plan their teaching in such a way that all types of learners are taken into account for meaningful learning to take place. The regular teaching methods do not support all learning styles as they appeal to men more than to women (Philbin et al., 1995). Wachanga (2004) reported that cooperative class experiment improved the achievement of both girls and boys equally in Chemistry, Chebii (2012) reported that mastery learning science process skills teaching approach equally improved the achievement of both boys and girls in Chemistry. Science process skills teaching approach (SPSTA) has shown that it is able to accommodate all types of learners both female and male when it is used

for instruction in Chemistry since findings of this study showed that both boys and girls exposed to SPSTA performed equally well in Chemistry

3. Methodology

Research Design

This study employed quasi-experimental research design in which Solomon four non-equivalent control group designs was used. The study used four intact classes from four different schools. Each class represented a group for the study as illustrated in figure 2

Group 1	O_1	X	O_2	experimental group
Group 2	O_1	------	O_2	control group
Group 3	-----	X	O_2	experimental group
Group 4	------	------	O_2	control group

Figure 2: the research design

Source: Wiersma and Jurs (2005)

Key: -Pre-tests 0_1, Post-tests 0_2, Treatment X
--------- Dashed lines show that the experimental and control groups were not equated by randomization hence nonequivalent

Sampling Procedure and Sample Size

Selection of the sample for the study was done through purposive and random sampling methods. The sampling frame consisted of the County co-educational schools in Kisii South Sub County, Kenya. Four schools were selected for the study using simple random sampling methods. Simple random sampling was further used to select two schools from the Four to form the experimental group while the other two schools constituted the control group. Each school sampled for the study formed a group for the study as follows:

Group 1-the true experimental group (N=92)

Group 2-the true control group (N=90)

Group 3- the experimental extension group (N=88)

Group 4- the control extension group (N=96)

The sample size of the study population was 366 students. These numbers were adequate for the study since Fraenkel and Wallen (2000) recommend at least 40 subjects per treatment group.

Instrumentation

A Chemistry Achievement Test (CAT) was used to determine the effect of SPSTA on students' achievement in chemistry.

Reliability of the CAT

Split-half reliability method was used to determine the reliability of the CAT. All items on the CAT that purported to measure the same construct were randomly divided into two sets. The entire instrument was then administered to the sample population for piloting of the instrument. After marking the CAT administered in piloting, the total score for each randomly divided half was calculated. The correlation of scores between the two halves was found using the Pearson product moment correlation coefficient. The reliability coefficient of the CAT was 0.863 hence the CAT was taken to be reliable since reliability was fixed at $\alpha \geq 0.7$; reliability considered large enough to declare an instrument reliable (Fraenkel & Wallen, 2000).

Data Analysis

Data collected from the research was coded, scored, keyed and analyzed using the statistical package of social sciences (SPSS) version 22.0 for windows. The nature of data was quantitative (the marks scored in the instruments by the student). Inferential statistics of t-test, ANOVA and ANCOVA were used

4. Results and Discussion

Influence of SPSTA on Students' Achievement in Chemistry

In this section, findings testing hypothesis 1 for the study were analyzed, hypothesis 1 stated:

HO_1: there is no statistically significant difference between the achievement of students who are taught using SPSTA and those who are taught using RT methods in chemistry

The instrument which was used to test this hypothesis was CAT which was administered as a pre- test to experimental group1 and control group 2. The CAT was also administered to all the 4 groups of the study as a post-test. The instrument was scored and the individual student's percentage scores were keyed and analyzed using SPSS version 22.0. Pre-test analysis is explained below

Table1 shows the means and standard deviation of the learners' pre-test scores in CAT

Table 2: Mean and Standard Deviation of Learners' pretest scores in CAT

Group	N	Mean	Std. Deviation	Std. Error mean
Group1	92	19.09	4.535	.669
Group 2	90	20.21	4.594	.693

Source: field data

Table 2 shows that group 2 had a higher mean than group 1 and that group 2 was more dispersed about the mean than group 1. Since the means of the pre-test scores in the CAT were not equal, an independent samples t-test was carried out to determine whether the means were statistically significantly different. The t-test results are presented in table 2

Table 3: Independent Samples t-Test for Pre – Test Scores on CAT

Group 1, N= 92 Group 2, N= 90

Variable	group	Mean	Std. dev.	t-value	df	p-value
CAT	1	19.09	4.535	.004	89	.997
	2	20.21	4.594			

CAT maximum score=100

t-test results (table 3) indicate there was no statistically significant difference between group 1 and group 2 at the beginning of the study $t(89) = .004$, $p > .05$. This implies that there was no group with an advantage over the other in terms of achievement in chemistry before the study and thus the groups had comparable characteristics. A treatment was administered to group 1 and group 3 these groups were taught using SPSTA while group 2 and group 4 were taught using the regular teaching (RT) methods. All groups were taught for a period of eight weeks the content "salts'' in the Form two Chemistry syllabus. At the end of the study, a post-test was administered to all groups. Table 4 shows the mean and standard deviations of learners' post- test scores in CAT

Table 4: Mean and Standard Deviations of Learners Post – Test Scores in CAT

Group	N	Mean score	Std. dev.
1	92	59.30	12.715
2	90	52.78	8.813
3	88	62.84	14.752
4	96	49.98	10.950
Total	366	56.10	12.935

Table 4 shows that group 3 had the highest mean followed by group 1 then group 2 and finally group 4 posted the least mean score. The overall mean for the four groups used for the study was 56.10. Group 3 was the most dispersed about the mean followed by group 1 then group 4 and group 2 was the least dispersed about the mean respectively. Since the means were different, a one way ANOVA way carried out to determine whether the mean differences were statistically significantly different. Table 5 shows the one way ANOVA test results for post-test scores in CAT according to groups.

Table 5: One way ANOVA Test for Post- Test Scores in CAT According to Groups

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	4766.645	3	1588.882	11.072	.000
Within Groups	25686.382	179	143.499		
Total	30453.027	182			

Table 5 results indicate that F= 11.072 with P= 0.000 < 0.05 implying that there was a statistically significant difference in some means. This necessitated a Least Significance Difference Test to generate a multiple comparison of post- test scores in CAT by group as presented in table 6

Table 6: Multiple Comparison of Post – test scores in CAT

(I) Post- test CAT	(J) Post -test CAT	Mean Difference (I-J)	Std. Error	Sig.
grp1	grp2	6.527*	2.512	.049
	grp3	-3.537	2.526	.501
	grp4	9.325*	2.472	.001
grp2	grp1	-6.527*	2.512	.049
	grp3	-10.063*	2.540	.001
	grp4	2.799	2.486	.674
grp3	grp1	3.537	2.526	.501
	grp2	10.063*	2.540	.001
	grp4	12.862*	2.500	.000
grp4	grp1	-9.325*	2.472	.001
	grp2	-2.799	2.486	.674
	grp3	-12.862*	2.500	.000

* The mean difference is significant at the .05 level.

Table 6 shows that the mean of group 1 was statistically significantly higher than that of group 2 and 4 (t = 6.527, P-value = .049 < .05 and t = 9.325, P-value = .01 < .05 respectively). This implies that the experimental group 1 performed better than both the control groups in the post-test CAT results. This means that the students who were taught using SPSTA performed significantly better in Chemistry theory than the students who were taught using regular teaching (RT) methods. The mean difference between experimental group 3 and control groups 2 and 4 were statistically significantly different (t = 10.063, P-value = .001 < .05 and t = 12.862, P-value = .000 < .05 respectively) this shows that the students who were taught using SPSTA performed better in Chemistry than those who were taught using RT methods. The mean difference between experimental group 1 and experimental group 3 were not statistically significantly different (t = 3.537 and P-value = .051 > .05), although both group1 and group 3 were experimental, it is worth noting that group 3 obtained a higher mean score in the post-test CAT than group1. This implies that the group1 exposed to a pre-test did not have an advantage over

group3 which did not do a pre-test and that the pre-test did not affect the implementation of SPSTA. The mean differences between the control group 2 and the control group 4 were not statistically significantly different (t = 2.799, P-value = 0.647 > 0.05)

ANCOVA was used since the study involved non-equivalent control group design. The Kenya Certificate of Primary Education (KCPE) mean mark was used as covariate. KCPE results were used since it is the standard entry examination for all the Form two students to secondary school in Kenya. ANCOVA is therefore used since the main threat to internal validity of non-equivalent control group experiment is the possibility that the group difference in the post-test may be due to pre-existing group difference rather than the treatment effect. Table 7 shows the adjusted post-test CAT scores of ANCOVA with KCPE scores as covariate.

Table 7: Adjusted Post- Test Mean Scores in CAT for ANCOVA with KCPE Mean Scores as Covariate

Group	N	Mean	Std. Deviation
1	92	59.30	12.715
2	90	52.78	8.813
3	88	62.84	14.752
4	96	49.98	10.950
Total	366	56.10	12.935

From Table 7, the experimental group 3 had the highest mean followed by experimental group 1 then control group 2 and control group 4 posted the least mean. Experimental group 3 was the most dispersed around the mean while control group 2 was the least dispersed around the mean.

The ANCOVA of the Post test Scores on the CAT are presented in table 8

Table 8: ANCOVA of the Post Test Scores on the CAT

	Sum of squares	**Df**	**Mean square**	**F**	**p-value**
Corrected model	5319.313	3	1329.828	9.418	.000
KCPE	552.668	1	552.668	3.914	.022
Error	25133.714	178	141.201		

table 8 shows that there was a statistically significant difference in the corrected mean scores in CAT when KCPE mean scores are used as covariate for the corrected model F (3,178) = 9.418, P= .000< .05. Further ANCOVA pair wise comparisons of the adjusted means test are presented in table 9

Table 9: ANCOVA pair wise Comparison on CAT

(I) Post test CAT	(J) Post test CAT	(I-J)	Std. Error	p-value
grp1	grp2	6.630*	2.492	.041
	grp3	-3.382	2.507	1.00
	grp4	9.382*	2.452	.001
grp2	grp1	-6.630*	2.492	.041
	grp3	-10.011*	2.519	.001
	grp4	2.753	2.466	1.000
grp3	grp1	3.382	2.507	1.000
	grp2	10.011*	2.519	.001
	grp4	12.764*	2.481	.000
grp4	grp1	-9.382*	2.452	.001
	grp2	-2.753	2.466	1.000
	grp3	-12.764*	2.481	.000

*The mean difference is significant at the 0.05 level

From table 9, there was a statistically significant difference between the marginal means of experimental group 1 and control group 2 and 4 (t=6.630, p-value .041<.05 and t=9.382, p-value = .001<.05) respectively. This implies that experimental group 1 performed better in Chemistry than control group 2 and 4, this higher achievement can be strongly attributed to SPSTA since experimental group 3 also had a significantly higher mean than control group 2 and 4 (t=2.519, p= .001<.05 and t= 12.764, p=.000<.05) respectively, however there was no statistically significant difference between the marginal means of experimental group 1 and group3 (t=3.382,p=1.000>.05) and between control group 2 and group 4 (t=2.753,p=1.000)

Objective 1 which sought to find out whether there is a statistically significant difference in the achievement of students who are taught through SPSTA and that of students who are taught using the regular teaching (RT) methods in Chemistry found that there was a statistically significant difference in the achievement of students who are taught through SPSTA and that of students who are taught using RT methods in Chemistry with the students taught using SPSTA having higher achievement scores and HO_1 which stated that There is no statistically significant difference between the achievement of students who are taught using SPSTA and those who are taught using RT methods in Chemistry was therefore rejected.

Findings of this study are in agreement with a study by Nyakan (2008) which investigated the effect of science process skills instructional approach on Form Two secondary school students' achievement in physics in Kenya. The study found that students who learned through science process skills instructional approach attained higher mean scores in physics than those who learned through traditional instructional approach after eight weeks intervention. Abungu (2014) carried out a study on the effect of science process skills teaching approach on students' achievement in chemistry, the study used Solomon four group quasi experimental designs. The study covered two topics (volumetric analysis and qualitative analysis). The results of the study revealed that science process skills teaching approach had a significant effect on students' achievement in chemistry. The findings of the current study support science process skills teaching strategy in Chemistry

The findings of this study are attributed to the fact that In Science Process Skills Teaching Approach, there was learner involvement which facilitated personal growth and skills development. By being involved, learners feel a measure of empowerment and safe to take responsibility for their own learning (Ngesa, 2002). According to Siegel (2005) science process skills teaching approach is a method by which the creation and transmission of knowledge can effectively be approached as a genuinely collective enterprise. According to the Training Needs Assessment (TNA) report (CEMASTEA, 2015), a majority of teachers do not adequately arouse learner's interest and curiosity through innovative and real life situations nor do they involve learners in developing creative ideas. Further a large number of teachers rarely develop activities that enable learners interpret, analyze and evaluate new information. CEMASTEA emphasizes the use of Activity, Student, Experiment and Improvisation- Plan, Do, See and Improve (ASEI-PDSI) principles in teaching and learning of mathematics and science to enhance the learning process through well planned lesson activities. SPSTA

used was consistent with the principles of ASEI-PDSI. The rationale for the science process skills teaching approach has strong support from constructivist psychology where the teacher applies procedures so that: - (i) there is a primary emphasis on hands-on, problem centered approach (ii) the focus lies with learning and applying appropriate investigational or analytical strategies. The approach is essentially reflective and judgmental with respect to investigations (Khan& Zafar, 2011). If secondary schools in Kenya implement SPSTA in Chemistry teaching, the students' achievement at KCSE in Chemistry examination is likely to improve significantly. Secondary school teachers of Chemistry are therefore encouraged to use SPSTA in their teaching.

Achievement of Girls and Boys Exposed to SPSTA in Chemistry

Trumper, (2006) explains that girls and boys of the same age tend to have different attitudes to similar teaching methods; however Kibirige and Tsamango (2013) showed that the attitude of girls and boys towards science are not different when using similar methods. Due to these conflicting findings, the current study sought to find out whether there was a statistically significant difference between the achievement of boys and girls who are exposed to SPSTA in Chemistry. This was determined by testing the second hypothesis for the study which stated; **HO_2**: there is no statistically significant difference between the achievement of girls and boys exposed to SPSTA in Chemistry. This hypothesis was tested by considering the post-test CAT scores of girls and boys in the experimental group 1 and experimental group3. There were 92 girls in the experimental group, (46 in group 1 and 46 in group 3) while there were 90 boys in the experimental group, (46 in group 1 and 44 in group 3)

Experimental group 1 and experimental group 3 post-test scores were analyzed and the means on the CAT post-test scores for experimental group 1 and experimental group 3 are presented in table 10

Table 10: Means and Standard Deviation of Experimental Group 1 and Group 3 in Post-test CAT

Group	N	Mean	Std. Deviation
group1Boys	46	60.04	9.088
group1 Girls	46	58.57	14.795
group3 Boys	44	62.95	16.961
group3 Girls	46	62.17	12.561
Total	182	60.91	13.758

From table 10, the means for the experimental groups 1 and 3 were different. A one way ANOVA was performed to determine whether the differences were statistically significantly different and the results are in table 11

Table 11: ANOVA on the Post-test Scores on CAT Accordiong to Gender

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	890.429	3	296.810	1.599	.195
Within Groups	16144.868	86	185.573		
Total	17035.297	89			

From table 11, the mean differences between groups are not significant at P< .05 F = 1.599, P= .195> .05 these results show that there was no statistically significant difference between the means of boys and girls exposed to SPSTA and that both boys and girls exposed to SPSTA gained equally from the instruction, this implies that the boys and girls exposed to SPSTA perform equally well in Chemistry. A t-test between the girls and the boys exposed to SPSTA was conducted and the results are presented in table 12.

Table 12: Independent Samples t-test on post-test scores for girls and boys exposed to SPSTA

Boys, N= 90 Girls, N= 92

Variable	gender	Mean	Std. dev.	t-value	df	p-value
CAT	Boys	61.5	4.535	0.022	89	.983
	Girls	60.37	4.594			

Table 12 shows that the mean differences between the boys and the girls exposed to SPSTA were not statistically significant(t=0.022, p= .983> .05). This implies that both boys and girls will benefit equally from SPSTA and that the boys' means which were slightly higher were not significantly different from that of the girls in the post-test CAT and that both boys and girls will improve their performance in Chemistry if SPSTA is used.

Having established that the mean differences between the girls and boys exposed to SPSTA were not statistically significant (Table 10 and Table 11), hypothesis $\mathbf{H0_2}$ which stated that there is no statistically significant difference between the achievement of girls and boys exposed to SPSTA was found to be consistent with the findings of the study that there was no statistically significant difference between the achievement of girls and boys exposed to SPSTA; therefore the hypthesis $\mathbf{H0_2}$ was retained .

KCSE Kenya National Examinations Council (KNEC) results analysis show that the boys attain a higher mean in Chemistry KCSE examination than girls over the years as illustrated in table 13.

Table13: National Students' Performance in KCSE Chemistry Examination

Year	Gender	Enrolment	Mean score (%)
2012	Girls	193426	25.95
	Boys	237293	29.54
	Total	427303	27.93
2013	Girls	200735	23.08
	Boys	239206	26.30
	Total	439941	24.83
2014	Girls	221659	30.81
	Boys	255734	33.88
	Total	477393	32.16
2015	Girls	240857	32.64
	Boys	275031	35.86
	total	515858	34.36

Source: KNEC KCSE essential statistics (2015)

This gap in performance may be addressed by adopting teaching strategies that stimulate girls' interests in Chemistry in order to alleviate the gender gap (Mackatiani, 2018). SPSTA on the other hand involves hands on activities for learners which helps learners to develop self confidence in their learning as a result there was no significant difference between the achievement of boys and girls exposed to SPSTA. Tetiana (2018) studied preffered learning styles of students majoring in Chemistry, pharmacy, technology and design and reported that future chemists and pharmacists are characterised by the apparent preferences of visual, sensitive and active style regardless of their gender, teachers should therefore design course materials so that they can be equally well learned by all students, a characteristic of the SPSTA used for the study. Baykan and Nacar, (2007) studied learning styles of first year medical students using turkish version questionnaire i.e (visual, auditory, read-write, kinesthetic) and reported that the learning styles did not differ between male and female students with the majority (63.9%) having a multimodality preference for learning Chemistry which is the use of much of their sensory modalities as possible to take in new information and SPSTA is a method which engages most of the learner's senses in learning and as a result both girls and boys learnt equally well as shown from the results of this study. Teachers are encouraged to use SPSTA in teaching Chemistry inorder to improve the achievement of both boys and girls in Chemistry and address the gender gap that exist in the performance of Chemistry in the KCSE.

5. Conclusion and Recommendations

5.1 Conclusion

Based on the findings of the study, the following conclusions were made:

1. Science Process Skills Teaching Approach positively influences secondary school students' achievement in Chemistry more than Regular Teaching methods

2. Both boys and girls will improve their achievement in Chemistry when they are taught using Science Process Skills Teaching Approach

5.2 Recommendations

Based on these findings, the study recommends the following:

1. Heads of schools, quality, assurance and standards officers and teachers of Chemistry to encourage the use of SPSTA in the teaching of Chemistry. This will improve the secondary school students' achievement in Chemistry

2. The Chemistry teacher education curriculum should include SPSTA in order to prepare the teachers effectively with the knowledge and skills necessary to implement SPSTA to achieve the educational goals and objectives

3. The in-service courses and workshops organized by CEMASTEA for practicing teachers of Chemistry should include the content of SPSTA

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