# INFLUENCE OF SCIENCE PROCESS SKILLS TEACHING APPROACH AND REGULAR TEACHING METHODS ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN CHEMISTRY IN KISII SOUTH SUB- COUNTY, KENYA

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**A Thesis Submitted to the Board of Post Graduate Studies in Partial Fulfilment of the Requirements for the Award of Doctor of Philosophy Degree in Curriculum & Instruction in the Department of Curriculum, Instruction & Educational Media, School of Education.**

**Kisii University**

**2022**

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## DEDICATION

This study is a dedication to my dear husband, Reuben Okiomeri, beloved children Abednego Obama, Shadrack Okero, Vivyanne Moraa, Meshack Mainye and my late father, Alphaxard Okero Onsomu.

**ACKNOWLEDGEMENT**

My sincere thanks go to all those who in one way or another either directly or indirectly, played a role towards the completion of t his thesis. My special thanks go to my supervisors Dr. Peter O. Nyakan and Dr. Enock Obuba for their indescribable efforts, time and professional guidance and dedication towards shaping the work. I take this opportunity to also express my deep gratitude to my husband and children, for their support and encouragement during the period of carrying out this study and compiling the thesis. I wish to specially thank my husband, Reuben Okiomeri for his continuous encouragement, moral and financial support throughout the study. I wish to appreciate Levy Ogechi for his patience and commitment to this work during data analysis. May I too acknowledge Kisii University for admitting me to pursue a PhD (curriculum and instruction). I salute the Government of Kenya through the National Council of Science and Technology Institute (NACOSTI) who granted me permission to carry out this research. I also wish to extend my gratitude to the Kisii South sub county education office, the school principals, the teachers and students who w ere more than willing to assist me carry out this research. I give Glory and honour to the Almighty God. In Him and through Him everything is possible. God bless you all.

## ABSTRACT

Chemistry which is fundamental to many disciplines becomes increasingly important, yet students' performance in it has been low, especially in the Kenya Certificate of Secondary Education (KCSE) since the inception o f 8-4-4 system of education in the year (1989). This could be addressed by considering the teaching methods, since students' achievement is greatly determined by the teaching method used. T his study focused on the influence of Science Process Skills Teaching Approach (SPSTA) on secondary school students' achievement in Chemistry when compared with using regular teaching methods (RTM). Further an analysis on how SPSTA influences achievement of learners in terms of gender was also studied. The science process skills which were selected for the study include experimenting, observation and classification. The objectives of this study were: To find out whether or not 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 theory, to determine whether or not the achievement of students who are taught using SPSTA is statistically different from that of students who are taught using the RT methods in chemistry practical, to compare the achievement of the boys and that of the girls who are taught using SPSTA in Chemistry theory and to compare the achievement of the boys and the girls taught using SPSTA in Chemistry practical. The study employed quasi- experimental, Solomon Four non-equivalent control group pre-test – post-test design. The target population was Form Two chemistry students in Kisii South Sub- County, Kisii County in Kenya. 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. Simple random sampling was further used to select two schools from the sampled schools to form the experimental groups while the two remaining 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 on the topic 'Salts' which is part of the Form Two Chemistry syllabus. Chemistry Achievement Test (CAT) and a Chemistry Practical Test (CPT) were used for data collection. Both instruments were piloted in Nyamira County in order to determine their validity and reliability. The reliability of the CAT was $\alpha = 0.863$, while the CPT had $\alpha = 0.8528$. Data was analyzed using one-way ANOVA, ANCOVA and t-test. Hypotheses were tested at a significance level of coefficient alpha ($\alpha$) value of .05. Results of the study show that there was a statistically significant difference between the achievement means of students who were taught through SPSTA and those taught through RT methods in Chemistry theory ($F = 11.189$, $p = .000$). The achievement of students taught using SPSTA was significantly different from that of students taught using RT methods in Chemistry practical ($F = 260.558$, $p = .000$). Further, there was no statistically significant difference in the achievement of boys and girls exposed to SPSTA in Chemistry theory ($t = 0.022$, $p = .983$) and the difference in the achievement of boys and girls taught through SPSTA was not significant in Chemistry practical ($t = 1.059$, $p = .295$). The researcher concludes that SPSTA facilitates students' achievement in both Chemistry theory and Chemistry practical, and that both boys and girls perform equally well when taught using SPSTA. The researcher recommends the use of SPSTA in Chemistry teaching in order to improve the students' achievement in both Chemistry theory and Chemistry practical.

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ANCOVA: Analysis of Covariance

ANOVA: Analysis of Variance

ASEI-PDSI: Activity, Student, Experiment and Improvisation-plan, Do, See and Improve

CAT: Chemistry Achievement Test

CEMASTEA: Centre for Mathematics, Science and Technology Education in Africa

INSET: In-Service Education and Training

KCPE: Kenya Certificate of Primary Education

KCSE: Kenya Certificate of Secondary Education

KIE: Kenya Institute of Education

KNEC: Kenya National Examination Council

NACOSTI: National Commission for Science and Technology Institute

NRC: National Research Council

RT: Regular Teaching

RTM: Regular Teaching Methods

SMASE: Strengthening of Mathematics and Science Education

SPS: Science Process Skills

SPSS: Statistical Package of Social Sciences

SPSTA: Science Process Skills Teaching Approach

TNA: Training Needs Assessment

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# CHAPTER ONE

# INTRODUCTION

## 1.1 Background to the Study

The science subject which deals with the study of structure, properties and composition of matter is referred to as chemistry. Chemistry is one of the areas of instruction in the Kenyan secondary schools. It offers various career opportunities in various fields such as medicine, pharmacy, food technology, education and engineering. Chemistry has helped to improve standards of living in areas such as: manufacture of drugs to fight diseases, food production to fight hunger, manufacture of detergents and production of fuels for transport and domestic use. In Kenya, Chemistry education curriculum offered at O' level is meant to initiate learners to handle the contemporary environmental challenges which they come by in society. Learners intending to pursue careers such as engineering, medicine and surgery, body therapy, education, pharmacy and food technology need the background of chemistry knowledge.

Performance in science subjects and Chemistry in particular has raised concern over the years the world over. For instance a report in the United States of America (USA) in the focus and urgency to school reform efforts for science education show that performance in the science subjects by students has been declining over the years. Anaso (2010) found that in Nigeria, chemistry's performance was of concern since it was poorly performed and it was not impressing. In Uganda, Nantongo (2011) raised concern over the poor performance in the national Uganda Chemistry examinations.

The objectives of Chemistry subject as outlined by Kenya Institute of Education; (KIE, 2002) are to:- (i)identify and work with appropriate apparatus in experiments (ii) make accurate measurements and observations for drawing generalizations (iii)learn and take up symbols and formulae when communicating through equations, (iv) make use of acceptable chemical language when referring to both physical reactions and chemical reactions, (v) Make use of the knowledge attained to cultivate ambiance and acceptable norms, (vi) apply knowledge and skills learnt in technological and industrial development and (vii) acquire sufficient knowledge in chemistry for higher learning and training. From these objectives, a learner who has gone through the Kenyan education chemistry syllabus should be able to understand the safety of household chemicals and also know how to prevent pollution and contribute positively towards the country's rapid industrialization (GOK, 2008).

The Kenya National Examination Council (KNEC) 2019 report (Table 1:1) shows how students scored in KCSE in both theory and practical examinations.

**Table 1:1: 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)

With reference to Table 1:1 it is observed that the population of candidates has kept on increasing over the years; from 566836 in 2016 to 606515, 656163 and 691802 in 2017, 2018 and 2019 respectively. Performance in Chemistry paper 1 declined from 19.15 in 2016 to 17.03 in 2017 which is decrease of 2.12 units, but in the two following years there was slight improvement by 2.33 and 0.64 units in 2018 and 2019 respectively.

Performance in paper 2 improved in 2017 by 3.31 units, but in 2018 it declined by 1.01 units and in 2019 there was an improvement by 1.04 units. Likewise in paper 3 there was an improvement by 0.47 units in 2017 and in 2018 it improved by 0.34. However in 2019 the performance in paper 3 declined by 1.44 units. The overall performance of chemistry improved from a mean of 47.42 (23.71 %) in 2016 to a mean of 48.09 (24.045%) in 2017.

In 2018 the mean improved to 53.76 (26.88%), but in 2019 the mean declined to 52.17 (26.085%). According to KNEC (2019), teachers should expose learners to as many practicals as possible in order to give them an opportunity to interact with apparatus and chemicals. Further, teachers should train their learners to perform experiments with strict adherence to the instructions with emphasis on calculations, manipulating data, graph interpretation and application of right scientific terms in reporting observations and inferences.

In Kisii South Sub - County, the performance in Chemistry is poor with students posting low grades in both national and local examinations. An analysis of Kisii south sub – county trial examinations is presented in table 1:2

**Table 1:2: Kisii south secondary schools trial examination analysis**

| **Number of students** | **subject** | **Trial1 mean score** | **Trial2 mean score** | **Trial3 mean score** | **Year** |
|---|---|---|---|---|---|
| **2611** | chemistry | 2.634 | 2.794 | 3.104 | 2020 |

Source: Kisii south sub – county 2020 trial analysis report

The analysis report shows that there is need to address the achievement issue in Kisii south sub – county since on a scale of twelve, the highest attainment during the year was 3.104.

According to CEMASTEA (2015), 'Salts' has been cited as one of the difficult topics in secondary school chemistry. This is said to be difficult for students, and teachers tend to avoid it. Further they argue that  the conventional methods used in teaching the subject do not enable learners to comprehend other related concepts due to the learners' inadequate understanding. The topic salts, according to KIE, (2002) has been designed to fulfil the following objectives:
To state and describe the different forms of salts, to classify salts into 'soluble' and 'insoluble' – achieved by carrying out experiment on solubility of salts. The teacher to guide learners in the expected observation and further classify salts as soluble or insoluble, to choose and put to use right methods of preparing salts; Achieved through following procedure to prepare given salts, the teacher discusses with leavers the appropriate method for preparing different salts. Learners further use this knowledge to give appropriate procedure for preparing a given salt a part from the one prepared in class, to define the terminologies: 'neutralization', 'saturated solution', 'crystallization' and 'precipitation' to illustrate reactions using stoichiometric equations, to discuss experimental observations made when various salts are heated and to give uses of some of the salts prepared.

Chemistry teaching methods emphasize practical or investigative learning; however, they do not usually offer the learners varied experiences and necessary exposure for an appropriate balance in the development of cognitive ability, psychomotor skills and affective behaviour KIE (2002). Moreover, the various constraints experienced in practical work, often make most teachers to rarely engage in authentic practical activities.

Leijen, Valtana and Pedaste (2012) hold that the learning opportunities provided in science lessons are inadequate for effective learning of science as envisaged within the constructivist framework and the nature and quality of teacher-pupil interaction in science lessons also fail to actively promote the acquisition of science concepts. They further argue that the quality of teacher - pupil interaction in the science lessons, does not encourage active and meaningful learning to take place. In a majority of cases, lessons are teacher dominated, implying an emphasis on the transmission view of learning as opposed to construction of knowledge.

Cakir (2008) a proposed solution for improving the cognitive ability and developing the psychomotor skills of students is to make learners flexible. This means that students can manage to solve their every day encounters when applying learnt content. He further argues that the way forward to this is to convert classrooms to become a learner dominated environment by using a constructivist approach. One such constructivist approach is SPSTA, which gives priority to learner involvement and facilitates 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).

Siegel (2005) envisions a method of teaching where, both teachers and learners will collaboratively contribute during the creation and transmission of knowledge. The Kenyan Government through Strengthening of Mathematics and Science (SMASE) organizes In-Service Education and Training (INSET) for teachers of mathematics and science; where the objective is to create a learning environment which recognizes the contribution the learner makes towards learning/teaching process.

According to the Training Needs Assessment (TNA) report (CEMASTEA, 2015), point out that the methods of teaching used by a good number of the teachers lack innovation and thus do not capture the attention of the learners, in other words , the leaner's contribution is never taken into account. They also found that the learning activities developed are not learner friendly to enable the learner to analyze, interpret or evaluate new information.

CEMASTEA (2015) further emphasizes the use of learner friendly activities where, a student participates in experiments. By improvisation from locally available materials; the teacher puts a workable lesson plan on how the experiment will be done, for the learner to see their achievement and work out to improve their performance (ASEI-PDSI principles) in teaching and learning of science and mathematics. This will enhance the learning process; since this will result in well planned, lesson activities. SPSTA is in line with the principles of ASEI-PDSI. It helps students to develop their ability in a plethora of skills such as manipulating apparatus, questioning techniques, prediction, observing, critical thinking and inferring skills.

According to Thomas (2014), SPSTA enhances the development of skills which equips students to be able to provide answers to problems which they encounter. It also makes learners to have a critical mind to become decisive in coming up with answers to quench their thirst. This process of finding solutions to questions is the basis of investigation in science. Science process skills teaching approach to teaching from another angle is a constructivist approach applicable to the teaching of science. It means that students discover new causal relations by coming up with hypothesis which are tried out. Hypotheses are tested using observations made from an experiment which has been conducted (Pedaste, Maetos, Leijen & Sarapuu, 2012).

The teacher; on the other hand; creates situations, which enables students to practice research procedures to identify problems. Through this practice; they are able to question as well as apply investigational procedures that will lead to consistency of descriptions, explanations and also predictions that are in tandem with experience existing in the physical world (Kim, 2005). Science process skills exercises are fundamentally used as the main source of the development of skills of science (Wilke & Straits, 2005).

According to Ketpichainarong (2010), SPSTA can improves students' performance for instance; at solving problems, meditating on their work, concluding based on their findings and trying to come up with prediction; characteristics of a top scoring student. The rationale for SPSTA has solid support anchored on constructivist psychology where the teacher uses procedures in a manner that: - (i) the main focus is that the learner is involved in the outlined activities to find solutions to questions using a problem centred approach (ii) the underlying issue is about learning and application of the right investigations or analysis strategies (iii)the role of "facts" of science that may result in the process is inconsequential in comparison to the understanding of the development of scientific constructs. The approach is crucially reflective and judgmental in light with investigations (Khan& Zafar, 2011).

In Science process skills instructional approach, learners combine attitudes, skills and knowledge in order to come up with a clear comprehension of scientific facts. Teachers target on teaching science skills by encouraging learners through scientific investigation to discover and apply scientific knowledge to execute scientific research and solve problems (Atkamis & Ergin, 2008). Studies have shown that SPSTA improves positively the score of learners 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 participation and focus of students is promoted. Learners' science skills are developed and improved as well. Their conceptual understanding is enhanced together with science content (Millar, 2009).

On the other hand, female and male students have different attitudes towards different learning methods according to gender preferences (Tindall & Hamil, 2003). This is because learners in the same class have different views to similar instructional methods (Trumper, 2006). Kibirige and Tsamango, (2013), however found no difference in perception on similar methods used. These conflicting results, on the perception of learners based on their gender towards a teaching method prompted the current study to find out how SPSTA influenced the achievement of learners with regards to gender in both chemistry theory and chemistry practical.

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). SPSTA was used to establish how it influences the achievement of secondary school students in chemistry. Further its influence on the achievement of learners according to gender was also studied. Findings of the study demonstrate that SPSTA helped secondary school students to improve their achievement in Chemistry.

## 1.2 Statement of the Problem

Despite the efforts advanced to improve teaching and learning in chemistry subject through practical investigation and demonstration, students' performance in the subject continue to be poor. One of the contributing factors to this is that probably learners are not given an opportunity to be actively involved in the teaching/learning process. This emanates from the fact that the teaching approaches adopted by the teachers of Chemistry are mainly heuristic in nature. Lack of active student participation during the learning process make learners passive or limits their activities to a few practical demonstrations. It is necessary to provide practical activities that give learners more opportunities to learn Chemistry in a socially interactive environment. SPSTA has been found to be efficient in teaching; however, its effectiveness has not been fully explored especially in teaching Chemistry. This necessitated undertaking this study. SPSTA was therefore designed to investigate its influence on the achievement of secondary school students in Chemistry in Kisii South Sub- County, Kenya.

## 1.3 Significance of the Study

SPSTA is a heuristic approach to teaching. Learners apply the scientific method to investigate a problem. 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 will limit the practice of lower level skills in Bloom's taxonomy (Dillon, 2008). This investigation was based on experimental approach to teaching that incorporated selected process skills of science of observing, classifying and experimenting in the learning process. This helped to improve the quality of the Chemistry experiments as it promoted the participation and interest of students. It has well-developed different levels of skills, science knowledge and conceptual understanding as advocated by Millar (2004).

The traditional teaching methods in which learners depend on the instructor as the only information giver to inactive learners are inappropriate since the learners are reduced to passive recipients of information. The method fails to encourage learners to work as a team, to share knowledge in a free environment amongst them to enrich their intellectual potential (Conole, Scanlon, Littleton, Keraware & Maholland, 2010). One suggested answer to this challenge is to train students to become adaptive. Learners need to participate in acquiring knowledge, relate it to what they already know and construct their own meaning (Cuevas, 2005).

Learners should put into use what has been learned in school even in unprecedented occasions that they may face in their lives. There is need to steer off from teacher dominated classrooms to learner centred classrooms, for learners to construct their own knowledge. The outcome of this study will be helpful in outlining the different roles that learners and the teachers should play in the learning-teaching process. The findings also provide Chemistry teachers with an alternative approach that may help them improve the learners' performance in the subject.

**1.4 Purpose of the Study**

The study purposed to explore how SPSTA influenced secondary school students' achievement in Chemistry. The study determined if there was a significant improvement in achievement scores of secondary school students in both chemistry theory and chemistry practical as a result of the use of SPSTA.

## 1.5 Objectives of the Study

The objectives of the study were to:-

i. Find out whether or not 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 theory.

ii. Determine whether or not the achievement of students who are taught using SPSTA is statistically significantly different from that of students who are taught using the RT methods in Chemistry practical.

iii. Establish whether or not the achievement of the boys and the girls who are taught using SPSTA is statistically significantly different in chemistry theory.

iv. Find out whether or not there is a statistically significant difference in the achievement of the boys and the girls taught using SPSTA in Chemistry practical.

## 1.5 Hypotheses for the Study

**$HO_1$:** 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 theory test.

**$HO_2$:** There is no statistically significant difference in the achievement of students exposed to SPSTA and those who are exposed to RT methods in Chemistry practical test.

**$HO_3$:** There is no statistically significant difference in achievement between boys and girls who are taught through SPSTA in Chemistry theory test.

**$HO_4$:** There is no statistically significant difference in achievement between boys and girls who are taught through SPSTA in Chemistry practical test.

### 1.7 Assumptions of the Study

This study was based on the following assumptions: - (i) that the participants in the groups co-operated well to enable execution of SPSTA during the study (ii) teachers in the selected schools executed SPSTA effectively. (iii) Using SPSTA during teaching of Chemistry is one of the recommended approaches in imparting chemistry content.

### 1.8 Scope of the Study

In this study, the research problem involved the determination of achievement in Chemistry by students prior to treatment and after treatment. The treatment was using SPSTA. A quasi experimental, pre-test- post-test non-equivalent control group design; which falls under Solomon 4 group design was used. The experimental group was exposed to SPSTA; the control group was taught through RT methods. A sample of Form Two students was drawn from selected schools in Kisii South sub-county.

The study used four selected County mixed schools in Kisii South sub-county, Kenya. Students of Form Two class were sampled from these schools and were used for the study. A population sample of 366 students participated in the study. SPSTA was the focus of the study. It was used to teach the Form two Chemistry content ‘salts’. The topic ‘salts’ was selected for the study because the nature of the topic according to the syllabus, presents a fantastic chance for engaging students to a variety of experiments while teaching. SPSTA was hence very applicable. What the study found is generalizable to the teaching of Chemistry subject.

**1.9 Limitations of the Study**

The following limits were associated with the study:

(i) The use of formally constituted intact classes. The researcher did not therefore randomly assign research participants to experimental group and to the control group. This led to the effect of using unequal groups having different characteristics. Quasi-experimental design used allowed the researcher to randomly select samples from the population which did not need to be randomly assigned for individual cases in view to comparison group.

(ii) The research design required exposure of the experimental group to conditions that may have been totally new and may have had negative effects on the participants, this limitation was minimized by using the quasi experimental Solomon 4 group design which involved the use of pre-test- post-test in an experimental setting. It provided an assessment of the time sequence as well as a basis of comparison; however, it did by Jean Piaget in the period (1935-1950), informed this not have severe reactive effects caused by the sensitizing of participants (Alfieri, Brooks, Aldrich & Terenbaom, 2011).

**1.10 Theoretical Framework for the Study**

Constructivist theory of learning guided the study, as advanced in the theory of cognitive constructivism. There is basically need to integrate the real world to the activities in class to help learners to build both personal and social knowledge. Good and Brophy (2003) explain the cognitive constructivist theory of learning as the one that emphasizes students' development of knowledge through active discussion processes that link new knowledge to prior knowledge. This is contrary to the transmission model of learning where the teacher acts as a sender of a fixed body of content to learners, and learners as receivers. On the other hand; Science Process Skills Teaching Approach emphasizes on learner involvement in the learning process in order to apply the scientific method to investigate a problem; an aspect which promotes the engagement and interest of students so that the students are not passive recipients in learning.

Students actively mediate the input by trying to make sense of it and relating it to what they already know about a topic. This construction process is important because unless the students build their own representation of new learning, it will be retained as relatively meaningless and inert rote memory (Good & Brophy, 2003).

SPSTA is consistent with constructivist theory since they explain that, meaningful learning occurs when students create ideas, from existing information such as facts, concepts and procedures, to solve a problem. People search their memory for information that can be used to fashion a solution. In this process, they are creating knowledge and thus are said to be constructing knowledge. Constructivism holds that one person's knowledge cannot be transferred exactly to another because knowledge in part, is the result of personal interpretation (Johnson & Johnson, 2009).

A learner builds knowledge structures from personal experiences. This can be contrasted with objectivism, which holds that knowledge exists in an absolute sense, independent of people. In the constructivist view the learner must be provided with conditions that will allow the personal interpretation of information and experiences. Therefore, meaningful learning is the active creation of knowledge structures such as concepts and rules, from personal experience. The learner builds a personal view of the world by using existing knowledge, interest, attitudes and goals to select and interpret currently available information (Johnson & Johnson, 2009). SPSTA emphasizes processes rather than products which are in line with constructivism. The teacher's role in learning is facilitation.

Other views of cognitive constructivism theory are.

i) The essence of a person's knowledge can never be totally transferred to another person because knowledge is the result of a personal interpretation of experience that is influenced by such factors as the learners' age, gender; race and knowledge base, when knowledge is transferred from one person to another some aspects of it are lost during translation.
ii) Individuals make observations, test hypothesis and draw conclusions about events that are largely consistent with one another. This leads to consensus about different people's view of the world.
iii) Constructivism has to do with the formation and changing of knowledge structures. Additions to, deletions from and modifications of these interpretations come mainly from the sharing of multiple perspectives. Systematic open-minded discussions are instrumental in helping individuals create personal views (Johnson & Johnson,2009).

The process of concept formation involves:- i) Identifying and enumerating the data that are relevant to the problem (ii) grouping those items according to some basis of similarity and (iii) developing categories and labels for the groups (Joyce & Weil, 1986). For example in the chemistry topic ‘salts’ which was covered by students in this study, the students had to differentiate between salts by identifying their specific properties. Once the properties were identified the students were expected to group and categorize salts in terms of their reactions. Also through science process skills teaching approach, the students were expected to show how salts affect people in their daily lives.

### 1.11 Conceptual Framework for the Study

According to Mutai (2000), a conceptual framework provides a model showing how various variables will interact during the study. It guides the study since it provides a hypothesized relationship among the variables. The conceptual framework for this study was based on ‘systems approach’.  From systems approach, the teaching /learning process is likened to a system which has got input, process and output. The input in an education system, include students, teachers, learning/teaching materials and equipment. Process refers to teaching/learning experiences a learner undergoes during learning. An example of a process is SPSTA. Output refers to the graduates of a system. If the graduates attained the relevant, desirable knowledge, attitudes and skills, then the outcome (output) show that the set objectives have been achieved. The learner’s score in a CAT or SPSPT is an example of output. According to Joyce and Weil, (1986) good results are achieved when suitable materials (input) into the system are processed using best methods. Figure 1.1 shows the relationship of variables for determining the influence of SPSTA on secondary school students’ achievement in chemistry.

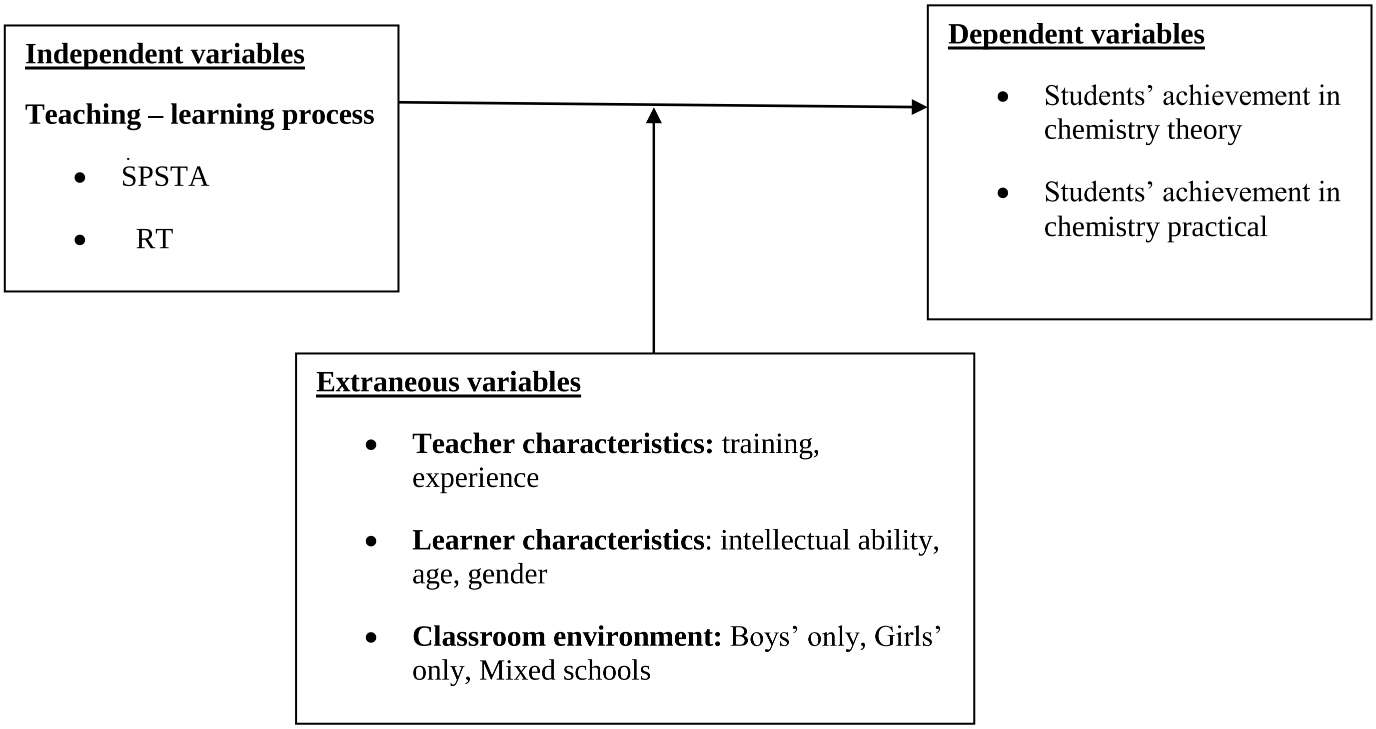


Figure 1.1: Conceptual framework for the study

The extraneous variables for the study which are likened to the input of a system include: the teacher characteristics like their training and their teaching experience; the learner characteristics of intellectual ability, age and gender; classroom environment (boys' only, girls' only or mixed schools). These variables can affect the implementation of SPSTA, hence there was need to control them.

Teachers with training in teaching Chemistry with a teaching experience of teaching Chemistry in secondary school of at least five years participated in the study. This was made to minimize the influence of training and experience on the implementation of SPSTA.

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 form two boys and girls used for the study have approximately the same age. This took care of the age and gender of the learner. The effect of classroom environment was controlled by using mixed schools only.

The independent variables which are ‘process’ were; the teaching learning process which occurred by using the RT methods for the control group of the study and the SPSTA which was used for the experimental group as a treatment for the study. The dependent variables are equivalent to the ‘output’. This was measured using the students’ achievement in CAT and SPSTA.

### 1.10 Definition of Key Terms

**Achievement** :Percentage score attained by a student in the Chemistry Achievement Test (CAT) or chemistry practical test (CPT).

**Basic science process skills**: Skills of classification, observation, conclusion, prediction, communication and measurement.

**Chemistry Practical test**: assessment of the learner's achievement in practical skills test.

**Chemistry Theory test**: Assessment of the learner's achievement in a written test.

**Classification**: organizing salts according to similarities, differences and reactions.

**Constructivism theory**: theory of learning which advocates that learner should create ideas from what they know such as concepts, procedures and facts.

**Experimenting** : Performing an experiment by carefully following laid down directions of procedure on the topic "salts" and verifying the results by repeating the procedure.

**Gender** :The sex of a participant, either boy (male) or girl (female).

**Integrated science process skills** :skills of hypothesis formulating, variable identification, description of relationships between variables, investigation designing, carrying out experiments, acquiring data, data organization in form of tables and graphs and analyzing investigations using data obtained.

**Meaningful Learning** **:** applying what is learnt to solve problems in new situations outside the learning environment.

**Mixed schools** **:** Schools which enrol both boys and girls.

**Observation** **:**Using the senses of: sight, hearing, touch and smell to determine attributes, properties, similarities, differences and changes in the reactions of salts.

**Regular Teaching Methods**: practices, teaching routines, rules, procedures used by the teacher to aid learning. They include but not limited to; lecture, demonstration and discussion.

**Science process skills teaching approach activities** **:**What teachers and learners do during SPSTA lesson.

**Science Process Skills Teaching Approach:** a method of teaching where the teacher designed activities for the students that involved the application of scientific skills of observing, classifying, and experimenting in the learning process.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Introduction

This chapter depicts a literature which reviews on Science Process Skills Teaching Approach. This study sought to establish out the influence of Science Process Skills Teaching Approach on Secondary school students' achievement in Chemistry. Therefore the Chapter seeks to contextualize the study within the background of existing knowledge. The existing related literature was captured within five broad sections: - Science Process Skills Teaching Approach, regular teaching methods for teaching Chemistry, gender and performance in Chemistry, Chemistry practical KCSE.

## 2.2 Science Process Skills Teaching Approach

According to Brunk and Towns (2009), science process skills (SPS) are skills applicable in other sciences, and that show the behaviour of those studying science. They further explain that they are the needed skills which enable studying in physical sciences. This also results to active student involvement thus developing a sense of responsibility in their personal learning. It also increases retention in learning among students and makes them acquire better research methodology, which enables them to think and behave like scientists. Consequently, it is a crucial method in teaching sciences. Equally SPS are milestones in evaluative reasoning and inquiry in science (Yager & Akcay, 2010). Therefore learning science lessons requires using science skills for teaching and, simultaneously having science process skills acquired means preparing scientists for the future; while having scientific literacy acquired is making students to apply science in everyday activities (Cepril & Cil, 2009). The gap identified is how to teach Science process skills. SPSTA was hence studied.

Nyakan (2008) carried out a study on how science process skills instructional approach would affect learner's achievement in physics subject. He used Form two students from selected schools in Kenya. He reported that, students subjected to science process skills instructional approach scored higher grades in physics, which were statistically different than that of students who learned through other instructional methods; this was found after teaching for eight weeks. The findings by Nyakan throws weight to instruction using science process skills strategy. There was need for a study in Chemistry subject to find out whether similar results will be realised.

Abungu (2014) carried out an investigation to show the impact of science process skills teaching approach on students' performance in chemistry. Results of his study revealed that science process skills teaching approach had a significant influence on students' achievement in chemistry. His findings support science process skills teaching strategy in Chemistry. Abungu's study was done in Nyando, Kenya and focused on the Chemistry content on the topics "Titration" and "rates of reaction" of the Chemistry syllabus. The current study was carried out in Kisii South Sub County, Kenya and the Chemistry content on the topic 'Salts".

In Kenya, the secondary school curriculum recommends that practical based approach should be applied in teaching science. The 8.4.4 secondary school science syllabus lays emphasis on importance of practical work. According to Kenya Institute of Education (2002), there is a great need for students to be engaged in practical activities. The importance of practicals cannot be over emphasized as it is explicitly outlined in the objectives of teaching Chemistry in secondary school syllabus, and also in Strengthening of Mathematics and Science Education (SMASE) programs (Changeiywo, 2000). The secondary schools' science and engineering fare mainly focuses on projects in schools carried out by students. The theme of the science and engineering fare is to assist students to attain science process skills. The methods of instruction used in the lessons of science should therefore advance the problem solving activities, project work and make use of local materials. Attainment of these skills is what SPSTA was designed to address.

The Kenya Vision 2030 intends to increase production and also improve economically in order to join those countries which have been lately industrialized through technology and science (GOK, 2008). According to CEMASTEA, 2015; science teaching applied in Kenyan secondary schools is supposed to ensure the acquiring of skills and the application of science knowledge too; which is core in revamping the economy in the realization of her vision. Science teaching skeleton focuses on a variety of skills and processes and confirms the essence of experimental contribution in the secondary science (Changeiywo, 2000). The secondary schools in Kenya are advised take up the challenge seriously in order to equip its graduates with process skills vital for the growth of technology (Changeiywo, 2000). SPSTA is used to find out how it will help in overcoming this challenge of skill acquisition.

In addition, the present Kenyan secondary school curriculum is designed to offer a variety of learning situations and knowledge to students to equip them completely as individuals. It aim is to prepare its graduates for commercial ventures as well as vocational training. It also provides social and personal satisfaction. It is broad based and practical oriented (Kenya Institute of

Education, 2002). Moreover, the learners who clear secondary school education effectively are believed to be well equipped in psychomotor skills in their areas of intended specializations (Okere, 1996). Further, he argues that the learners who drop out of school while in secondary classes are hoped to have gained sufficient skills and knowledge to enable them to be meaningful people in society. From these studies, it is evident that the most significant way of attaining vision 2030 is by using the school curriculum that covers science process skills activities of learning of science. Specifically, Chemistry as a subject occupies a great role in the curriculum of secondary school and this is triggered by its day to day use by students in the growth of intellect and science process skills. Through SPSTA in Chemistry, it will be established whether or not students will be able to acquire practical science process skills, which are necessary for solving problems in real life situations.

Walters and Soyibo (2001), classify Science process skills as either basic or integrated. These skills can be acquired through training or improved using different activities for example; from observing a demonstration experiment, carrying out experiments in the laboratory and graphical activities which form part of the natural science subjects' programs. Basic science process skills include according to them:

i) To observe is to determine attributes, similarities, properties, differences and changes taking place in natural phenomena. This can be attained by making use of objects like instruments, or using one or more of the senses. Observation is an explanation of what one perceives. Once information is gathered, it is used for qualitative data analysis to test phenomena.

ii) Classification is about arranging objects or events based on their similarity and differences identified by whoever observes. Classification focuses on assigning elements into strata on the basis of shared characteristics and sequencing them by the relationship that exist among them.

iii) Measurement focuses on comparing unknown quantity. This may include temperature, mass or length with a quantity of reference. This is done by using instruments which include student designed or standards of metrics of volume, length, mass, area, electrical charge, temperature, force or time. Measurement demonstrates the ability to have estimation or comparison of an object or event against a standard of reference. Measurement therefore deals with efficacy and skilful use of instruments.

iv) Conclusion in simple terms can be said to be the usage of data gotten through observing and measuring. An imperative conclusion is then arrived at. This conclusion must be connected with possible causal relationship or generalizations. Conclusion is based on analyzed, collected data. This is a crucial science skill. Though the existing information may be inadequate for arriving at a conclusion, the skill ignites a decision that shows continuity or discontinuation of futuristic research that entails collecting more data.

v) Prediction comprises of giving possible future occurrences anchored on what one observes, measures or infers available amongst observed variables. Prediction answers the concern: "What will be the most possible outcome of any given process?" this is determined circumstantially and builds on the law of objectivity.

vi) Communication involves presenting and explaining experiences which deals with objects or events which can either be descriptions that are written or verbal. They are in the form of photographs, maps, constructed charts, demonstrations or some other methods (Walters &Soyibo, 2001).

Integrated science process skills include:

i) Constructing Hypotheses involves suggesting probable solutions or expected outcomes for an intended experiment. The projected solutions to a problem must be verifiable.

ii) Variable identification and naming the extraneous factors that can impact on the outcome of an experiment. It is crucial to alter only the dependent variable, which is being tested and keep the independent variable constant. It should be noted that the variable being managed is the independent variable, while the one being measured to show its response is the dependent variable. All the other variables that do not experience change may be viewed as extraneous variables which are constants.

iii) Description of relationships between variables implies explaining the connection of variables in any given experiment. For example showing the association between the independent and dependent variables.

iv) Investigation designing. This is the ability to plan an experiment by providing the right apparatus and reagents to be used. It also entails, giving an elaborate description of the right steps to be followed in the process of testing a hypothesis. Any precaution to be considered in the experiment is highlighted.

v) Experimentation. This is doing an experiment following the right procedure. This can be attested if the procedure is severally repeated and the results are the same.

vi) Data acquisition. This involves collecting both qualitative and quantitative data through observations and experiments.

vii) Data organization in form of tables and graphs. It entails presenting data that has been collected in tables and graphs.

viii) Investigation analysis. This is interpreting data collected statistically. At this point both human and experimental errors are identified. Hypotheses are also evaluated and consequently conclusions, recommendations and further testing are done where appropriate (Walters &Soyibo, 2001).

### 2.2.1 Science Process Skills in SPSTA

In using SPSTA, class experiment teaching method was incorporated with science process skills to teach the topic 'salts'. The science process skills which were identified and used were: - observation, classification and experiment as discussed in subsequent sections of this study.

(i) Observation skill and its use in SPSTA

The process-skill of observation demands the engagement of one's senses of sight, smell, hearing and touch to comprehend objects and events; by considering their behaviour and properties. It is necessary for learners to listen attentively to some concerns of what is under scrutiny since an observation includes explanation of a phenomenon (Ozlegen, 2012). SPSTA, for instance, in describing the appearance of a salt, the student was expected to note and record the colour and texture of the provided solid. When determining whether a salt was soluble in water or not, the learner added water to a salt in a test tube, shook and observed whether the salt dissolved or not and if it dissolved, they had to observe and state the colour of the resulting solution.

In this view, observation is said to be a process-skill which results to different process-skills. When teaching Chemistry, students ought to be trained on how to do observation keenly so as to come up with right observation (Ozlegen, 2012). He further emphasizes on observation skill as being applicable to the learning of science and is beneficial to the learners in their day to day activities. Carrying out practical activity can be a way to increase learners' prowess in observation while engaging all senses to make averment and partial observations (Ozlegen, 2012).

The syllabus for Chemistry in secondary school stresses on the use of observation skill not only for the students' instant appealing and the short-lived satisfaction which they contribute in the classroom arrangement. It is also to assist them in advancing the skill of science process in observing (Kenya Institute of Education, 2002). The KNEC Chemistry Syllabus clearly exposes need for precise observations while carrying out experiments in class as it is considered a key objective of practical work in Chemistry (KNEC, 2006). Consequently, SPSTA required of students to make an observation and describe the changes occurring during the preparation of salts using the senses of sight, smell, hearing and feeling in describing chemical properties of salts.

Mbaluka (2012) explains that the preliminary tests that learners are required to carry out need to be trained to learners in order for them to be conversant with what is expected of them. An example is when the learner is expected to heat in a boiling tube, the learner should be trained to look for the gas produced, its colour, smell and effect on blue and red litmus paper. The learner should also look for the sound produced, the learner should also find out whether the solid melts the colour of the residues, look for water of crystallization or even a sublimate. The learners need to be told that when they are required to heat gently, they are only looking for the water of crystallization; which can be tested using blue dry cobalt (ii) chloride paper which turns pink. When told to heat strongly, then the learner should look for gases evolved which are tested using litmus papers or wooden splint (KCSE, 2019). In this study SPSTA used the observation skill in the heating of salts. Learners were trained on the skill of observation during heating.

The weakness identified in the candidates is that they are not able to make the correct observation hence it becomes difficult for the candidates to make the right inferences (KCSE, 2019). SPSTA on the other hand insisted on teaching using the observation skill in the levels outlined by KCSE (2019) and supported by Mbaluka (2012).

These levels of observation when a candidate is required to heat are seven in number and they include: Colourless vapour that condenses on cooler parts of the test- tube to form colourless liquid or blue dry cobalt, Chloride paper turns pink. This observation enables the learner to make an inference that a hydrated salt or water of crystallization is present in the salt; a gas that turns moist red litmus paper blue and does not affect the blue litmus paper. This observation guides the learner to infer that ammonium ion is present. A gas that turns moist red litmus paper to blue and a moist blue litmus paper to red; a white sublimate formed on cooler parts of the test- tube. The inference here is ammonium ion present since ammonium chloride decomposes on heating to ammonia and hydrochloric acid gas; the solid melts, a brown gas is evolved, and a cracking sound is produced, a yellow residue remained. The learner will then infer that both nitrate and lead ions are present. When a colourless gas is produced which relights a glowing splint; and the gas does not affect the colour of both red and blue litmus paper; the learner will infer that either a chlorate or a nitrate or a manganese ion is present and that the substance is neutral; a colourless, odourless gas that extinguishes a burning splint is produced. The learner can then infer that a carbonate is present; a colourless gas is evolved that turns a filter paper soaked in acidified potassium chromate from orange to green. The learner will infer that a sulphite is present (Mbaluka, 2012).

The science process skill of observation is also used to teach learners when adding water to a solid. For example, a learner may be given a procedure which reads; Put a spatulaful of the solid provided in a boiling tube; add ten cubic centimetres of distilled water. In this instance, the learner is expected to look for whether the solid dissolved or not. If it dissolves the learner should give the colour of the resulting solution (KCSE, 2019). There are four levels of observation in this case identified by Mbaluka (2012).

If the observation is, the solid dissolves to form a colourless solution, the inference will be:-

i) The Solid is a soluble salt / substance and that iron (II), iron (III) and copper (11) ions are absent.
ii) When the learner observes that the solid dissolves to form a green solution, the inference will be that iron (II), copper (II) ions present and that the solid is a soluble salt or a soluble Substance is present.
iii) When the observation is that the solid dissolves to form a blue solution. The inference is copper (II) ions present; the solid is a soluble salt or a soluble substance is present.

iv) on the other hand; if the solid dissolves to form a brown or yellow solution; then the inference is iron (III) ions present; the solid is a soluble salt or soluble substance present.

In another procedure, the learner can be required to filter the contents of the mixture obtained after dissolving. In such a case the learner is supposed to mention the colourless of residue and colourless of filtrate. Mbaluka (2012) identifies four levels of observation.

i) The solid dissolves partly to form a colourless filtrate and a white residue. The inference for this observation is: the solid is a mixture of a soluble and an insoluble salt; iron (II), iron (III) and copper (II) ions absent.

ii) When the solid dissolves partly to form a green filtrate and a white residue; then the learner can infer that the solid is a mixture of a soluble and insoluble salt; and iron (II) or copper (II) ions are present.

iii) In the case where the solid dissolves partly to form a blue filtrate and a white residue; in this observation; the learner will infer that the solid is a mixture of a soluble salt and an insoluble salt; and copper (II) ions are present.

KCSE (2019) identifies the following common Mistakes in the learners' observation and inference: Students write a white precipitate instead of white residue; there is a wrong assumption that only iron (II) salts are green; some copper (II) salts are green for example copper (II) carbonate.

A learner can be required to describe the appearance of a solid. In that case KCSE (2019) outlines the following possible observations: - a white powder, a white crystallize solid, a blue crystallize solid, a brown crystallize solid, a green crystallize solid.

The Common errors that candidates make in chemistry practical identified by KCSE (2019) are:-

i) No observable change – the learner should instead write no white precipitate is formed.

ii) No colourless change – the learner should state the colourless that does not change.

iii) White solution – the learner should write a white precipitate is formed.

iv) Clear solution –the learner should instead write that a colourless solution is formed.

It is evident that observation as a science process skill is key to making any progress in Chemistry practical. Teachers should use appropriate teaching method which will enable the learners to master the skill of observation. SPSTA in this study was to address the gap in observation skill mastery through training.

(ii) Classification skill and its use in SPSTA

As per the Kenya Institute of Education (2002), one of the objectives of chemistry entails that after finishing the course, the learner should be in a position to identify patterns in the physical and chemical behaviour of substances. Classification also involves the organization of events or objects, regard to similarity and differences as picked by the observer. Classification too is about arranging elements into classes guided by shared characteristics and the sequencing of elements resulting from the relationships amongst them (KIE, 2002).

In the use of SPSTA, the learners identified patterns in solubility of salts and classified salts as either soluble or insoluble; learners also exposed salts to the atmosphere and classified them as deliquescent, efflorescent or hygroscopic. The learner also classified salts as carbonates, nitrates, chlorides, sulphates or ammonium salts by observing the effect of heat on these salts as per the secondary school Chemistry syllabus.

(III) Experiment and its use in SPSTA

KIE (2002) recommends that Chemistry should be taught using experiments. The secondary school chemistry syllabus states course objectives that; the student should be able to pick and use the right apparatus involved in experimental work. The learner should be able to demonstrate accuracy in measuring, observing and in coming up with well argued deductions emanating from experimenting. Learners should also be able to appreciate the importance of safety precautions when carrying out experimental investigation (KIE, 2002).

Consequently in the use of SPSTA, the learners were required to follow a given procedure to carry out experiments and make logical conclusion on methods of preparing salts, determine their solubility and find out how heat affects the salts; according to the secondary school Chemistry syllabus.

### 2.2.2 SPSTA and Acquisition of Science Process Skills

Science process skills are vital skills in giving solutions to challenges faced or carrying out experiments in science (Mutlu & Temiz, 2013). Integrated science process skills in particular demand an advanced and informed understanding base (Ozgelen, 2012). The acquisition of science process skills is better attained in advanced stages of learning (Cepni&Cil, 2009). Findings of a study by Khan and Zafar, (2011) in Pakistan on how inquiry laboratory instruction will affect the development of scientific skill in biology subject, show that the students taught using inquiry laboratory teaching method had a better performance in scientific process skills as compared to that of the group of students who were taught using the traditional laboratory teaching method.

These findings are also supported by Remziye (2011) in Turkey who reported that students succeeded in science through being trained on science process skills in projects while learning. Bilgin (2006), also in Turkey supports using hands on activities together with cooperative learning approach. This way, he found out that students gained more science process skills in learning science and their attitude towards science changed positively when comparing with those of students taught using traditional laboratory methods. In view of Clough (2002), laboratory experience should go beyond being an activity with already known results, but instead they should be true experiments, and not made up activities that do not occupy the mind of the student.

Involving learners as proposed by Clough (2002), is by integrating investigation as an activity in teaching. This happens when laboratory exercises are used in a way which the students formulate the questions and then do investigate. The procedure is then followed by reporting the findings of the investigation. In this, the teacher in the classroom provides guidance and advice, the teacher should however, not inform students of the possible results before the learners complete the exercise (Burak, 2009).

The sex of the student, the locality and category of school does not impact on how the learner acquires science process skills. Meanwhile, students' attitudes, availability of enough, well equipped laboratories and class population influence the gaining of science process skills (Jack, 2013).

Activities for teaching science process skills are useful for planning solutions to identified problems (Mutlu & Temiz, 2013). When teaching integrated skills, it calls for a well developed mind in knowledge (Ozgelen, 2012). The science process skills teaching approach activities become deeper in higher stages of learning (Cepni&Cil, 2009). Findings of Khan and Zafar (2011) on how this approach will affect the advancement of scientific skill in the teaching of biology showed that students who were exposed to the treatment of instruction using science skills approach exhibited good development in the scientific skill when contrasted with students who were instructed with other regular methods.

SPSTA focused on two basic science process skills: observation and classification, and one integrated science process skill: designing an experiment. These were the skills the learners were trained on and this was intended to fill the gap of poor achievement by learners in chemistry.

Sukarno (2013) identifies three main steps in science process skills teaching approach as follows below:

(i) Lesson planning

Planning is the first important step in science process skills teaching activity. Good planning leads to a lot of achievements on the learning process. With regard to SPSTA, planning includes, determination of science process skill which will be taught to students, prepare what will indicate that the skill has been attained by the learner, put in place evaluation techniques to be used and to develop the teaching/ learning activities to be employed during the lesson (Sukarno, 2013).

(ii) Carrying out teaching activities

Sukarno (2013) identifies the step which comes second in science process skills teaching approach as putting into action what had been developed earlier. The success of this stage in SPSTA is largely embedded in the planning level.

(iii) Assessment of teaching approach

This is the last stage in the instruction process using SPSTA as outlined by Sukarno (2013). During this stage, decision on whether there was success in learning done. The effectiveness of the levels of planning and execution is evident from the end product of assessment. In SPSTA, evaluation of science process skills of students becomes crucial (Sukarno, 2013). Activities in this stage would entail, availing grading instruments, acquiring evaluation instruments and designing the evaluation styles, determining the authenticity of instruments, difficult index is calculated difficulty and display the findings of evaluation.

In SPSTA, the teacher was provided with the plan for teaching in each lesson in the teachers' manual (Appendix A) which specified the content, the resources and the science process skill to be used for the lesson. The expected outcome was well spelled out which enabled the teacher to assess whether the science process skills teaching approach helped in achieving the lesson objectives.

### 2.2.3 SPSTA as a Form of Inquiry Learning

Inquiry is the skill through which students realize new causal relations by coming up with a proposal of solutions to a problem. These proposals are then verified through carrying out experiments and collecting data (Pedaste, Maeotos, Leijen & Sarapuu, 2012). Scientific inquiry is defined by the National Science Education Standards (NSES) and the National Research Council (NRC), 2000 as various means which a scientist investigates the cosmic world and presents explanations anchored on the results they come up with from their research. The instruction processes during which students are allowed to pose personal concerns, make arrangements on how they will perform their inquiries, analyze and explain their results and come up their self understanding results in acquiring knowledge which is efficient and memorable (Metz,2004).

Pedaste et al. (2012) identify five phases of inquiry-based learning which include; (i) orientation, (ii) conceptualization, (iii) investigation, (iv) conclusion and (v) discussion.

Orientation phase is the level where the learner is appealed to the problem and the desire to find out is aroused. The topic to be handled is introduced by the immediate surrounding or it can be initiated by the teacher or it can be identified by the learner. The independent and dependent variables are identified. This leads to the statement of the problem (Scanlon, Anastropoloulou, Kerawalla& Mulholland, 2011). Conceptualization calls on the learner to have an understanding of the concepts that will relate to the stated problem in the orientation phase. This phase is categorized to the following two sub genres: questioning and generating of hypothesis. Questions will help the learner to generate research questions to the stated problem. When a learner generates hypothesis, then the hypothesis is testable. Both questioning and hypothesis are anchored in justifying the theory with the independent and dependent variables (Maeotos et al, 2008). Investigation entails the learner turning their curiosity into doing so as to be able to tackle any given research questions or hypotheses (Scanlon et al., 2011).

Bruce and Casey, (2012) hold that the investigation phase is where the learner's desire to know is turned into action, so as to give response to questions of research or premises. This calls on learners to explore experiment and interpret data. Conclusion will involve making basic conclusion of a study are stated. The students should focus on their hypotheses and research questions (De Jong, 2006). Discussion phase entails the learners reflecting, communicating and presenting their results and deductions to the rest, and as well get responses and the mind of others by using practices like, assigning a duty to fellow students, diary jotting and narrating are evidence of this phase (Runnel, Pedaste & Leijen, 2013).

SPSTA employed the steps of inquiry-based approach in teaching where the learners were presented with the problem first. The teacher then explains to the learners what is expected of them by issuing to them the intended objective of the lesson. The learners proceeded to generating the question which enabled them to meet the objective of the lesson. This was followed by an investigation through an experiment in order to answer the questions generated. As the information was being gathered during the experiment, the learners used this information to draw conclusions on the lesson. This conclusion was followed by a discussion with the teacher as learners presented their findings to the whole class. SPSTA thus followed these steps.

Following these steps brings about values which consequently benefit students in areas like, becoming pro- active, building understanding, increasing techniques on how to research and understanding of what science is about as explained by (Metz, 2004).

Bilgin (2006) incorporated co-operative learning strategy with guided inquiry and used it for instruction to investigate the effect it will have on the achievement scores of learners. Bilgin (2006) carried out the study on university students. His purpose was to find out how this approach to teaching influenced their achievement on acids and bases concepts and what feelings the learners had toward guided inquiry instruction in Turkey. A population sample of fifty-five first year university students, from two classes of chemistry was used. One of the classes was taught using the inquiry strategy, while the other class was taught using regular methods of teaching. The findings of his study indicated that students in the inquiry class had better understanding of the concepts involving acids and bases, and also had a more positive attitude towards guided inquiry instruction when compared with students in the other class where instruction was through other methods of instruction in both cases.

Ibrahim (2009) also studied on how of inquiry based science teaching affected elementary school students' science process skills and science attitudes in Turkey where a total of 241 students took part in the study and a pre test-post test control group and experimental group research design was applied, the outcome of the research indicated that the use of inquiry based teaching methods largely promotes the learners' feelings and skills.

Wachanga (2004) carried out a survey on secondary school teachers whose teaching experience was three years and above. The purpose Wachanga (2004) study was to investigate whether secondary school chemistry teachers were incorporating inquiry approach in their teaching. He sought to find out how often inquiry approach was being incorporated into chemistry classroom activities and to find out whether teacher's gender affected the use of inquiry teaching approach.

Chemistry lessons of the sixty-four teachers were observed and rated using an inquiry teaching observation instrument. The evaluation criteria were organized into four categories which were: - the lesson, student behaviour, teacher behaviour and questioning techniques. The research design used was a quantitative study, in which a survey was done on secondary school teachers of chemistry.

The outcome of Wachanga (2004) study indicated that 33 male teachers scored 55.79% while female teachers scored 60.65%. The overall mean was 58.14%. These results indicate that the level of inquiry is not enough because most chemistry lessons should give the students a chance to find out information themselves rather than the information being exposed to them by their teacher. Further inquiry teaching approach by male and female teachers test indicated that the scores in terms of the mean, for male and female teachers was not different, statistically, $t(62)=0.32' > 0.05$ values indicating that the male and female teachers should use inquiry method for teaching equally.

During data collection, it was observed that teachers had special difficulties in areas involving student's activities such as; students formulating and testing hypothesis, student's analyzing, interpreting and evaluating data. These are areas where chemistry trainers should give special attention during training.

The revelation that, the application of inquiry teaching approach in the classroom for instruction by teachers is average; is an indicator that there is a high amount of direct teaching in chemistry classrooms. On the other hand, when inquiry approach is used for teaching Chemistry, students acquire and retain chemistry skills better than when direct teaching approach is used. Wachanga, (2004) reported that the performance both male and female teachers is not statistically different in inquiry approach. These findings suggest that inquiry approach should be emphasized more during pre-service and in tertiary colleges. In this study, SPSTA was used incorporating the phases of inquiry learning developed by Pedaste, Maeotos, Leijen & Sarapuu (2012) of orientation, conceptualization, investigating, conclusion and discussion. SPSTA was put in place to address the problem of teachers failing to adopt inquiry lessons.

SPSTA is an inquiry form of teaching. In its use; it put into account the four levels identified by Banchi and Bell (2008) enlisted as: (i) confirmation level, (ii) structured level, (iii) guided level and (iv) open level of inquiry. At confirmation level, the learner is presented with the problem and the steps to follow in order to come up with an answer to the stated concern. The expected outcome is made known to the learner in advance. Essentially, the aim of the lesson is to proof the given answer. This level is useful when reinforcing already learned content, to participate in outlined investigative processes or to master a specified science process skill for example, gathering and organizing data. In SPSTA, the teachers were using this level of inquiry learning especially in reviewing the previous lesson in trying to find out whether the learners had mastered the skill in the previous lesson.

Structured level is the kind of learning where the learner has access to the question and the clear procedure to lead to the answer to the question. The learner is charged with the task to come up with an explanation which is backed up by the evidence gathered from the investigation (Banchi & Bell, 2008). This is the level which most of the SPSTA lessons employed; the learners were given the objective of the investigation. The procedure to be followed in the investigation was also given. The learner was expected to follow the given procedure to collect data which the learner uses to draw conclusion on the lesson.

In guided inquiry, the learner is presented with only the research question. It is up to the learner to come up with the methodology to enable him/her to answer the question and provide supporting explanations. Guided inquiry involves the learner more than a confirmatory or structured inquiry, it will be more useful when learners have been given many opportunities to learn and practice different ways to plan experiments and gather information for responding to presented problems (Bell, Smetana & Binns, 2005). Guided inquiry was used in SPSTA to teach the science process skill of planning an experiment. After learners had several opportunities to learn, they were provided with opportunities to plan an experiment to investigate a given question of study. The learner was expected to provide the aim of the experiment, the procedure of the experiment and to carry out the experiment using the provided procedure, collect and record data. The learner was also expected to use the data obtained in order to make appropriate conclusions based on their findings.

In open inquiry, learners create a problem for investigation. The learners decide on the way to plan activities to enable them to find solution to their problem. The learners then report their findings. In SPSTA, learners were advised to formulate independent investigations to be able to answer questions which come up during their personal study time on the topic “salts” the teacher provided the required apparatus and reagents for the leaner to carry out the investigation. Each level of inquiry focuses on how much information is made available to students and the amount of guidance the teacher will need to provide to the learners (Banchi & Bell, 2008). This study employed the four levels of inquiry in order to fill the gap identified by Wachanga (2004) that teachers rarely use an inquiry approach to teaching in class.

When students are presented with an opportunity to explain some knowledge to their peers, they develop a high level of concept knowing of shared content; they also recall it easily because the learning becomes more permanent. Using groups for teaching allows learners to develop socially and attain their academic goals at the same time (Johnson & Johnson, 2009).

Duplass (2006) agrees that there is an increasing need for interdependence in all levels of our society. Using groups give students an opportunity to develop collaborative techniques, since is it is individual contribution and commitment which will bring about attainment of group goals.
Expository teaching approach is likely to encourage competition among learners. In a competitive environment, the students who compete tend to resent those who succeed, a situation that negatively affects learning. Co-operative learning on the other hand is an instructional procedure which depends on students’ motivation and hence improves their performance (Gewertz, 2006).

Johnson and Johnson (2009) warn that students should not just be put in groups without considering the workability of the groups. They say that this in itself does not produce co-operation and higher achievement; they argue that some group members sometimes will depend on others to work and this will benefit the high ability group members who will be willing to go an extra mile to work as lower achievers become spectators; as a result, peer pressure to be like the rest may kill team spirit. If students are to gain from co-operative group work, they have to believe in one another, share information accurately and unambiguously, be willing to help one another, and address their differences amicably.

On this argument, Johnson and Johnson (2009) have outlined seven basic elements that should be included for the successful functioning of the co-operative groups; they include:- (i) Group harmony brought about by combining four to five members with varied personalities to encourage group competition and not individual competition.(ii) clearly stated group goals and beneficial interdependence. It calls for every group to come up with one goal and members should assist one another to achieve the group goal. (iii) Healthy interaction requires students to be guided how to assist one another to work towards the stated objective in the group. This can be done by training them in techniques such as peer tutoring where they are encouraged to ask questions to develop one another's reasoning and mutual encouragement. These are some of the ways which can assist the group achieve its goals, (iv) personal responsibility calls for every member to put their individual effort towards the goal. This comes in the form of minimum grades, group averages above a specified level, and/or particular contributions to the overall activity, (v) Social skills: good relationships occur when group members are able to effectively share information during group meetings. Such skills would include good leadership, logical decision making, clear communication and conflict resolution. These should be taught to students, (vi) Equal opportunity of success – each students' individual contribution should be welcome to the group, (vii) Group competition – this can be achieved by forming groups with well matched members who act as a team to compete favourably with other teams for the success of a group. SPSTA used small groups of between three and five members for teaching. The groups were formed by taking into account the elements of cooperative learning.

Co-operative learning has been found to develop in students the ability to improve the depth of comprehension of subject matter (Molly, Dingel & Aminul, 2014). Dallmer (2007) holds that through co-operative learning, learners' individual responsibility and social skills are enhanced. These attributes are important for both cognitive and psychomotor learning since they create the propelling drive to learn and this leads to more permanent learning (Davidson & Major, 2014).

Cooperative learning also increases students' reception of content, academic performance and class participation. The conditions in this kind of learning environment gives students an opportunity to respond to the concern raised by their peers; this arouses the desire and the flexibility to take more time to understand the content that was not read well by consulting from their peers (Dallmer, 2007).

Thomas (2014) found that first year students in Lowa University, America, developed a demand for authenticity more positively when they were instructed using cooperative learning activities, as opposed to learners who did not engage in cooperative activities. These results support cooperative learning as it exposes students to engage their mind, a fact which is likely to change their lives.

Norah (2015) studied how cooperative learning would affect academic performance of students in Saudi Arabia. One set of students were instructed through cooperative learning technique while another set used expository lecture method. Results showed that students who were taught using cooperative learning approach gave an impressive performance on the content when compared to the students who were taught using lecture method, hence cooperative learning had a positive impact on the students' academic performance in Saudi Arabia.

Andrew and Scott (2017) carried out a descriptive survey with follow up statistical tests to determine how choice of instructional method impacts on the efficacy of cooperative learning in chemistry using meta-analysis. The results indicate that cooperative learning pedagogy leads to learning gains on various aspects chemistry which include; chemistry achievement, various evaluation techniques, frequency of application and the size of the group.

Johnson and Johnson (2009) have given the intended purpose of cooperative learning as; to develop students' interpersonal skills of interaction and expression, increase appreciation of individual differences, and to increase the learner's academic attainment. Other Research findings indicate that through participated in cooperative learning, students expose minimal competing nature, and increased ethnic appreciation when compared with those engaged in entire class teaching. This implies that Cooperative learning promotes flexibility and adaptability amongst students with special needs, varying races and ethnicities.

From research, it has also been proven that through collaboration, human beings process personal meaningful content which makes them to learn well. Cooperative learning has been identified as an innovative teaching practice which will help the learner to realize their potential as it promotes greater cognitive fulfilment, provides ways of finding answers and attainment (Johnson & Johnson 2009).

Moore's (2005) research found out that after an expository lecture, students were only able to retain only five percent of the subject matter presented after twenty-four hours. In a teacher demonstration, students retained thirty percent of the information after twenty-four hours of instruction. In contrast, when students are exposed to content using strategies having major components of co-operative learning, for example, by practicing their new learning or teaching it to others, or making use of their learning immediately, they were able to retain between seventy-five and ninety percent of the material after twenty-four hours of instruction. These realizations call upon additional strategies to be used to support the existing instructional strategies to promote student learning.

Co-operative approach to teaching aids students to develop their mental faculties. This is achieved when the learners come up with their own style of learning to enable them understand content. The students are able to tell to others clearly what they know.  Through sharing and listening to others; what was not clear to them when they were reading becomes clear (Chin & Brown 2000).

When students are taught using Cooperative strategy, students are kept busy throughout their lesson because they do not have to wait for the teacher to engage them. When the learners set their own targets, then they will research and have an opportunity to expose to group members their thoughts and also get to accommodate the ideas of peers (Johnson & Johnson, 2009). Learners have an opportunity to 'tell' others as well as train in the skill of listening to others and take up learning responsibly creating a learning environment conducive for academic excellence (Warfa 2016). The groups for teaching SPSTA were constituted based on cooperative learning elements in view of constructivism which holds that knowledge is both individually and socially constructed.

### 2. 2.4 Science Process Skills Teaching Approach and Chemistry Practical

UK(2002) House of Commons Science Technology Committee raises concern over the quality of science practical and laboratory work in schools. If the attainment of learners in science has to improve, then the quality of the science practical and laboratory work is fundamental. According to Ottander and Grelson (2006); the goal of science practical is help learners to advance in analysis and positive criticism together with interest in science learning. Good quality Chemistry practical 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 both levels of science process skills.

In SPSTA, Chemistry Practical involved both teacher demonstrations and class experiments; where the pupils performed experiments. In SPSTA, Class experiments were preferred more than teacher demonstration for reasons discussed in other sections of this study.

According to Wachanga, (2005) Practical work aims at imparting the following to the pupils

(i) Develop accuracy in making observations and readings during experiments for example, colourless changes, formation of precipitates, evolution of heat and taking burette readings, (ii)The ability to interpret practical experience that is the interpretation of results, (iii) the ability to plan and carryout experiments, (iv) appropriate manipulative skills. Handling approaches such as answering and asking questions and gives a clear representation and interpretation of experimental results.

Further, he identifies the following main parts of a practical; (i) Teachers preparation where; the teacher considers the apparatus and chemicals to use, Tests the apparatus and chemicals considers the method of giving out instructions e.g. by writing them on a chalkboard or by preparing a worksheet. (ii) Performance of practical: the efficiency of this will depend on the instructions given. (iii) Discussion of the results: This will always lead to the conclusions. These steps were followed during execution of SPSTA.

With the following three types of class experiments which include: (i) each pupil or group performs identical experiments at the same time. The results are collected, discussed and conclusions made. This class experiment is used when the apparatus is simple and plentiful. This is the most common type of class experiment. (ii) Each pupil or group of pupils performs different experiments. Through rotation, all pupils perform all the experiments. This pedagogy is applied when apparatus are insufficient. (iii) Each group of pupils performs different experiments. There is no change of stations. The findings are gathered and analyzed with everyone in class. This is suitably used when the same response is sought using a variety of substances. The type of class experiment to use depends on the following; the nature of experiment, equipment available, time available, the size of the laboratory, the ability of the pupils the teachers' skill and the control of the class. In this study, SPSTA used the type of class experiment where each group performed identical experiments at the same time.

Wachanga (2005) holds that in Planning of a class experiment, the worksheet is the best method of giving instructions to the pupils in a class experiment is through a worksheet. This is because worksheets have the following advantages: -They allow the pupils to work at their own pace, they help the teacher to avoid repeating him/herself severally giving oral instructions, Through the worksheet, we encourage the pupils to think for themselves about the results of their own conclusions, they save time, the teacher does not have to copy the instructions on the chalkboard, numerical results could be recorded in tables, diagrams and graphical work are included, Worksheets replace or organize written notes .Copying of notes into notebooks is not an effective reinforcement and careless copying can cause inaccurate records They help they teacher to keep an accurate record of what the pupils actually learnt in a piece of work.

A worksheet must have; an introduction, having fundamental information regarding that particular work. Length of introduction depends on the material to be covered. The other part of the work sheet is the main body. The design of the main body includes; Experimental procedure, ways of capturing findings for example a table of results guidelines on safety and warnings statement on summary which entails the deductions from experiments. By doing this; the practicality is exercised in daily life. Question relating to the experiment should be asked as this helps pupils to apply their results in problem solving. SPSTA used worksheets which made it easier for the teachers to give instructions to the students during experiments.

Wachanga (2005) identifies the following procedure in conducting a class experiment session. First ensure that the students have the apparatus they need in their groups. Once the pupils have the apparatus they need in their groups, next thing is to give instruction. If pupils are given good instructions, then they can work very well on their own. It is not sufficient to give only written or oral instruction .The instruction in the worksheet should be clarified orally with the help of a chalkboard if necessary. There is need to demonstrate how to use any new apparatus and discuss the safety precautions before the pupils are allowed to start working. It is generally good to give all instructions before the start of the practical, but that does not bar the teacher from clarifying a point by calling the class to attention to give further instructions or go round to all groups and give them new instructions.

While the pupils are working, the teacher supervises them by moving from one group to the other, explaining, responding to questions as well as asking questions bordering the conducted experiments and rectifying mistakes. The teacher should give an ample time for pupils to clean up and hand in the material they have used. After experiments are over, a summary of the results and a discussion should follow direct in the same period. The teachers should conduct the discussion by asking for observations made and the results obtained with the help of these, the class draws the desired conclusions (Wachanga, 2005).

The skills and abilities that may be tested in an experiment are classified according to the categories in the cognitive domain of the taxonomy of Bloom of objectives of education. Some traditional methods of instruction have had their roots in Blooms taxonomy of learning (Bloom, 1956). It is from this taxonomy where it is contended that different levels of learning call for different teaching methods. Levels of learning according to Bloom are cognitive, affective and psychomotor. These are also referred to as domains.

Cognitive domain has six, outlined learning levels namely:(i) knowledge,(ii) comprehension, (iii) application, (iv) analysis, (V) synthesis and (VI) evaluation. Walklin (1982) advises a traditional approach of teaching that also incorporates programmed instruction as a more advisable approach for effective delivery at secondary school level. The affective domain, which emphasizes value, degree of internalization such as attitude, feelings and emotions would be approached from instructions such as discussion, case studies or role playing.

Psychomotor learning is best acquired by active physical participation so that demonstration followed by practice experimentation or project work may be employed. It has been argued by several authors (Sharma, 1967; Walklin, 1982) that when such methods incorporate process skills that are learner centered, the combination would be the best approach for a Chemistry lesson. This research on SPSTA was about science process skills that could be incorporated with some expository (traditional methods) forms of instruction such as teacher dominated lecture, teacher discussion, laboratory practical and teacher demonstration as reviewed below.

(i)Knowledge: Pupils were examined to test their knowledge of chemical language and conventions including definitions and the meaning of techniques and setups and basic generalizations in chemistry.

(ii)Comprehension: Pupils were tested to determine how well they understand common phenomena by drawing valid conclusion from observation made or from results of experiments. The extent to which the learners can utilize chemical laws and principles in solving standard problems and their ability to spot common mistakes to determine the validity of arguments was tested.

(iii) Application: Pupils were tested on the ability to apply the law and principles underlying chemical knowledge to problems and to choose the most appropriate methods of designing investigations.

(iv) Higher abilities and skills: Pupils were tested on the ability to establish how far certain generalizations can be put into use to specific situations; by taking into consideration assumptions that were explicitly or implicitly stated in those generalizations.

## 2.3 Regular Teaching Methods for Teaching Chemistry

Chemistry should be taught by using discovery approaches to teaching which are learner centered. The teacher becomes the facilitator of the learning process. KIE (2006) identifies teaching strategies which are commonly used to instruct chemistry in schools which include: Class experiment, teacher demonstration, class discussion, projects, question and answer and informal lecture.

(i) Class Experiment

KIE (2006) recommends the use of class experiment for the teaching of chemistry where the learner is given an opportunity to put theory into practice by engaging in a practical activity. This enables the learner to develop manipulative, managerial and scientific skills. According to Mohanty, (2003), observes that at times, the large size of the class, lack of equipment and insufficient materials can make it expensive, becoming difficulty for a learner to conduct an experiment individually. It is also time consuming in terms of preparation for the class experiment. This study investigated class experiment method which was incorporated with science process skills and used it for teaching. The skills which were incorporated were skills of observation, classification and experiment. These skills were practiced as the teacher was guided by the teacher's manual (Appendix A) for SPSTA.

Chemistry experiments encourage precise observation and explanation. Dillon, (2008) too argues that chemistry experiments make the situation more real; they also stimulate and maintain attentiveness in the learners. Experiments also promote logical reasoning technique. Despite the advantages of experiments and the fact that the teaching of science makes an appeal to teachers to allow students to carry out experiments; research has shown that there is a gap between practice and policy since teachers advocate the use practical (Dillon, 2008).

Lunetta et al (2009) established that students take a lot of time in reading procedures in as much as there is need to overhaul this practice to embrace equality experiments. They explain further that the learner will not be able to conceptualize from that procedure the intended experimental aim. Lin and Lin (2007), refer to the situation where learners obtain data by emphasizing on showing to learners , reading steps to be followed then measuring and recall as 'traditional approach'. On improving Chemistry experiments, they suggest that learners should be given enough opportunity to creatively conceptualize on how they will carry out an investigation to enable them achieve set targets.

Dillon (2008) argues that such traditional practice makes the students to remain passive during the experiment, a behaviour which makes the learners to practice skills at low level only. SPSTA helped improve the quality of experiments in that the learners were given an opportunity to practice some selected science process skill in line with the experiment to explore the skill in a new situation, this way the learner's interest was maintained throughout the experiment, understanding of the content was enhanced and further learners became innovative in learning.

The kind of teaching experiment where teachers had developed the habit that the learners follow a 'recipe' in order to become thorough in a scientific skill by following a step-by-step procedure in the laboratory manual without allowing students to internalize, might not assist to advance knowledge of science and specifically in the subject of Chemistry(Johnstone et al, 1994). This implies that the way the experiment is carried out and the level to which the learner is engaged during the experiment determines the level of attainment during the experiment. Curricular in many countries including Kenya (KIE, 2002) recommend the use of experiment for the teaching of Chemistry. This will greatly assist in imparting knowledge as well as abilities; there is concern on how to carry out experiments to realize its usefulness. SPSTA helps improve learner engagement and science process skills development.

Some of the successful countries in teaching science in the world include Japan, America and England. These countries give prevalence to student-oriented and active teaching styles. Japan's education system for example, is comprehensively student oriented where the student takes part in class activities, carries out researches and studies books. In this system, the teacher is a student's consultant and guider where necessary (Japan's ministry of education site).

England on the other hand, the teacher should set a series of challenging programs for students, caring for learning needs of students and also individual and group evaluation of students. The teacher is a consultant and guider. Priority of the learning activities is designed for learners in Britain (Britain's ministry of education site).

In America, the teaching programs of all science subjects should be through exploring and discovery, where the teacher organizes activities along with guiding and evaluating the learning process. The teacher should develop an academic environment conducive to make it possible for learners to have maximum gain from instruction. The teacher guides the learning, such that the student is able to explore and discover relations on their own. SPSTA on the other hand occupies the place as a leaner centered method of teaching where the teacher guides learners and allows learners to be actively involved in learning as they practice the science process skills and make discoveries in new situations.

Ibrahim (2014) carried out a case study among Chemistry student teachers who had been taken through practical teaching at the University of Technology, Malaysia, and faculty of education. The purpose of the case study was to critically review the approach to teaching chemistry by student teachers. Qualitative data was gotten from video recording of student teachers' lesson as they applied teaching through experimentation. The lesson plans which were being used by student teachers were analyzed. Student teachers were also interviewed. Brief interview with the student teachers were held to establish their point of view on supporting experiments. Each of the student teacher's approach was related to inquiry strategy, direct instruction or constructivism approach to draw familiarity.

Direct instruction, as described by Santrock (2009) is the type of experiments which are highly skewed towards the instructor who directs and controls learning. The teacher has high expectations on student progress, hence concentrates on academic task activities. There are less non-academic interactions between the student and the teacher.

Inquiry strategy, as explained by Savery (2006) is the kind of teaching which is learner centered. The teacher provides hands on learning opportunities to students by ensuring there are right resources for the learners to use. The learners are accorded freedom to move at their own speed, and how they want to learn. The teacher facilitates and guides when needed. Inquiry strategy experiment focuses on presenting opportunities to learners to ask self directed questions. They then engage their mind to come up with the steps they will follow to be able to answer their questions.

Constructivism approach is a five phase model. The first phase is orientation, where the teacher introduces an experiment in such a way as to attract the students' attention and interest in the experiment that follows. Elicitation is the second phase. The teacher gets ideas on what the students' prior knowledge is concerning the experiment beforehand. It is followed by restructuring phase, where the teacher using the learners' prior knowledge and ideas concerning what the learner perceives what they are about to do, identify the ideas that need improvement, development or replacement with scientific data. This can be done through for example explanation to learners and exchanging ideas in order to establish available choices and criticize existing knowledge. It can also be achieved through exposing the conflicting ideas to test whether they agree with current knowledge. This will lead to the development of new ideas through improvisation, development or replacement with new ideas. The validity of the new ideas needs to be tested by evaluating them. The fourth phase is application of the new ideas to a different situation. The final phase is reflection which requires that the learner's ideas are adapted to the scientific ideas (Good & Brophy, 2003).

Ibrahim (2014) used ten student teachers in five groups of two student teachers each and observed them three times on how the experiment method of teaching was being practiced by the student teachers. Group one, which was teaching the Chemistry content 'soap preparation' the teacher asked questions to draw their attention and establish the depth of their knowledge. The teacher attracted the learner's attention by showing the students a video clip on soap commercial. The teacher told learners what was in the experiment before the start of the experiment.

The teacher expected to achieve two learning objectives in a forty minutes lesson. This was a high set of expectation towards students' progress. The students were given a prepared guideline having steps to adhere. The teacher stressed the need of academic resources as they discussed queries in the book of practical. The teacher dominated student activities throughout the experiment. Two students took part in demonstrating the experiment to the rest of the class hence there was minimum learner participation in practical work. During the demonstration, the teacher continued to give instructions to students on what to do in every step. Generally direct instruction dominated the teaching by this group with two early stages of constructivism approach of orientation and elicitation. The lesson was highly structured and teacher centered (Ibrahim, 2014).

The second group taught the Chemistry content ‘rusting as a redox reaction’. Teachers’ set induction was not having any relationship with the experiment. The instructor asked learners how a rusted spoon affected their lives; which did not relate to a redox reaction. The teacher preferred to display a video where the student teachers were demonstrating the experiment. The student teachers dominated the discussion on the findings of the experiment. The lesson was teacher controlled with very few amount of hands on assignments for learners (Ibrahim, 2014).

The third group taught the Chemistry content ‘Thermochemistry’. During the lesson, Ibrahim (2014) observed that there was a great extent of interaction involving the teacher and the learner when discussing photographs having a bearing on exothermic and endothermic concepts. The lesson lacked questioning or inquiry experiment. It was a very theoretical and teacher friendly approach.

The fourth group taught the Chemistry content ‘chemical properties of Ethanol’. Ibrahim (2014) observed that the student teacher missed out pointing out clearly the safety precaution for students and that student teachers were in charge during the experiment and they were very focal when discussing results. There was minimum learner participation as the student teachers used direct instruction. It was a highly structured and teacher centered lesson.

Group five taught the Chemistry content ‘oxidation’. Ibrahim (2014) noted that the student teacher’s lesson introduction attracted the learner’s attention by carrying out an experiment to show colourless change at the start which was relevant to the lesson. Students were explained to about the safety precaution required in the experiment and were then were required to go through the procedure before conducting the experiment. The student teachers showed a video clip of findings of an experiment which used similar reagents. There was no student involvement through question and answer as students presented their findings. Student teachers in this group gave to students well written instructions about the procedure and this acted as a guide to students throughout the experiment. The experiment was carried out in groups. The student teachers in this group employed moderate level of academic and demonstrated a level of student involvement. The lesson exhibited inquiry learning; especially when students were presenting data. The lesson also included constructivism approach stages of orientation and elicitation.

From Ibrahim (2014), it can be shown that all teachers in the five groups applied a method which organized activities pointing towards the teacher instead of a learner based approach to experiment teaching. Weakness was shown from the student teachers especially in discussing what was expected in the experiment before doing it, emphasis on academic material, setting high expectations from students within a short time, minimum learner activities, teacher controlling and directing learning activities during the lesson and the entire discussion. There were rare occasions for which students attempted to inquire throughout the steps of the lesson.

For SPSTA to be successful, these weaknesses have to be taken into account so that the teacher ensures maximum learner involvement during the lesson.

The interview results from Ibrahim (2014) with the student teachers concerning their decision to teach experiment method the way they did shows that they preferred to teach this way because they found it time saving. They also taught that by controlling the learner's activities, they were managing the class. Others said that they read the procedure to reinforce expectations in the lesson. Still others said that they were ensuring that the instructional objectives that they had set earlier were being achieved; however others said it was a common method that they had been used to.

Despite all these views held by teachers to justify the use of the experiment method applied, it is important to point out that with proper laboratory activities selected in learning Chemistry; cognitive, metacognitive and practical skills as well as the learner's interest to learn Chemistry are enhanced (Hofstein, 2004). Experimentation maximizes the learning of abstract concepts and theories in Chemistry; the main barrier for student's learning is not the experiment itself, but the way in which the teacher chooses to teach the experiment (Ibrahim, 2014). SPSTA is an intervention which can be applied to teaching to look into the issue of quality of experiments so that the learner is enabled to learn expected concepts and skills.

(ii) Teacher Demonstration

In the event that the availability of chemicals and apparatus are insufficient, or an experiment poses danger, like when hydrogen burns in oxygen, production of toxic gases, and reactions involving very reactive chemicals such as sodium, potassium and phosphorous, a teacher may perform an experiment assisted by learners (KIE, 2006). This approach when contrasted with the class experiment, is more manageable in view of materials needed and in terms of teacher's preparations, it requires much planning and preparation. Its disadvantage is that it is expository in nature. As a result students do not find time to interact with materials effectively and come up with something new (Nayak & Singh, 2007).

Demonstration is a pedagogical technique which can be used in the classroom to engage students in a scientific lesson better than typical lecture (Meyer et al. 2003). Demonstrations enables the teacher to assess the understanding of the learners since the teacher poses questions on the topic being demonstrated and receives instant response, which is then used to assess the need for a follow up on what has just been taught (Pierce & Pierce, 2007).

From as early as the 1930's Knox (1936) observed that using demonstrations to teach could save money. With increased class size and steady stream of budget cuts and short falls, comes less money for the purchase of necessary equipment and supplies for Laboratory experiments. Demonstrations will go a long way to cut down some of these costs, for instance the expense on equipment and chemicals since a set of apparatus and reagents can be used for the entire class (Dillon, 2011).

Demonstrations on the other hand are useful in giving learners an opportunity to learn the properties of chemicals and their reactions that might have seemed otherwise difficult, due to lack of sufficient equipment and facilities. Demonstration can be very helpful for students who are highly gifted in spatial intelligence; when combined with traditional method (Erlis & Subramaniam, 2004).

Erlis and subramaniam (2004) found that demonstration helped to reach students with different learning needs. In their study, they used two groups of students. One of the groups was instructed using demonstrations in the topic of electrochemistry. The second group was instructed without using demonstration approach. From the findings of the study; the researchers concluded that the group where demonstration was used showed good performance in the test compared to the group which did not use demonstration approach.

Rade (2009) observed effectiveness of teacher centered demonstration using four classes of chemistry of $12^{th}$ grade girls in Tehran, lran. The experimental group was taught using the chemistry text book. The girls in this group participated in eleven teacher demonstrations on what was being taught. The other group was taught rationally using a textbook only, the section which could have been done in a demonstration and observed, was explained to students orally to this group; at the end the study; a comprehensive test was given. Results indicated that the group which was instructed using demonstrations achieved good results, than the group which was taught without demonstration.

Langlois (2013) found that demonstrations improved learning more than lecture method. From his study, the students who were instructed using demonstration method attained better scores in terms of the mean score than the group which was taught using lecture method.

Naji and Hofstein (2016) studied how effective demonstrating to students was to aid the understanding of the oxidation - reduction concept. They also wanted to establish how using demonstration would impact on students' attitudes toward the learning of chemistry. The sample of 131 students, 64 students were taught using demonstrations while 67 students were taught without using demonstrations. Their study used two instruments for data collection; (the attitude questionnaire and a multiple-choice test). Findings from their study support the use of demonstration to teach oxidation – reduction concept and electrolysis in chemistry.

According to Sweeder and Jeffery (2013); demonstrations greatly influence the development of a rich depth in understanding of chemical concepts if they are properly planned and effectively integrated into the learning of concepts. The demonstration sessions build mental capacities of students which will contribute to the students' logical thinking. The students expressed a deep interest in learning more about oxidation - reduction and electrolysis processes. Therefore, teaching by use of demonstrations helps to improve students' disposition of the importance of demonstrations.

Thompson and Soyibo (2002) too found that learners who were instructed through demonstration method scored significantly high marks in a test given at the end of instruction. They were found to have better understanding of concepts; which was statistically significantly different than that of the group of students that was taken through the same content with other pedagogies, apart from demonstration. According to Price and Books (2012), demonstrations improve how students work on class assignments, laboratory investigations and in final exams, as well as enhance students understanding of concepts.

Demonstrations should be well planned so as to realize the advantages it brings to learning such as enhancing learners' comprehending of the concepts in Chemistry, improve students' desire and interest to learn Chemistry (Muhammad, 2017). In SPSTA, teachers demonstrated what was to be experimented to learners and then allowed the learners to carry out the experiment in their groups.

Whenever some ideas may not be demonstrated using experiment, class discussion can be used to explain concepts. These discussions may be anchored on demonstration, and then followed by common principles of teaching chemistry; which calls for experiment, then discussion and conclusion (KIE, 2006). 'Radioactivity, Atomic structure, Haber process, Solvay process, and Frasch process' are among the topics in Chemistry where the method can be applied. This can also work well in schools that find it hard to conduct practical due to insufficient facilities. In this case, the only available option for the student and the teacher is to entirely depend on other available materials that include: diagrams, biographical materials, pictures, articles, charts, audio visual and any other readily available teaching aid (Nayak & Singh, 2007).

When teachers engage students actively in a discussion; it helps students to learn by developing new knowledge and this makes students to be ready for personalized learning (Howe, 2012) When discussing, students are presented with an opportunity to become co-creators of knowledge (Brookfield and Preskill, 2005). Exchanging ideas brings out deeper meaning which enriches students' understanding (Eeds & Wells, 1991). Those who support discussion method argue that it makes learners to be ready for learning, engages the learner' mind, increases the learners, interest in class activities, gives immediate feedback to teachers, makes the learners to develop a positive attitude towards classroom teaching (Crone, 2001).

According to Michaels et al., (2008), academically vigorous discussions bring about high academic achievements in a plethora of subjects in school, such as art, language (Lee, 2001), Physics (minstrell, 1989) and mathematics (Chapin, O'Connor & Anderson, 2003). Cazden, (2001) found that in as much as classroom discussions have many advantages, teacher talk occupies the centre stage in classrooms, hence classroom interaction in a discussion may be rare (Mccann, Johannessery, Kahn & Flanagan, 2006).

Harton, Richardson, Barreras, Rockloff, and Latane (2002) studied 'focused interactive discussion' approach to discussion, where students in class respond by jotting down answers to sets of multiple-choice questions. The students are allowed to share their answers with other students in duration of utmost two minutes, which may lead to whole class discussion. He discovered that student scored highly on the end of chapter test item on the chapters the students had earlier interacted with in comparison to the chapters that the students had not had an opportunity to discuss.

De Grave, Schmid, and Boshuizen (2011) used forty eight medical students who were in their first year to find out how much students recalled. One group used discussion that was problem-based on blood pressure control, before the teacher taught the topic. Another group participated in the problem vision. The group which participated in problem –based discussion recalled 25% more than the group which participated in problem vision. Christianson and Fisher (1999) concluded that laboratory discussion in a class of biology enabled students to have a good depth of mastery of content on the topic ‘osmosis and diffusion’ as compared to students in a larger lecture laboratory class.

Lyon and Lagowski, (2008) reported that participation in small group discussions in a chemistry class enabled students to get more marks in course examinations and better final grade too. Jeusen and Owen (2011) collected data from students registered in introductory economic courses from thirty-two universities on how students perceived classroom discussion in college classrooms. They found that generally, students enjoyed attending classes with less lecture and more discussions. This according to their perspective was going to make many of the students to like training in economics in the days to come.

A survey conducted on MBA students who were in their second term in their final course year by Dallimore, Hartenstein& Platt (2008), found learners testified that, when they participated in discussions, their verbal and communication skills in writing was improved. They also found that participation in discussions supported their acquisition of knowledge and in particular increased their understanding. Rocca (2010) argue that through discussion, more learner activities are brought into play, it makes students to participate and engage more and then finally the student learns.

Hyde and Ruth, (2002) observed that when students are shy or when they have not adequately prepared for the discussion, then it becomes hard for them to participate in a class discussion. This was found from research that targeted group interviews of four hundred students who were in their second year in the department of social work. In identifying parameters, that leads to student laxity to engage in discussions in class.

Kaufmann (2010) confirms that in learning; students do so well and participate actively when put in some small groups as compared to the whole class. From his study, he found that quiet students during class discussions were contributing most when they were assigned to small groups. In using SPSTA, there was a session for discussing the results of each group with the whole class and then came up with logical conclusions from the discussion. This was to address the gap on expository lesson and allow learners to participate in a lesson.

(iii) Project work

Project work is a heuristic approach to teaching which assists students to Marshall Confidence in coming up with a variety of skills and to demonstrate their potential, skills and even attitude towards achieving creativity and originality. This in turn, leads to communication of scientific facts in an organized manner (KIE, 2006).

Ann-Marie (2008) explains that learners are justified to apply literally objects to stand in for and deliver to the rest the knowledge under study in their areas of learning, as they make careful observations and inquiries. Project method is a platform for young people to learn acceptable behaviour and character; in their thoughts on acquiring knowledge both for others and themselves (Katz & Chord, 2000).

Through projects, students can be involved in investigations of topics of potential interest to them. This is only possible if the instructor is able to evaluate the needs of the children, and their knowledge on the given study area. The teacher then guides learners by developing a list of questions for the learners to go through and provide solutions. The teacher also avails situations that will enable to come up with comprehension (Helm &Katz, 2001).

The activities in project work, provides learners with several chances for learning, applicable events. This allows children to show their ability by making use of their critic and creativity, and show their thinking ability, dispositions, skills and knowledge in ways which are productive to the rest (Beneke & Ostrosky, 2009).

Project implementation contributes to meta-cognition growth and personal-directed study, since learners are asked to come up with their personal mechanisms for the challenge, which involves collecting of data, analysis of data and building of hypothesis as well as testing, comparison of varied techniques. This in turn is disseminated to the mentors and the rest of the students' strategies (Daniel, Stephane, & Paraskevi, 2009).

Instruction using project method makes learners to co-operate well with their colleagues and by extension the mentors and this is applicable where the environment availed is learner friendly, and the students are enticed to venture into difficult topics of their taste (Ediger, 2000). Okero (2010) on the other hand, found that cooperative project based learning approach (CPBL) immensely improves learners' achievement in Chemistry and also enhances the learners attitude towards learning Chemistry.

These findings were reported from a study which was conducted in Sameta Sub - county, Kenya. Learners in a Form Two class participated in the study. One group of the students was taught through CPBL and another group was instructed using other regular methods for teaching Chemistry. After treatment, the first group scored fifty seven percent in a test given, while the second group managed forty six percent, values which had a statistically significant difference on further analysis. On student motivation, group one attained seventy nine percent in a student motivation questionnaire while in group two their mean was seventy three percent, values which were different significantly, in favour of CPBL (Okero, 2010).

Real life skills acquired by students through project implementation include; good collaboration with others, making right decisions, taking initiative in project works and encounters complex challenging situations and self-evaluation. These give learners a feeling of satisfaction. They too instil personal concern towards acquiring knowledge (Daniel, Stephane & Paraskevi, 2009).

Synteta (2003) identified some obstacles which emanates from students when implementing project method of learning. He found out that students had difficulty in; initiating an inquiry in order to come up with coherent research questions; to employ a research plan and employ appropriate methodology; to obtain resources for direct investigations; deal with complex situations and time, to collaborate with others and give feedback.

Khaled et al (2009) identified obstacles in the school to implementation of project method of teaching in Kuwait; they include:

i) Lack of cultural plans which support and develop creativity in school projects.

ii) Clear scholastic resilience in support for school projects.

iii) Lack of cooperation between schools administration, teachers and parents on many aspects of scholastic projects.

iv) Lack of financial support.

Zudonu, (2014) investigated how project teaching method impacted on learners' attainment in separation technique in chemistry in senior secondary schools in Niger Delta. In his study, a pre-test- post-test control group, quasi experimental design was used. A sample of one hundred and ten students were taught using project strategy of teaching; This group higher achievement scores than those in the group which was not taught using project method, attaining an average score of 31.30 in the pre-test and 58.69 in the post -test with a gain of 27.39 marks. Students in the control group scored 30.11marks averagely in the pre-test and 43.44 marks in the post-test with a mean gain of13.33 marks. The mean differences were statistically significant when t-test was performed. The results show that project method help students in understanding concepts and principals taught which facilitated the students' better achievement in chemistry compared to lecture approach used in teaching the control group.

Project method can be demanding when it comes to equipment and materials to be used and also that the learners on their own display inadequacies of organizing for activities and projects and hence may require aid from the instructors (Wachanga, 2005). In using SPSTA, the learners were guided in preparing salts such that each group came up with their salt. This was to address the learner participation and involvement in classrooms.

**(iv)** Question and answer method

Question and answer can be used to stimulate a learner's analytical thought and diagnose student difficulties. To get better results, the questioning technique has to be well thought out to motivate the learners (KIE, 2006). It should be noted that learners feel discouraged when their responses are mostly incorrect hence the teacher should guide and give a summary of the students' concern and answers in order to concentrate on the lesson's objective (Nayak & Singh, 2007). SPSTA applied questioning from the instructor and also gave learners an opportunity to ask questions, answering was also done by both instructor and leaner, during discussion of the experiments in order to arrive at a logical conclusion with learners.

Kira, Komba, Kafanabo, and Tilya (2013) looked at the level to which the instructor's style of inquiring of learners and how the instructor's response to learner's concerns, enhanced learning and increased imagination in learners. From Duschl, Schweingruber and Shouse (2007), the skilfulness with which an instructor questions, may influence learners to engage meaningfully in a scientific practice or in a discussion.

Bloom(1956) classify questions that guide learning to questions of recalling, analyzing, synthesizing, discovering new facts based given on information or evaluating knowledge. Wilson (2002) categorized questioning approaches on the basis of the pattern of thinking they promoted in the learners, that is Socratic, divergent, evaluative or convergent type of questions.

Bybee (1997) established learning cycle to use in determining whether questioning is being done effectively by teachers. The cycle involves starting with engaging, exploring, explaining, elaborating and evaluating in that order. Steps in the cycle incorporate both divergent and convergent questions through all phases of the cycle (Lewis, 2010).According to Ramnashern, (2011) for students to manipulate factors in a scientific inquiry; it calls for application of probing questions to enhance their critical thinking about the relationship between variables under investigation.

Exforsys (2009) recommended that the teacher paraphrases his/her questions from time to time to enable most of the students to come up with important components tested in the question. The analyzed questions must not differ in what they were intended to communicate or thought from the original question and the response to the paraphrased question should be similar to the response of what was there initially, and provide another way of ordering and arranging words.

Lewis, (2010) holds that when students are asked a question, the teacher should give a few seconds before reacting instead of providing an instant answer. This makes learners to be happy that, their responses matter and they are factored in. This is very important especially in science and laboratory experiments where students require time to interact with their data, revisit the steps they followed so that they can come up with answers and share with the whole class.

Kira, at al. (2013) carried out a study with the purpose of (i) examining the depth to which the instructor’s question techniques benefitted the students in understanding the main tenets of the area of learning, (ii) Establish the extent teacher’s questioning styles enhanced learners’ imagination and (iii) examining the extent to which teacher’s responses facilitated student’s learning. In establishing the level to which, the instructor’s questioning behaviour, enabled learners to understand main aspects of the theme. The researchers sought to determine if the teacher understands the essence of questioning when teaching new content, and when evaluating the learner's knowledge.

Their findings show that in assessing the instructor's ability in measuring students' understanding, 20% showed high ability, the ability y to give students an opportunity for self-expression was tested. The results found that 20% of the teachers showed high ability, in making the question understandable by all students; only 10% showed high ability, in assessing the ability in framing and sequencing questions; 0% (no teacher) , the ability to formulate clear questions was assessed. The results indicated that o% (no teacher). The ability to ask for questions from students was investigated and only 10% had high ability, When the teacher's ability to identify gaps in students' knowledge was assessed; 0% (no teacher), on assessing the teacher's ability in going through the learner's responses and giving a chance to those who cannot freely offer themselves; 0% (no teacher) had high ability, the teacher's ability in making constructive ideas from students known to all found that only 20% showed high ability and when the ability of teachers to balance between convergent and divergent questions was assessed; 0% (no teacher) showed high ability (Kira, at al., 2013).

Danbeech (2020) outlines ten ways of improving questioning technique which will make students to gain most out of it. They include:-Wait time- students need time to consider their responses hence allow adequate time after asking a question before taking answers from pupils, no hands up, no opt out, say it again better, probing, pepper, think-pair-share, entire-class response, call and response, hinge questions. SPSTA addressed the gap on questioning technique by teachers which promotes learning.

**(v)** Informal lecture method

The focus is on the teacher. This is applicable in introducing a lesson. It can also be appropriate in introducing new concepts or when giving a clincher of the lesson. It should take between three to five minutes (KIE, 2006). This method however, does not cater for individual needs, the potentiality of the learner and the feedback is usually poor and takes a long time to be received (Wachanga, 2005). In SPSTA, the teacher used informal lecture method to introduce a lesson, to define terms and to summarize a lesson.

In a lecture, the teacher gives all the content to a large number of students. The students take in information without making any contribution (Barbara, 2012). Traditionally, the use of lectures was justified by the fact that access to content was not easy, but in this era, unlimited content is available, hence not a limiting factor. The only challenge is helping students manage their information (Sauliner, 2009).

Tanner (2009) found out that lectures do not help in effective learning as much as the methods which put into use the abilities of learning by giving them an opportunity to contribute to learning during the lesson. However they can be useful for introducing a new content or lesson to prepare learners of what they expect in the subsequent classes, giving instruction, concluding based on information from different sources, explaining complex concepts and giving direction on what is expected (Bligh, 2000; Chalton, 2006; wooding and wooding, 2007; Adsit, 2012).

Lectures are economically effective delivery mechanisms (Barbara, 2012). A skilful incorporation of active learning strategies can remarkably improve a lecture to make use of students and keep the engaged which brings about more permanent learning. Further, he identifies various techniques to improve a lecture; such activities include; reader's theatre, 'think-pair-share', 'roundtable', 'jigsaw', 'short quizzes', 'minute papers' and stating goals. A teacher using SPSTA should try as much as possible when introducing or concluding a lesson using lecture method to employ any of the active learning strategies skilfully so that the learners are engaged.

(vi) ICT in Chemistry teaching

Zohreh and Saedah (2009) carried out a study on how ICT is used in the teaching of Chemistry in the schools in Iran. The purpose of their study was to find some features which would help them to incorporate the use of ICT, especially information technology and communication in classes while carrying out practical. They developed a questionnaire to investigate experts' views towards integrating ICT in a practical class. The results of their research, highly recommended that there is need to change chemistry curriculum using ICT. This can be achieved through using the internet and any facility that can provide the same services.

Studies have shown that use of technology and suitable environment has improved to students skills. Henessy and Deaney (2004) for instance; in their study found that, offering chemistry as a subject using computers demands for adjustments both in pedagogy and technology. If one these features are absent; then using computers to teach Chemistry will not meet the international standards.

Denisia and Suresh (2013) studied on how effective offering Chemistry by use of computers can be. In their research, they concluded that using computers for instruction in chemistry is very useful as it makes the learner to learn at their own speed. Bobin (2006) developed a computer assisted instruction (CAI) package called ‘ix standard computer science’ and used it for instruction to determine its effectiveness. From his results, the group of students who were instructed using CAI package obtained higher scores in the mean of an achievement examination when compared to the group of students who were not exposed to the CAI package. He also concluded that the overall effectiveness of computer use in the chemistry classroom should be improved through acquiring advanced and modern computer hardware and software.

Generally, the use of computer supplements for what might not have been accomplished in the students’ understanding, knowledge, application and manipulative techniques in Chemistry in their daily endeavours. Teachers using SPSTA should incorporate the use of computer technology in their instruction.

Information communication technology (ICT) can support and improve instruction in chemistry. Award (2014) considers ICT as a competent spring of data that is scientific, information that is theoretical and other possible ways to support real learning. All that a student wants to learn can easily be gotten through goggling the internet. Internet provides quite a number of instructional materials which include electronic and encyclopaedia, also e-books and htm documents are available in the internet (Award, 2014).

ICT also provides the student with an opportunity to visualize the spatial three dimensional, structures of elements and molecules. It also enables learners to collaborate through interacting with teachers and students (Award, 2014). Through internet, the student learning experiences are extended outside the class since they introduce the world as it is with drama as well as animated and simulated issues. These enhance seeing things in the perspective of science in the world of reality. The teacher using SPSTA can use ICT to provide learners with an opportunity to extend their learning experiences beyond the classroom experiences.

The Computer video clips that are mediated can be used to display hard, luxurious, dangerous or time wasting real projectile motions which are not attainable in the normal class set up. These true-life physical setting shown in video clips provide entertaining and applicable situations for learners (Kearney, 2004). ICT is thus used as and coming about with communities that are ready to learn. the e-learning is thus applicable for instruction in chemistry in electronic forms. The applicable forms include: e-mails, www-page and discussion forums which enhance the instruction and acquisition of knowledge in chemistry (Award, 2014).

In science education, the models of computer that are animated, are in use to describe, explain and predict processes of science. Superior skills of thinking, meditating and explaining potentials are promoted through these transitions. These skills and abilities are fundamental to learning of science (Baruck & Dori, 2009). Cole (2000) too argues that the flexibility state of ICT and the internet give students an opportunity to interact with research and thus they cooperate and collaborate; ICT can potentially solve real life issues in classrooms as compared to the traditional classroom setting.

Through the use of various multimedia means which include video, television and computer application; Instructional processes are enhanced by means of planning one to one instruction materials which advance the students' longing and desire, and makes it easy to attain basic attributes. They also provide very interesting and more involving learning environment for students of any level (Haddad & Jurich, 2017). ICT affects academic fulfilment of students in science subjects positively (Ziden, 2011). ICT also increases the effectiveness of seeing the environment of interaction as being educative as well as communicative to students. The thoughts of attainment are also enhanced. The intellectual ability and emotional characteristics of a student for example; ability to distribute attention, attention span and analyzing the activities of a partner are developed (Blasco-Arcs et al., 2013; Koch & Vogt, 2015).

Nirma and Annaraja (2005) found that when PowerPoint was used to present zoology to senior secondary learners, it helped them to attain knowledge, understanding and skill objectives better than the students who were taught without PowerPoint presentation; there was a clear demarcation between the control group and the experimental group; where the experimental group was better in knowledge, understanding and skill objective than the experimental group. Subramanian (2006) found that CAI package drastically increased the achievement of learners in accounting class in senior secondary school.

Maresova and Klement (2011) identify the following areas in Chemistry where ICT can be an efficient instrument in instruction and acquiring knowledge; the teacher using SPSTA can identify an area where they can apply ICT to make their teaching more effective. These areas include:-As part of scientific equipment (in measuring and recording data), to stimulate or illustrate difficult or dangerous experiments, simulate natural processes such as formation of atoms and molecules, using video microscope for imaging microscopic processes, organize and display holistic data using databases, spreadsheets and software and to create high quality student presentations. ICT too enhances learners' attainment scores in chemistry compared to other conventional pedagogies (Avirash & Shailja, 2013). In order to implement SPSTA incorporating ICT, the teacher training institutions should include use of ICT in teaching so that the graduates are equipped with the necessary skills. The practicing teachers to have in service training courses on the use of ICT. The school heads should provide proper and well organized ICT infrastructure for teachers to incorporate ICT in the implementation of SPSTA.

## 2.4 Gender and Performance in KCSE chemistry

The analysis of KCSE Chemistry demonstrates differences in gender performance between boys and girls in KCSE examination; the boys having a higher mean score than the girls as illustrated in Table 2:1.

Table 2:1: National Performance of Students 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)

Table 2:1 shows that in the year 2012, the population of learners who did the chemistry national examination was 427303 and they attained a percentage average score of 27.93. In this year, the number of boys was 237293 who attained a percentage mean score of 29.54 while the number of girls was 193426 with average percentage score of 25. 9.

In the year 2013, the enrolment was 439941 and the percentages mean score was 24.83 this score is lower than the previous year's score in chemistry but however there was an increase in candidature enrolment by 12638. Boys were 239206 with a percentage mean score of 26.30 while the number of girls was 200735 and they scored a percentage mean score of 23.08. In the year 2014, the enrolment was 477393 and the scores on average was32.16 percent. In 2014, the mean mark improved by 7.33 with 255734 boys having a percentage mean score of 33.88 and 221659 girls with a percentage mean score of 30.81, the enrolment also increased by 37452 from the year 2013. In the year 2015, the enrolment was 515858 this was an increase from the year 2014 by 38465 the percentage mean score was 34.36 which was an improvement by 2.20 from the year 2014 with 275031 boys posting a percentage mean score of 35.86 and 240857 girls with a percentage mean score of 32.64 (KNEC, 2015).

These results show that for the four years, performance in chemistry was low and that the enrolment of candidates continued to increase and that the girls' percentage means were below the boys' mark score in chemistry in the four years. They did better in terms of average mark score in chemistry in the year 2014 and 2015.(KNEC) 2015 (KCSE) essential statistics reveal that chemistry is poorly performed in both practical and theory papers. This according to KNEC 2015 can be attributed to low content mastery by learners and the lack of skills such as: evaluation, application, interpretation and synthesis.

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. According toTrumper (2006), girls and boys who are peers, seem to view differently the teaching methods that are similar.

Ssempala, (2005) studied disparities in gender attainment scores in chemistry practical techniques. The study was conducted in Kampala district, using students in senior six classes. This was done using a cross sectional descriptive research design, which helped to find out whether there were Gender disparities in performing chemistry practical among boys and girls in senior six the performance of chemistry practical skills among senior six girls and boys. The practical skills which Ssempala (2005) focused on were: - manipulation of apparatus and equipment, making observation, reporting, computing, interpreting, analyzing and perception of abilities.

Ssempala, (2005) Found that: -

(i) Both boys and girls performed equally at the skills of manipulating apparatus and equipment, accuracy of observing, reporting/recording results and computing/interpreting/analyzing data obtained.

(ii)Both male and female students indicated that interpretation and analysis of data most challenging technique to carry out.

(iii) Girls did not believe in their potential to carry out Chemistry practical on their own. SPSTA, being a practically oriented subject can be used to teach both boys and girls. While using it to teach; the teacher to help learners to master the art of interpreting and analyzing their results. The teacher should consider instilling self confidence in the girls as they perform practicals.

Ajayi and Ogbeba (2017) studied how gender contributes to the achievement of senior secondary school chemistry learners in stoichiometry using hands on activities. The study occurred in Nigeria. They used two hundred and ninety-two students. They intended to find out how using hands on activities affected the achievement of both girls and boys as students. Ajayi and Ogbeba (2017) used pre-test- post-test quasi experimental design. The experimental group was instructed stoichiometry through hands on exercises, while the control group was taught by demonstration lesson notes. The boys had a better a mean score than that of girls. The difference between the male and female students' score was 0.24, however this difference was not statistically significant ($F(1, 45) = 4.160$, $P > 0.05$).

This implies that, hands on activities enhanced both male and female students' attainment scores in stoichiometry. Further, the interaction effect between methods and gender on the mean achievement scores of students in stoichiometry was not different, statistically ($F(1, 291) = 0.011$, $P > 0.05$). These findings show that there is no gender difference which exists between the achievement of male and female students of chemistry who are taught stoichiometry, hence hands on activities can be used successfully for both male and female students. SPSTA ought to be used to teach male students as well as female students, since it is intended to involve the learner in practical activities, just like hands on activities.

When comparing the mean scores of boys who were taught using hands on activities and that of boys who were taught using demonstration method; their mean scores were 24.47 and 16.23 respectively. These mean score differences were statistically different. On the other hand, the mean achievement scores of female students taught stoichiometry using hands on activities and that of female students taught using demonstration method were 23.88 and 15.92 respectively. These mean differences were statistically different. The findings of the study show that there was no significant difference in the mean achievement scores between male and female students taught stoichiometry using hands-on activities. Hands on activities promoted student achievement scores of both male and female student in stoichiometry (Ajayi & Ogbeba, 2017) SPSTA puts emphasis on learner involvement through experiment activities. SPSTA concerns with the performance of girls and boys in both Chemistry theory and Chemistry practical.

Cuomo, et al., (2007) recommends educational programmes which are attractive for both boys and girls to be designed. Kolb and Kolb (2005) recommend that learning experiences of men and women alike should be enhanced to give learners freedom to come up with knowledge and encourage experiential learning and self-authorship. Heffler (2001) identify four learning styles classification was triggered by how and where an individual’s score is using the 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 score of both girls and boys equally in Chemistry; Okero (2010) reported that CPBL helped both girls and boys to improve in achievement scores in Chemistry and Chebii (2012) too reported that mastery learning science process skills teaching approach equally improved the achievement of both boys and girls in Chemistry. SPSTA was responding to the concern whether or not it will accommodate all types of learners both female and male when it is used for instruction in Chemistry.

Chemistry needs to be taught using experiment method. This can be possible when learners can interact with facilities in the laboratory and the equipment so that they can enhance their scientific process skills (Tsai, 2003). In Ethiopia for example, research indicates that the official science curriculum specifies the practical experience the learner is supposed to undergo, however on the ground, students do not receive that practical experience in their learning (Samuel & Welford, 2010). In the same way Endalamaw et al (2017) report that seventy five percent of students learning physics in Nigeria were not engaged in practical activities.

Challa (2019) reviewed the challenges faced when implementing practical work at secondary school level; He identified that the challenging factors include; Facility and resource related issues; these are very significant constraints in attempt to implement any form of practical work including experiments. This calls for a variety of laboratory apparatus and equipment for students to perform the required task. These apparatus and equipment need to be availed at the appropriate time. This argument is supported by (Ciroma & Bakori, 2010) when they stated that it can only be possible to work in the laboratory if there are enough apparatus for experiments.

According to Shaibu and Mari (2000), experiments in schools do not make it possible for learners to do investigations dealing with: planning and performing experiments, observing accurately, gathering data and analyzing data for interpretation; since there is to lack of appropriate laboratory equipment. Ughamadu (1992) argue that when apparatus are creatively used by students; it increases the possibility of students learning and improving their performance. Abimbade (1999) support that when laboratory materials are appropriately used, learning is enhanced and the teacher's competence improves and learning becomes more meaningful to learners. Jatau (2008) however notes that appropriate utilizations of laboratory equipment depend on the teacher's ability to use them efficiently.

Ajayi (2008) observed that most secondary schools in Nigeria had a challenge of science laboratories; and the few which had science laboratories; the situation was not sufficient as per the acceptable measure of standard as stated by the Federal inspectorate division of the education ministry of Nigeria (2002). Ajaja (2009) noted that learners failed to excel in practical examination in Nigeria. This fact was attributed to lack of teaching science using experiments since there was inability to provide well equipped laboratories. As a result learners exhibited lack of knowledge that is fundamental in carrying out easy experiments in sciences.

Kibirige et al., (2014); Onwu&Stoffels (2005) and Mokotedi (2013); found that in south Africa Schools lacked laboratories, equipment as well as laboratory technicians to give support to teachers. A study by Swain et al (1999) reported that teachers did not carry out practical work frequently because they lack resources and equipment. In Ethiopia, Endalemaw et al (2017) established that science instructors rarely make laboratory teaching a centre of instruction and they usually cry foul for lack of laboratory equipment and chemicals to enable them to do an experiment. In Kenya Oyoo (2013) reported that most of science laboratories lack necessary supplies for practical, and even apparatus for effective curriculum implementation.

Schools in Africa generally and in particular Kenya; Lack equipment and other laboratory facilities for proper implementation of SPSTA. Teachers are advised to be creative in improvisation and using available resources effectively.

Laboratory manuals are another challenge to proper implementations of experiments method of teaching. A laboratory manual provides a guideline to enable a big population of learners to participate in similar exercise; this saves on time, human resources and equipment and materials (Lagowyski, 1990). In Kenya, Oyoo (2013) reports that there is a shortage in the supply of curriculum materials like laboratory manuals. Feyera (2014) confirms that in Ethiopia, there are no elaborate and well explained manuals for the laboratory experiments. In Nigeria; Adedayo (2015) reported lack of instructional materials like laboratory guidance.

Their findings indicate that laboratory manuals are very crucial for successful use of SPSTA. Teachers are advised to prepare in advance for the lesson to ensure that the instructions to be used for the experiment are available in time. In this study, Chemistry worksheets were prepared in advance for teachers to use for SPSTA.

In most schools in Africa, the challenge is a laboratory room. According to Kapting'ei and Kimeli (2014), most schools have a single room to serve all the sciences. In these cases, it will not be possible to allocate time on the timetable for all science subjects to effectively carry out frequent experiment activities. Abebe et al (2019) too reported that only one school in their sample had three different laboratories for the specially three science subjects of: Biology, Chemistry and physics. The rest did not have separate laboratory room for each subject. A laboratory room ought to be spacious, with proper supply of electricity, sufficient water and gas supply (SCORE, 2008).

Large class size allocation is a challenge to experiment method of teaching. This will lead to very few opportunities for direct contact with the teacher and there will be very little possibility for meaningful group or individual work (Oli, 2014). With a large class, there is a very high likelihood that the teacher cannot cheek up their students' work both class work and home work, and it will affect the attitude of students when it comes to practical work with large population than the available apparatus (Adedayo, 2015). In this study; SPSTA was implemented using small size groups of three to five students who were engaged in the same task to overcome the challenge of large class size.

The teacher's qualification and experience are very crucial in implementation of laboratory teaching and helping students in handling practical work, otherwise the teachers will have a problem on the content (what to teach) and the methodology (how to teach) (Adeboyenga,2010) Endalemaw et al (2017) interviewed teachers and reported that teachers lacked skills in manipulating the provided laboratory materials in the instruction of their learners. The teacher's skills competence can be improved through attending professional development activities like workshops, seminars, panel discussion (Solomon et al, 2015). Teachers experience on other hand enables the teachers to develop confidence to develop to overtake planned activities in practical work, but with the assistance an experienced technician, the teacher can have full laboratory experience (Teenaw, 2015). SPSTA used teachers who have trained to teach Chemistry and with a teaching experience of five years. This was to deal with the problem of confidence in implementing SPSTA.

According to Maslow (1994) theory of worker motivation and in his “hierarchy of needs” identifies an adequate salary as the initial needs, followed by support and recognition, once these level needs are met ten workers start working towards excellence and self-actualization. Instructors, whose needs are not met, might not deliver effective and well-planned lessons; while teachers who are satisfied with their Job tend to yield better results in teaching (Baker & Smith, 1997).

Trained laboratory technicians are experts in knowledge of practical techniques, health and safety, efficiency and economy. They give support to teachers by making it possible for them to offer varied and stimulating science lessons (Abebe et al 2019). However, the role of science laboratory technicians is poorly considered for instance in the UK, many secondary schools have not considered the service of laboratory technicians as shown in consortium of local Education Authorities that gives services in science (2009); A factor which has locked up benefits which could be realized in practical work to offer support for teachers of science. This is associated with the failure to comprehend and follow on how the laboratory role of the technician is structured by the administrators of the school (Soares & Lock, 2007).

Kapting'ei and Kimeli (2014) established that most schools in African countries do not have laboratory technicians. This implies that teachers are over whelmed by work load in trying to balance between teaching and being a laboratory technician, this compromises laboratory practice and practical teaching. Effective laboratory practice requires a skilled professional which can only be done by a trained technician.

Tolessa, (2016) carried out a survey in secondary schools in Ethiopia and discovered that the bigger majority of the school laboratory assistants lack training; a factor which caused the few available facilities not to be put into use, equipment and reagents were not stored in well ventilated rooms; leading to wastage as a result of using unskilled laboratory technicians. Abebe et al (2019) discovered that most teachers are not implementing laboratory teachings in south to East Ethiopia due to lack of laboratory technicians. This deficiency of laboratory technicians in science subjects (Biology, physics and chemistry) lead to a negative impact on the academic achievement in the science subject (Feyera, 2014). For SPSTA to be well implemented by the teachers there is need for the schools to hire a trained laboratory technician.

Abraham (2011) observes that during a practical lesson, most of the time is spent in doing the technicalities of the task, like reading instruction to students, replacing and collecting chemicals and apparatus, handling the equipment in coming up with data then thereafter do the cleaning of the apparatus.

Mwangi, (2016) investigated how secondary school chemistry practical influenced learning. Respondents were rated on the scale of disagree, not sure and agree. On finding out whether Chemistry practical increases understanding, 10% of the students disagreed, 7% of the students were not sure and 83% of the students agreed. Findings revealed that the majority of the students in secondary school (83%) agree that Chemistry practical increases understanding.

On finding out whether or not Chemistry practical increases enjoyment; Mwangi, (2016) found that 18.4% of the students disagreed, 12.6% of the students were not sure and 68.9% of the students agreed. These percentages indicate that large number students (68.9%) agree that chemistry practical increases enjoyment. Hence the teacher of chemistry teaching using chemistry practical will capture the learner's attention and motivates the learner in chemistry learning.

Millar and Abrahams (2009) had earlier found that twenty four out of twenty-five teachers of their study devoted very little time or completely ignored to discussing the findings of the practical with the learners. This resulted from constraints from other challenges; for example, inadequate laboratory equipment, and lack of adequate laboratory space; is time wasting during change over and in many cases, practical activities are not well concluded (Kapting'ei & Kimeli, 2014). SPSTA recommended that the teacher allocates adequate time for the discussion of the experiment results in their lesson plan to deal with lack of time for discussion of results.

Yung (2001) observes that in many cases during assessment, the students' final grades do not include a component which shows what the learners are able to do or what they understand in practical work. This can be pegged on the fact that most instructors are short of experience in assessing methods in the Students' performance and understanding of practical work. Alison (1997) recommends that for a measure of attainment to be valid in any school science subjects, the assessment should then entail of examinations which are skewed towards practical, and make them fundamental aspect of science. SPSTA provided an opportunity for recognition of practical work in chemistry since a practical examination was part of the assessment of learners' achievement.

Mwangi, (2016) established that when practicals are used to teach chemistry; the students were able to perform well. This was found in Kenyan public secondary schools. He used quasi-experimental approach of pre-test – post-test design. Students' score on attainment exams were analyzed to determine learner's achievement in Chemistry; Questionnaires for both instructors and learners were also used to collect data.

### 2.5 Chemistry Practical KCSE Examination

The KCSE Chemistry practical is marked out of forty marks. The analysis of the performance of the students in KCSE chemistry practical is presented in Table 2:2.

**Table 2:2:** KCSE Practical Performance

| Year | Candidature | Mean score | Standard deviation |
|---|---|---|---|
| **2016** | 566836 | 13.63 | 6.31 |
| **2017** | 606515 | 14.10 | 6.11 |
| **2018** | 656163 | 14.44 | 6.45 |
| **2019** | 691602 | 13.00 | 6.07 |

Source: KCSE KNEC report 2019

From Table 2:2, the performance of the candidates has been below average for the four years. An average score is 20 since the practical's maximum score is 40. The highest mean score was posted in the year 2018; which was 14.44 it was followed by the year 2017 where a mean of 14.10 was recorded. In 2016, the score on average was 13.63. The lowest mean was 13.00 in the year 2019. The standard deviation for the year 2016 was 6.31, 6.11 in 2017, 6.45 in 2018 and 6.07 in 2019. The year 2018 had the highest standard deviation. Generally, the performance in Chemistry practical should raise concern over the years since it is far much below average over the four years.

From KNEC (2006), the aim of KCSE practical Chemistry examination is to assess whether the learner is able to: - Handle apparatus and equipment, make accurate observations and record results accurately, analyze and interpret scientific data, follow a sequence of instructions and carry out experiments, describe a sequence of instructions and carry out experiments.

KNEC (2006) further outlines the major areas which can be tested in chemistry practical for example; Heating and cooling curve for instance cooling curve for naphthalene which was tested in the year 2005 (KCSE2005),Qualitative analysis-test for cat ions and anions, Qualitative analysis in organic chemistry test, Rates of reaction, Thermo chemistry and graphs, Solubility and solubility curves and Titration.

Table 2:3 gives areas which have been tested in chemistry KCSE practical in some years.

**Table 2:3:** Topics Tested in Chemistry KCSE Practical

| Year | Topic tested | Marks awarded |
|---|---|---|
| **2016** | Rates of reaction | Sixteen |
| | Inorganic qualitative analysis | Fourteen |
| | Organic qualitative analysis | Ten |
| **2017** | Thermo chemistry | Eleven |
| | Titration | Nine |
| | Inorganic qualitative analysis | Eleven |
| | Organic qualitative analysis | Nine |
| **2018** | Thermo chemistry | Nine |
| | Titration | Eleven |
| | Inorganic qualitative analysis | Eleven |
| | Organic qualitative analysis | Nine |

Source: KCSE report 2016, 2017, 2018

From Table 2: 3, it is evident that all the areas are tested in KCSE chemistry practical. In the three years, inorganic qualitative analysis was tested and it carried the highest marks in each of the KCSE examination. Organic qualitative analysis was too tested every year for the three years. Thermochemistry and titration were tested in KCSE 2017 and KCSE 2018; however they were not tested in KCSE 2016. Rate of reaction was tested in KCSE 2016; while it was not tested in KCSE 2017 and KCSE 2018. This analysis is an eye opener to the teacher so that they prepare their learners well with science process skills to equip them for KCSE Chemistry practical examination. SPSTA is one such way of preparing learners with science process skills necessary for KCSE Chemistry practical examination. Considering the fact that learners need to be able to conduct experiments and come up with a clear record of observation and make correct inferences based on their observation; there is need for the teacher to employ a teaching method which will enable the learner to develop and master science process skills. SPSTA enables learners to develop the science process skills which enable learners to perform better in the Chemistry practical.

Mbaluka (2012) advises that in SPSTA the teacher should teach the filling a titration table by ensuring that the learner is able to: Complete table, Use decimals consistently on the table and Calculations involving number of moles should be given to at least four decimal places. Accuracy in carrying out the titration should be encouraged and the learners should be taught the skill of averaging their values.

The learners should be trained in the skill of observation during Qualitative Analysis. Mbaluka (2012) further explains that in qualitative analysis, a candidate should be able to identify or test for cations and anions by making use of the senses for instance; what you hear, that is; the sound produced for example a cracking sound. What you see, that is the colourless of product, the colourless of the precipitate, the colourless of the filtrate , the colourless of the residue , the colourless of the gas produced, the colourless of the sublimate, the colourless of the liquid formed when vapour condenses ,effervescence ,effects on red and blue litmus papers/universal indicators ,glass rod dipped in hydrochloric acid, burning or glowing wooden splint, anhydrous cobalt II chloride paper and the colourless of the solution formed. What you smell for example a choking irritating smell, a pleasant-smelling compound, odourless gas among others (KCSE, 2019). SPSTA in this study emphasized on teaching using the science process skill of observation where learners were trained on how to make accurate acceptable observations which improved their achievement in Chemistry practical.

### 2.5.1 Current dynamic in the setting of Chemistry KCSE Practical

In some Chemistry KCSE practical examinations, candidates are required to describe the procedure testing a particular cat ion and anion and then carry out the procedure to confirm presence or absence of cat ion, anion or both in a compound (KCSE, 2017) .In such a case candidates are required to read and understand practical notes use the knowledge of salt analysis in order to be able to handle such tasks.

It is crucial to know that, the first step is key the scoring subsequent parts of the question. For instance KCSE 2017 question two, the candidate was given a solid suspected to be lead (II) carbonate and reagents. From the reagents, the candidate was expected to choose and explain three steps of an experiment that would be followed simultaneously to confirm whether, solid K is lead (II) carbonate. In doing this the candidate was required to write the results and the expected observations. Later the candidate was to perform the experiment described, give clearly what they observe and make deductions based on the gathered data (KCSE, 2017).

This question exposed the following weaknesses among learners;

i) The students added excess acid, this made the solution acidic

ii) The students started by adding water, yet the salt lead (II) carbonate is an insoluble salt

iii) Students used the wrong order of reagents.

The candidates generally lacked the science skill of designing an experiment. The KCSE (2017) report recommended more exposure to such questions. This can only be achieved through using a teaching strategy where the science process skill of planning an experiment forms part of instruction and learning process. In this study; SPSTA considered ‘designing an experiment’ as part of the science process skills for teaching during this research.

Discipline of students helps to provide a friendly learning environment. Mwangi (2016) found that only 65% of the students were disciplined and 22.8% were not disciplined; a classroom where discipline prevails, it supports effective learning. Studies have shown that discipline affects academic achievement of students (Khuluse, 2009).

Mwangi (2016) provided the rating on academic ability and indicated that only 48% of the students showed average academic ability, while 28.5% of the students have a high academic ability, 14% of the students had a very high academic ability, 3.9% of the students very low academic ability and 5.5% low academic abilities generally. These findings indicate that only 9.4%of the students have academic abilities which are below average. The majority of the students (90.5%) have academic abilities which are average and above average. This is a strength on which teachers of Chemistry should tap and use appropriate teaching methods like SPSTA to explore the potential of the students in order to improve their achievement in Chemistry.

Analyzing the academic ability of students in sciences; Mwangi (2016) found that 3.9% of the students had very low academic ability in the sciences while 18.2% of the students had low academic potential to perform in the science subjects, 51.1% of the learners had average potential in the sciences and 18.7% of the students had high academic ability in the sciences and 8.1% of the students had very high academic ability in the sciences. These figures indicate that in the science subjects (chemistry, biology and physics) 77.9% of the students have ability in science which is average and above. This shows that the students have potential of performing very well in the sciences. The students whose ability in the sciences is below average can be improved through the use of SPSTA to improve their skills in handling chemistry practical.

Results on academic ability in chemistry reveal that 8.8% of the students had very low academic ability in Chemistry, 25.0% of the students had low academic ability in Chemistry, 39.7% of the students had average academic achievement in Chemistry, 17.6% of the students had high academic achievement in Chemistry and 9.0% of the students had very High academic achievement in Chemistry (Mwangi, 2016). From these findings, 33.8% of the students have academic ability in Chemistry which is below average while 66.2% of the students have academic ability in Chemistry which is at least average. These results should inform the teacher of Chemistry in making choices about teaching method. The teacher should accommodate learners of all abilities so that they can both learn at their pace. The percentage of learners whose ability is below average in chemistry is high; the teacher should make use of every opportunity possible to enable all these learners to make good progress in the learning of Chemistry. The purpose of the current study was to establish how SPSTA will influence learners' achievement in Chemistry.

Looking into the students' Ability in chemistry practical, Mwangi, (2016**)** found out that8.7% of the students had a very low ability in chemistry practical, 15.6% of the students had a low ability in Chemistry practical, 39.1% of the students had an average ability in Chemistry practical, 21.7% of the students had a high ability in Chemistry practical and 14.8% of the students had a very high ability in Chemistry practical. From these findings; 87.6% of the students have at least average ability in Chemistry practical. This implies that most of the students will easily learn through experiments. The teacher planning to teach then should have their lessons mostly taught through experiments and make use of every opportunity to train the students in science process skills. This way, even the students whose ability in Chemistry practical is below average will be improved. SPSTA looked into achievement of learners in Chemistry practical.

The feelings of learners towards several exercises in Chemistry established that; 13.8% of students had a negative attitude towards science subjects, 48.8% of the students did not know what attitude they had towards science subjects, and 37.4% of the students had a positive attitude towards science subjects. These facts reveal that only 37.4% of the students are sure that they have a positive attitude towards science. A greater percentage of 48.8% of the students are not decided on whether they have a positive attitude or not. At this point in time; the teacher of science should take advantage of this situation to make the science lessons as interesting as possible in order to gain the confidence of this group of learners so that they can develop positive attitude towards science. Lessons can be more interesting if they become more learner centered. SPSTA is a learner centered approach to teaching where learners are engaged in hands on activities during the lesson that is why it was studied deal with learner involvement challenges in Chemistry subject particularly.

The students’ attitude towards Chemistry subject showed that 25.5% of the learners had a feeling of dislike towards Chemistry subject, 37.6% of the students were undecided about their attitude towards Chemistry subject and 37% of the students had a positive attitude towards Chemistry subject (Mwangi, 2016). These findings about the students’ attitude towards Chemistry show that about 63% of the students; who are the majority are not sure or have a negative attitude towards Chemistry subject. This large number of students will negatively impact on the results of Chemistry at KCSE examinations. Sharpe (2012) clearly explains that the classroom climate that the teacher establishes greatly impacts the learners’ motivation and attitude. This calls for the teacher of Chemistry to creatively plan their lesson so that it can stimulate the learners’ curiosity in the subject. One such way is to involve learners in the learning through use of experiments. SPSTA is one such a way that learners can be engaged in a lesson for the sake of appealing for the learners’ liking of Chemistry.

The attitude of students towards Chemistry assignments revealed that 18.7% of the students had a negative attitude towards chemistry assignments, 33.7% of students did not know which attitude they had towards chemistry assignments and 47.6% of the students had a positive attitude towards chemistry assignment. These results expose the fact that a great percentage of students; approximately 53% are not sure or have a dislike for Chemistry assignments. As a result this leads to, in a way low grades posted at the KCSE Chemistry examinations (KCSE, 2019). The task given to the learner therefore should be followed up to ensure that the learner has completed with the expected response. More varied forms of assignments can be given to the learner at different times. A teacher can give group assignments but supervise to ensure that every learner participates in the group task (Johnson & Johnson, 1999).

SPSTA used varied forms of assignments which included individual tasks which were take away assignments with a deadline for submission which was checked by the teacher, short quizzes which the learner was expected to accomplish within the lesson and it was to be marked by the teacher within the lesson; there were group assignments given which were followed up and supervised to ensure every group member participates. This was achieved through giving different tasks to the members of a group. Learners were also given projects to accomplish and present their completed projects to the class. The projects which learners were engaged in were projects to prepare different salts in the Chemistry syllabus topic "salts" which was taught to learners in this study.

The attitude of students towards Chemistry theory lessons revealed that 17.7% of the students had a negative attitude towards Chemistry theory lessons, 32.4% of the students did not have an idea of their attitude towards chemistry theory lessons and 50.2% of the students had a positive attitude towards chemistry theory lessons. These findings evidently show that about half of the student population has a positive attitude towards a chemistry theory lesson. This calls for the teacher to prepare well when presenting the subject matter for these learners to benefit. It also calls for the teacher to explain the experimental procedure clearly and create time for the discussion of the results since half of the learners have a strong like for the theory of what is being taught. The other half of the student population should not be left out too. Hence the teacher should organize the lesson in such a way that there is a time to be engaged in an activity so that all the learners in a class benefit from the lesson. Teachers implementing SPSTA should take this into account such that the learners who dislike Chemistry theory lessons are engaged and the learners with a positive attitude towards chemistry theory are also not left out by creating a session for discussion to explain the theory behind the activity the learners were engaged in.

Mwangi, (2016) investigated how learners rate themselves on the various aspects of Chemistry practical. On the aspect of making accurate observations; 5.9% of the students were very weak in making accurate observations, 12% of the students were weak in making accurate observations, 46.6% of the students had an average ability in making accurate observations, 22.6% of the students had a high potential in making accurate observations and 13.0% of the students had a very high potential in making accurate observations. These findings show that only 13% of the students had a very high ability in making accurate observations. What these revelations imply is that the larger population of the learners (about 87%) is not capable to make the required observation during chemistry practical. With the incorrect observation, the inference will be incorrect hence performance in Chemistry will be low as it is evident in the KCSE practical examination results (KCSE, 2019). In this study, SPSTA used observation skill. the learner's achievement in Chemistry practical studied.

The learner's interest in doing investigation found that 10% of the students were very weak in interest in doing investigation, 16.3. % of the students were weak in interest in doing an investigation, 33.3% of the students were average in interest in doing an investigation 28.7% of the students had a strong interest in doing investigations and 11.4% of the students had a very strong interest in doing investigations (Mwangi, 2016). These findings are an indicator that a large percentage of the students do not have interest in doing investigations. This implies that they may not be able to carry out an experiment on their own. This may make it had for the learner to follow a given procedure to obtain accurate results. This will greatly affect the performance of the students in KCSE Chemistry practical as results indicate (KCSE, 2019).

An investigation on the ability of using theory when doing investigations found that 9.4% of the students were rated very weak on using theory when doing investigation, 19.1% of the students rated weak in using theory when doing investigation, 36.5% of the students rated average on using theory when doing investigation, 23.3% of the students rated strong on using theory when doing investigation and 11.7% of the students rated very strong on using theory when doing investigation. These findings show that 65% of the students rate average and below on using theory when doing investigation.

The teacher should train the student on how the chemistry theory and chemistry practical are related so that the learner realizes that practical is an application of the theory content of Chemistry. This implies that if the student has to perform well in chemistry practical; they must also be doing well in chemistry theory. In the current study, SPSTA was used to study its influence on the learner's achievement in both chemistry theory and chemistry practical.

Further in SPSTA; the teacher should make a point of checking the learner's notes and experimental results and discussions to ensure that the learner has neat notes, well and accurately drawn diagrams and with neat, well recorded experimental procedure, experimental results and their discussion.

The findings on the learner's ability to make accurate interpretation and predictions; 7.2% of the students rated very weak in their ability to make accurate interpretation and predictions, 22.1%

of the students rated weak in their ability to make accurate interpretation and predictions, 40.2% of the students rated average in their ability to make accurate interpretation and predictions, 20.2% of the students rated strong in their ability to make accurate interpretation and predictions and 10.4% of the students rated very Strong in their ability to make accurate interpretation and prediction (Mwangi, 2016). These results reveal that many students (69.5%) have an average or weak ability in making accurate interpretation and prediction based on their results from experiment. For SPSTA to be successful, the teacher should train the learner so that the learner is able to identify causal relations based on the theory behind the investigation in order to make correct inferences with reference to their findings.

Learners rating on eagerness to investigate after school, Mwangi, (2016) found that 15.3% of the students rated very weak on eagerness to investigate after school, 17.9% of the students rated weak on eagerness to investigate after school, 23.5% of students rated average on eagerness to investigate after school, 19.4% of the students rated strong on eagerness to investigate after school and 23.8% of the students rated very strong on eagerness to investigate after school. From these findings, 59.7% of the students are average or weak in their eagerness to investigate after school. The teacher using SPSTA can improve the student's eagerness by giving the student a project which they can be engaged in after school and make a follow up to see the learner's progress on the project.

The learner's eagerness to relate observations to theory work was investigated by Mwangi, (2016). The results show that 10.4% of students rated very weak, 15.3% of students rated weak, 38.4% of students rated average, 20.2 % of students rated strong and 15.7% of students rated very strong on eagerness to relate observations to theory work. These results show that 64.1% of the students are not eager to strongly relate observations to theory work. When using SPSTA, the teacher should train the students the skill of relating observation to theory work.

On the analysis of the various aspects of chemistry practical; it reveals that the very important are science process skills. Teaching should therefore assist the student to experience the science process skills in science (Abrahams & Millar, 2008). Wafts (2013) contend that when a student is taught science using practical, the achievement and science process skills are improved. SPSTA on the other hand used experiment method which incorporated the process skills of observation, classification and designing an experiment for teaching Chemistry.

In determining whether the demand from concerned quarters to clear the syllabus is a stumbling block to chemistry practical; Mwangi, (2016) found that 55.6% of the teachers disagreed, 14.7% of the teachers were not sure and 29.7% of the teachers agreed that the high demand and coercion to finish the syllabus was a hindrance to chemistry practical. From these percentages; majority (55.6%) of teachers disagree that syllabus coverage is an obstacle to syllabus coverage. Therefore teachers of chemistry should not teach chemistry without practical, since the syllabus will still be covered within the stipulated time. SPSTA used experiment method to teach the topic “salts” in the secondary school chemistry syllabus; it was possible to cover the content within the allocated time.

An investigation to find out whether high demand on the teacher to produce better results is an hindrance to Chemistry practical; Mwangi, (2016) recorded that 45.9% of the teachers disagreed, 21.2% of the teachers were not sure and 32.9% of the teachers agreed that high demand to produce better grades on the side of the teacher is an hindrance to chemistry practical. These findings indicate that a greater population of teachers disagrees with the fact that high demand on teachers to produce good grades is an obstacle to chemistry practical. All teachers of chemistry should be encouraged to teach Chemistry using practical as this enables learners to improve their achievement in both chemistry theory and chemistry practical this was the purpose of SPSTA.

Mwangi, (2016) studied on whether Chemistry practical increase achievement of good grades; his findings were that 14.2% of the teachers disagreed that chemistry practical increase achievement of good grades, 9.2% of the teachers were not sure whether chemistry practical increase achievement of good grades and 76.6% of the teachers concurred that chemistry practical enhances attainment of better grades. These results show that majority of the teachers (76.6%) support that chemistry practical helps learners to obtain good grades. This fact has got support from studies discussed in this study indicating that when learners are taught chemistry using hands on activities, the learners' achievement in chemistry is improved.

Mwangi, (2016) inquired whether Chemistry practical reduces syllabus coverage. Results of the inquiry indicate that 54.3% of the teachers disagree that chemistry practical reduces syllabus coverage, 20.3% of the teachers were not sure whether chemistry practical reduces syllabus coverage and 25.4% of the teachers agreed that chemistry practical reduces syllabus coverage. The percentages show that many teachers disagree that chemistry practical reduce syllabus coverage. this is because when the teacher plans to teach a given chemistry content using experiment method; the teacher takes into account the available time and how all the syllabus which is intended to be covered within a given period of time is covered within the stipulated time to ensure that the syllabus is covered. In this study SPSTA had scheme of work to follow.

On analysis of whether Chemistry practical is routine and boring thus fails to engage and inspire students; Mwangi, (2016) found that 51.2% of teachers disagree, 26.5% of the teachers were not sure and 22.2% of the teachers agree that Chemistry practical is routine and boring than it being engaging and inspirational. The results show that a greater percentage of the teachers (51.2%), are confident that Chemistry practical is not monotonous and routine; instead it is engaging and inspiring.

Further, on finding out whether Chemistry practical are rote and practiced with the sole aim of doing well in examinations; 52.1% of the teachers disagree, 16.4% of the teachers were not sure and 31.5% of the teachers agree that Chemistry practical are rote and practiced with the sole aim to pass examinations (Mwangi, 2016). This shows that many teachers (52.1%) disagree with the fact that chemistry practical are drills and practices only for passing examination has received support from Tsai, (2003) who holds that Chemistry should be taught using experiment method of teaching as this enables the learner to develop science process skills. SPSTA in teaching Chemistry, studied its influence on achievement in both Chemistry theory and Chemistry practical; develop their science process skills which are helpful to them in their day to day lives were taught.

Challa, (2019); identified teacher's work load as a challenge to implementation of experiment method in teaching chemistry. Mwangi (2016) investigated whether the number of lessons the teacher teaches is a hindrance to chemistry practical found that; 61.4% of the teachers disagree, 12.1% of the teachers were not sure and 26.55% of the teachers agree that teacher's work load is an obstacle to Chemistry practical. Hence work load of a teacher does not affect the use of SPSTA. Mwangi (2016) further investigated whether a big population of learners in the classroom is an hindrance to chemistry practical. His results show that 40.7% of the teachers disagree, 4.7% of the teachers were not sure and 44.6% of teachers agree that a big population of learners is a hindrance to chemistry practical. The number of students is not a challenge to implementation of SPSTA since using small size groups for teaching is recommended.

These findings are supported by Lerma (2014) who holds that one of the methods which assist the learners to recall and comprehend challenging concepts of science is practical approach. Hostein (2004) found that chemistry practical make chemistry learning enjoyable. The challenge of teacher's work load can be overcome by the government employing more qualified teachers. This will greatly contribute to ease congestion in class in order for SPSTA to be effectively implemented.

Teachers use either demonstration or class experiment in teaching chemistry. An investigation on the use of demonstration experiment for teaching Chemistry by Mwangi, (2016) found that 24.35% of the teachers never use demonstration experiment for teaching Chemistry, 38.55% of the teachers occasionally use demonstration experiment for teaching chemistry, 25.9% of the teachers frequently use demonstration experiment and 11.3% of the teachers use demonstration experiment very frequently to teach chemistry. The findings on the use of Class experiment for teaching chemistry revealed that 56.3% of the teachers never use class experiment to teach

Chemistry, 19.9% of the teachers occasionally use class experiment to teach chemistry, 16.6% of the teachers frequently use class experiment to teach chemistry and 7.2% of the teachers use class experiment very frequently to teach chemistry.

Teachers use either teacher demonstration or class experiment for teaching Chemistry. The two kinds of practical work lead to attainment of very distinct goals. According to Kibirige, Maake and Mavhunga (2014), there is practical work used to attain the fundamental skills of measuring, observing and recording. On the other hand, there is practical work used to attain integrated science process skills which include analysis and drawing inferences. In order to select the type of practical work relevant for the purpose intended requires that teachers get equipped with knowledge on which practical applies to what concept. The institutions that provide in-service and Pre-service teacher training institutions should consider imparting confidence, practical skills and the right attitude for practical work as they offer skills and training to teachers of chemistry. When these attributes are instilled in teachers; then it will be possible for the teachers of chemistry to use SPSTA for teaching.

The skeleton of the implementation of curriculum as suggested by Rogan and Grayson (2003) gives the factors to consider when determining the quality of chemistry practical applied in teaching and learning chemistry. These factors include: - frequency of student practical in chemistry lessons, frequency of teacher demonstration in chemistry lessons and efficiency of instructional resources.

Mwangi, (2016) investigated the students' understanding on kinds and amount of chemistry practical done. The findings on the frequency of students' practical in chemistry lessons show that 0%  of the learners showed no time on the frequency of students' practical in Chemistry, 6.4% of the students indicated  a little time on the frequency of students' practical in Chemistry, 16.1% of the students indicated half the time on the frequency of learners' practical in chemistry, 44.1% of the students indicated most of the time on the frequency of students' practical in chemistry and 33.4% of the students indicated all the time on the frequency of students' practical in chemistry.

These outcomes show that the practicality of chemistry practical is not popular in most of the classes of chemistry; however it is worth noting that at least chemistry practical is used for teaching some times since 0% of the students indicated no time. This implies that teachers need to work out on the effectiveness of the chemistry practical by increasing the frequency of learners' chemistry practical. The use of SPSTA can be used to improve on the frequency of students' practical in Chemistry.

The frequency of teacher demonstration  chemistry lessons  by Mwangi, (2016) found 5.5% of the students indicated no time for teacher demonstration chemistry lessons, 25.7% of the students indicated  a little time for teacher demonstration chemistry lessons, 24.3% indicated half the time for teacher demonstration chemistry lessons, 40.2% of the students indicated most of the time for teacher demonstration chemistry lessons and 43% of the students indicated all the time for teacher demonstration chemistry lessons. These findings reveal that teachers mostly use teacher demonstration chemistry lessons; where learner participation is not allowed. Teachers should instead be encouraged to embrace learner centered approaches to teaching chemistry lessons. SPSTA is much associated with heuristic teaching approaches and instructors are encouraged to apply it for teaching chemistry.

An analysis of the efficacy in teaching and sufficiency of resources in schools, Mwangi, (2016) found that on adequate chemistry laboratory space and equipment, 26.5% of the students disagree on adequate chemistry laboratory space and equipment, 10.4% of the students were not sure on adequate laboratory space and equipment and 62.8% of the students agree on adequate laboratory space and equipment. Based on efficacy of chemistry apparatus and reagents; 16.6% of the students disagree on adequate chemistry apparatus and reagents, 13.4% of the students were not sure on adequate chemistry apparatus and reagents and 70% of the students agree on adequate apparatus and reagents. These results indicate that adequacy of chemistry laboratory space and equipment is well above average. The government should continue to ensure that schools have enough well-equipped laboratories for teaching science subjects. Availability of adequate chemistry laboratory and equipment will make it easy for the teacher to implement SPSTA. The government should continue to ensure that all schools have adequate chemistry apparatus and reagents.

Further Mwangi, (2016) investigated whether there were adequate qualified chemistry teachers. His results indicate that 16.0% of the students disagree on adequate qualified chemistry teachers, 10.7% of the students were not sure on adequate qualified Chemistry teachers and 73.4% of the students agree on sufficient trained teachers of Chemistry. Also, on enough teaching time for chemistry; 17.6% of the students disagree on adequate time for teaching chemistry, 12.7% of the students were not sure on adequate time for teaching chemistry and 69.7% of the students agree on sufficient time in teaching Chemistry. Concerning enough time for chemistry practical; 32.2% of the students disagree on adequate time for chemistry practical, 15.2% of the students were not sure on adequate time for chemistry practical and 52.5% of the students agree on adequate time for chemistry practical. These results indicate that schools do not have enough teachers qualified to teach chemistry; the government should hire enough qualified teachers to teach chemistry. SPSTA used trained teachers with a teaching experience of at least five years.

Research has shown that there is a remarkable change in attainment in Chemistry between students who have interacted with a variety of practical compared to those who are not. According to Pavosic (2008), students benefit a lot from chemistry practical. This is because chemistry practical increases students' interest in learning chemistry; it improves the learners' abilities as well as the learners' attainment in chemistry. Instructors should be enticed to teach chemistry using practical. An investigation by Mwangi, (2016) on how often various types of chemistry practical in chemistry are adopted; he found that on the frequency demonstration experiment only 6.6% of the students don't know whether the teacher used demonstration experiment only, 17.7% of the students rated never on the use of demonstration experiment only, 38.5% of students rated occasionally on the use of demonstration experiment only, 25.9% of the students rated frequently on the use of demonstration experiment only and 11.3% of the students rated very frequently on the use of demonstration experiment only.

Further, an investigation on the rate at which a demonstration experiment and discussion go together; 6.45% of the students don't use demonstration experiment and discussion, 13, .8% of the students never use demonstration experiment and discussion, 29.1 of the students occasionally use demonstration experiment and discussion, 31.1% of students frequently use demonstration experiment and discussion and 19.6% of the students very frequently use demonstration experiment and discussion (Mwangi, 2016). A teacher should strive to discuss the experimental results of the student in order to make any corrections on the results to enable the learners to draw logical conclusion based on their findings. This will enable the learner to make generalizations on situations similar to the experiment. SPSTA creates time in the lesson for discussion of the experimental results.

A study on the frequency of demonstration experiment in the classroom; Mwangi (2016) found that 8.1% of the students don't know the frequency at which demonstration experiment takes place in class, 20.4% of the students never use demonstration experiment in the classroom, 38.8% of the students occasionally use demonstration experiment in the classroom, 24.15% of the students frequently use demonstration experiment in the classroom and 8.7% of the students very frequently use demonstration experiment in the classroom.

On the frequency of small groups class experiment lesson; 12.9% of the students don't know whether they use small groups experiment lesson, 43.45% of the students never use small groups experiment lessons, 19.9% of the students occasionally use small groups experiment lessons, 16.6% of the students frequently use small groups experiment lessons and 7.2% of the students very frequently use small groups experiment lessons (Mwangi, 2016).

Investigating the frequency of large group experiment lesson; 11.35% of the students don't know the frequency of large group experiment lesson, 25.9% of the students never use a big group during an experiment lesson, 21.6% of the students occasionally use large group experiment lesson, and 21.5% of the students frequently use large group experiment lesson and 17.8% of students very frequently use large group experiment lesson (Mwangi, 2016). KIE, (2002) recommends that chemistry should be taught using small group experiment lesson. SPSTA used small group experiments for teaching.

# CHAPTER THREE

# METHODOLOGY

## 3.1 Introduction

Details on Methods and procedures that were put in place to investigate the research problem are provided in this chapter. These details are organized into the following sections: - research design, study area, the population for the study, sampling procedure and sample size, instrumentation, piloting of the instruments, data collection and data analysis procedures.

## 3.2 Study Area

The study was carried out in Kisii South sub-county of Kisii county, Kenya. The sub-county constitutes the Bonchari constituency. It is made up of eight county assemblies which include: Riana, Bomokora, Bokeire, Insaria, Nyangiti, Bogiakumu South, Bogiakumu north and Bomariba. Kisii south Sub-county boarders Kisii County; to Migori and Homabay counties to the west. Its neighbouring sub-counties in Kisii are; South Mugirango and Gucha to the South, Nyaribari Chache to the East and Mosocho to the North. Kisii south sub-county is made up of thirty three secondary schools. The examination analysis of the Kisii south sub – county, shows that the learners' performance in Chemistry is dismal. This indicates a need to work towards improving this performance. SPSTA was used to teach form two students in Chemistry in the sampled experimental group in Kisii south sub-county.

## 3.3 Research Design

Experimental method of research was adopted. Quasi-experimental research design was employed in the study. This is because experimental group and control group were not randomly assigned since schools do not constitute classes in order to be used for research. Four groups were involved in the study hence it falls under Solomon four non-equivalent control group designs (Fraenkel & Wallen, 2000).

Gall and Borg (2007) consider the Solomon four group design as rigorous enough for experimental and non-experimental studies. This design helped the researcher to do assessment and show the influence of pre-test on the findings when related to conditions of no pre-test, to establish how pre-test and treatment condition interact, find out how the treatment influences the outcome of the study when compared to control conditions, to determine the similarity of the groups at the beginning of the study.

The study used four intact classes from four different schools. Each class represented a group for the study as illustrated in Table 3:1

Table 3:1:Research Design

| | | | | |
|---|---|---|---|---|
| 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 |

Source: Wiersma and Jurs (2005)

Key: -Pre-tests $0_1$, Post-tests $0_2$, Treatment X

--------- Dashed lines show that the groups are non-equivalent

Group 1 was the experimental group, which was subjected to the pre-test, SPSTA and a post-test. This group helped to evaluate the effect of the treatment relative to control condition, when compared to group 2, which was the main purpose of the study.

Group 2 was the control group which was given a pre-test and a post-test. This group was helped to determine the influence of SPSTA relative to control condition when compared to group 1.

Group 3 was the experimental extension group which was exposed to SPSTA and a post-test. This group was used to study how pre-test and treatment conditions interacted by comparing it to group 1.

Group 4 was the control extension group which received the post-test only. This group was helpful in assessing the effect of the pre-test relative to no pre-test when compared to group 2. It was also used to assess the homogeneity or academic contemporary position of the groups. Groups 1, 2, 3 and 4 represent schools 1, 2, 3 and 4 respectively selected for use in the study.

From quasi-experimental procedure, it is possible to control some major threats to internal validity. However threats associated with selection and maturation, selection and history and selection and instrumentation cannot be controlled by the procedure (Gall & Borg, 2007). To take care for interaction between selection and maturation, assignment of schools to the control and treatment groups was done randomly. To control for interaction between selection and maturation, instruments were administered ensuring that conditions across all schools were kept as similar as possible (Mugenda & Mugenda, 2005).

### 3.4 Population for the Study

The target population for this study was students of Form two in secondary schools in Kisii South Sub - County. The Form Two class was chosen for the study because at this level, all students take Chemistry as a compulsory subject and due to the fact that, the topic 'Salts' is taught at this level. This study was carried out in Kisii South Sub - County, Kenya. Kisii South Sub- County has twenty eight out of thirty three schools in the sub-county being mixed schools, which constituted the sampling frame for the study. The performance of the students in the science subjects in the KNEC examination in this sub-county is also poor as exhibited in KCSE 2018. Kisii south sub county subject analysis where physics was the best performed of the sciences with a mean standard score of 3.14 on a scale of twelve, followed by Biology with a mean score of 2.57 and Chemistry posted the least mean of 2.56 all measured on a scale of 12. Kisii South joint examination analysis further shows that performance is still low in three consecutive examinations in chemistry. The score was 2.634 in the first trial, 2.794 in trial two and 3.104 in trial three. At the time of the study; the total Form Two population was 2737. 1292 were boys and 1445were girls as per the Kisii south sub county education office records (2020).

### 3.5 Sample and Sampling Procedures

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, Kisii. 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. The selected schools had organized students into girls' only classes and boys' only classes. Simple random sampling techniques were used to select one girls' class and one boys' class from each selected school for the study.

The formula for sample size for the proportion by Chinelo and Chioma (2021) was used to determine the sample size for the study. The formula was used with 95% confidence level and p = .05 assumption. The equation for determining population sample is given by: $n=N/1+N(e)^2$ where; n is the sample size, N is the population size, e is the level of precision. Thus, from a population of 2737 students, the sample size was calculated as

Sample size = $2737/1+2737(0.05)^2$= 349 students

The study used intact classes. A total of eight classes were used for the study. 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 from Chinelo and Chioma (2021), a population of at least 349 participants were proportionate from a target population of 2737.

### 3.6 Instruments for data collection

The study used two instruments; Chemistry Achievement Test (CAT) and Chemistry Practical Test (CPT). The CAT was used to establish how SPSTA influenced achievement of students in chemistry theory. The CPT was used to investigate the students' achievement in chemistry practical.

### 3.6.1 Chemistry Achievement Test (CAT)

CAT was developed in this study. It was used as a pre-test. Items in the CAT were then reorganized for it to be used as a post-test. The CAT was constructed using the table of specification of items to ensure that all content areas and abilities were covered. The CAT was based on the content 'Salts' covered in the study. According to Furtak, Seidel, Iverson and Briggs (2012) tests must be carefully planned, developed and used as intended. To achieve this, the following factors were considered when preparing the CAT; validity, reliability, objectivity, comprehensiveness, economical use of class time and simplicity in use. This instrument consisted of completion, short answer and structured items. These types of items were appropriate because they provided little likelihood of correct guessing (Furtak, Seidel, Iverson & Briggs, 2012). The test consisted fourteen items on 'Salts'. The instrument tested comprehension, application of the learned material and acquired knowledge, (Appendix B).

### 3.6.2 Chemistry Practical Test (CPT)

The CPT consisted of practical items with the objective of testing the ability of learners on the practical examination since Chemistry is also tested on a practical paper during the KNEC examination. The CPT contained two items which tested the learner's ability to follow a given procedure, make the correct observation, draw logical conclusion based on their observation. The CPT further tested the learner's ability to design an investigation and perform the designed investigation to answer a given question. This instrument was constructed based on the content taught in the topic 'salts' (Appendix C).

### 3.6.3 Piloting of the Instruments

A pilot test for the two instruments was done in Manga Sub County, Nyamira County in order to determine their reliability and validity. Manga Sub County was used for piloting the instruments to avoid any possible interaction of the instruments with the population before the study.

### 3.6.4 Validity of the CAT

Content validity was determined by constructing the CAT using the table of specification of items which ensured that all content areas and abilities were covered. For face validity, this instrument was given to five teachers of chemistry with a teaching experience of at least five years in order to determine their suitability for the Form Two Chemistry students. The teachers' comments were taken into account when the CAT items were being improved.

### 3.6.5 Validity of the CPT

The CPT was given to five teachers of Chemistry with a teaching experience of at least five years to analyze its suitability for the Form Two Chemistry students. The teachers' comments were used to improve the CPT items.

### 3.6.6 Reliability of the CAT

Split-half method of determining reliability was used to establish the reliability of the CAT. All items on the CAT that purported to test the same concept were divided into two sets randomly. 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 whose formula is given as:

$$r = \frac{\sum XY - \frac{(\sum X)(\sum Y)}{n}}{\sqrt{\left(\sum X^2 - \frac{(\sum X)^2}{n}\right)\left(\sum Y^2 - \frac{(\sum Y)^2}{n}\right)}}$$

Where,

X = scores of first half, Y = scores of second half and n = total frequency The reliability coefficient of the CAT was 0.863 hence the CAT was taken to be reliable since reliability was fixed at $\alpha = \geq 0.7$; a reliability considered large enough to declare an instrument reliable (Fraenkel & Wallen, 2000). The application of the product moment correlation formula is explained in the following example, where, if scores of the first half is X and scores in the second half is Y for a set of six students; Table 3:2 illustrates how the correlation between the two halves was calculated.

**Table 3:2 Example of students' scores in two split halves (X and Y) of a test**

| **X** | **Y** | **XY** | **$X^2$** | **$Y^2$** |
|---|---|---|---|---|
| **8** | 10 | 80 | 64 | 100 |
| **4** | 6 | 24 | 16 | 36 |
| **4** | 4 | 16 | 16 | 16 |
| **5** | 8 | 40 | 25 | 64 |
| **3** | 6 | 18 | 9 | 36 |
| **6** | 8 | 48 | 36 | 64 |
| **$\sum X = 30$** | **$\sum Y = 42$** | **$\sum XY = 226$** | **$\sum X^2 = 166$** | **$\sum Y^2 = 316$** |

Where n=6. Then

r=16÷ 18.7617=0.8528. The value of 0.8528 shows that the instrument in the example was reliable since a value of r ≥ 0.7 is considered large enough to declare an instrument reliable (Fraenkel & Wallen, 2000)

Pearson product moment correlation coefficient provides a more conservative estimate of reliability of a set of test results hence more flexible (Brown, 2012). And since the items in the instrument yielded a range of scores during scoring, split-half reliability was the most suitable measure of internal consistency.

**3.6.7 Reliability of the CPT**

Reliability of the CPT was determined using Split-half reliability method. All items on the CPT that targeted to measure the same construct were randomly divided into two sets. The entire instrument was given to the sample population for piloting of the instrument. After marking the CPT 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 whose formula is given as:

$$r = \frac{\sum XY - \frac{(\sum X)(\sum Y)}{n}}{\sqrt{\left(\sum X^2 - \frac{(\sum X)^2}{n}\right)\left(\sum Y^2 - \frac{(\sum Y)^2}{n}\right)}}$$

Where,

**X** = Scores of first half **Y** = Scores of second half and **n** = total number of items in each half

The reliability of the CPT was 0.836. The CPT was considered reliable since reliability was fixed at α = ≥ 0.7; a reliability considered large enough to declare an instrument reliable (Fraenkel &

Wallen, 2000). Pearson product moment correlation coefficient provides a more conservative estimate of reliability of a set of test results and hence more flexible (Brown, 2012). And since the items in the instrument were scored with a range of difficulty, split-half reliability was the most suitable measure of internal consistency (Mugenda & Mugenda, 2005).

### 3.7 Data Collection Procedure

After the graduate school had given permission to conduct research, the researcher sought for necessary permission from the National Commission for Science and Technology Institute (NACOSTI). The sub-county director of Education of Kisii South sub- County was informed of the intended study. Sampled schools were then visited and both the head teachers and teachers of chemistry were notified of the study. Before implementation of SPSTA, teachers who were going to use SPSTA for instruction were trained on its use in a period of two weeks. The pre-test was given to group 1 and group 2. The treatment was then administered in a period of eight weeks. During this period, the topic 'salts' was taught to both the experimental and control groups. The experimental group was taught using SPSTA while the control group was taught using regular teaching methods. Soon after the treatment was over, the post-test was administered to all groups. The researcher scored both the pre-test and post- test.

### 3.8 Ethical Considerations

According to Alfieri, Brooks, Aldrich and Terenbaom (2011), ethical issues that arise from the kind of problem investigated and the method used may affect the validity of data obtained. The research process involved stages of ethical and scientific considerations. The researcher sought permission from NACOSTI and from heads of schools which were selected for the study. The researcher explained to the heads of schools and teachers of Chemistry the intended purpose of the study. The researcher discussed with chemistry teachers the methods to be used to carry out the study. The teachers involved in the study were trained and instructed on the need to uphold ethical standards. Confidentiality of the respondents' identities and the protection of private information given during the study were adhered to these were treated with utmost anonymity.

**3.9 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 ANOVA, t-test and ANCOVA were used. ANOVA and t-tests were used to test the hypotheses for the study and where there was a statistically significant difference; ANCOVA was used to determine whether the difference was as a result of the treatment. Table 3:3 gives a summary on how each hypothesis was tested.

Table 3:3: Summary of Data Analysis

| **Hypothesis** | **Independent Variable** | **Dependent variable** | **Method of analysis** |
| --- | --- | --- | --- |
| **$H_O$1: There is no statistically significant difference between the achievement of students who are exposed to SPSTA and those who are exposed to RT methods in Chemistry theory test.** | Teaching method | Students' Scores In CAT | ANOVA t-test ANCOVA |
| **$H_O$2: There is no statistically significant difference between the achievement of students exposed to SPTA and those who are exposed to RT methods in Chemistry practical test.** | Teaching method | Students' Scores In CPT | ANOVA t-test ANCOVA |
| **$H_O$3: There is no statistically significant difference in achievement between boys and girls who are taught through SPSTA in Chemistry theory test** | Gender | Students' Scores In CAT | ANOVA t-test |
| **$H_O$4: There is no statistically significant difference achievement between boys and girls who are taught through SPSTA in Chemistry practical test.** | Gender | Students' Scores In CPT | ANOVA t-test |

CHAPTER FOUR

# DATA ANALYSIS, INTERPRETATION AND DISCUSSION

## 4.1 Introduction

This chapter provides the analysis that was carried out on the data collected in order to test the hypotheses for the study. The chapter is divided into the following sub-topics: influence of science process skills teaching approach (SPSTA) on students' achievement in Chemistry theory, influence of SPTA on students' achievement in Chemistry practical; achievement of girls and boys exposed to SPSTA in Chemistry theory; achievement of boys and girls in Chemistry practical. The study was guided by the following objectives:-

(i) To find out whether or not 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 theory, (ii) to determine whether or not the achievement of students who are taught using SPSTA is statistically significantly different from that of students who are taught using the RT methods in Chemistry practical, (iii) to establish whether or not the achievement of the boys and the girls who are taught using SPSTA is statistically significantly different in chemistry theory and (iv) to find out whether or not there is a statistically significant difference in the achievement of the boys and the girls taught using SPSTA in Chemistry practical.

The hypotheses for the study were derived from the objectives of the study and they were:-

(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 theory. (ii) To determine whether the achievement of students who are taught using SPSTA is statistically significantly different from that of students who are taught using the RT methods in Chemistry practical. (iii) To establish whether the achievement of the boys and the girls who are taught using SPSTA is statistically significantly different in chemistry theory and (iv)To find out whether there is a statistically significant difference in the achievement of the boys and the girls taught using SPSTA in Chemistry practical.

Data was collected from Form Two students in sampled schools in Kisii South Sub-County. The study employed quasi-experimental research design in which Solomon four non-equivalent control groups was used as shown below.

| | | | | |
|---|---|---|---|---|
| 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 |

In this design, the four groups of the study were handled differently for the purpose of comparing the effectiveness of the treatment. The treatment in this study was using Science Process Skills Teaching Approach (SPSTA) for teaching Chemistry and then its influence on secondary school students' achievement in Chemistry was determined. The groups are described as: Group 1 was the experimental group which received the pre-test, the treatment and the post-test. Group 2 was the control group which received the pre-test and the post-test. Group 3 was the experimental group which received the treatment and the post-test and group 4 was the control group which received the post-test only.

Two instruments were used for the study, a Chemistry Achievement Test (CAT) which was used to determine the students' achievement in Chemistry theory involving objective 1 and objective 3, and a Chemistry Practical Test (CPT) which was used to determine the students' achievement in Chemistry practical in objective 2 and objective 4. 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). ANOVA and t-tests were used to test the hypotheses for the study. Where there was a statistically significant difference, ANCOVA was used to determine whether the difference was as a result of the treatment, KCPE scores were used as a covariate. Significance level was set at $\alpha \leq 0.05$. Results of the study are presented in tables.

### 4.2 Influence of SPSTA on Students' Achievement in Chemistry Theory

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 theory.

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. Table 4:1 shows the means and standard deviation of the learners' pre-test scores in CAT

**Table 4:1: Mean and Standard Deviation of Learners' pre-test 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 4:1 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 per-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 4:2.

**Table 4:2: 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 | 0.004 | 89 | 0.997 |
| | 2 | 20.21 | 4.594 | | | |

Source: field data

CAT maximum score=100

One tail t-test results (Table 4.2) indicate there was no statistically significant difference between group 1 and group 2 at the beginning of the study t (89) = 0.004, p > 0.05. This implies that there was no group with an advantage over the other in terms of achievement in chemistry theory 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 syllabus. At the end of the study, a post-test was administered to all groups. The post-test mean scores in CAT for learners are presented on a graph as shown in figure 4.1

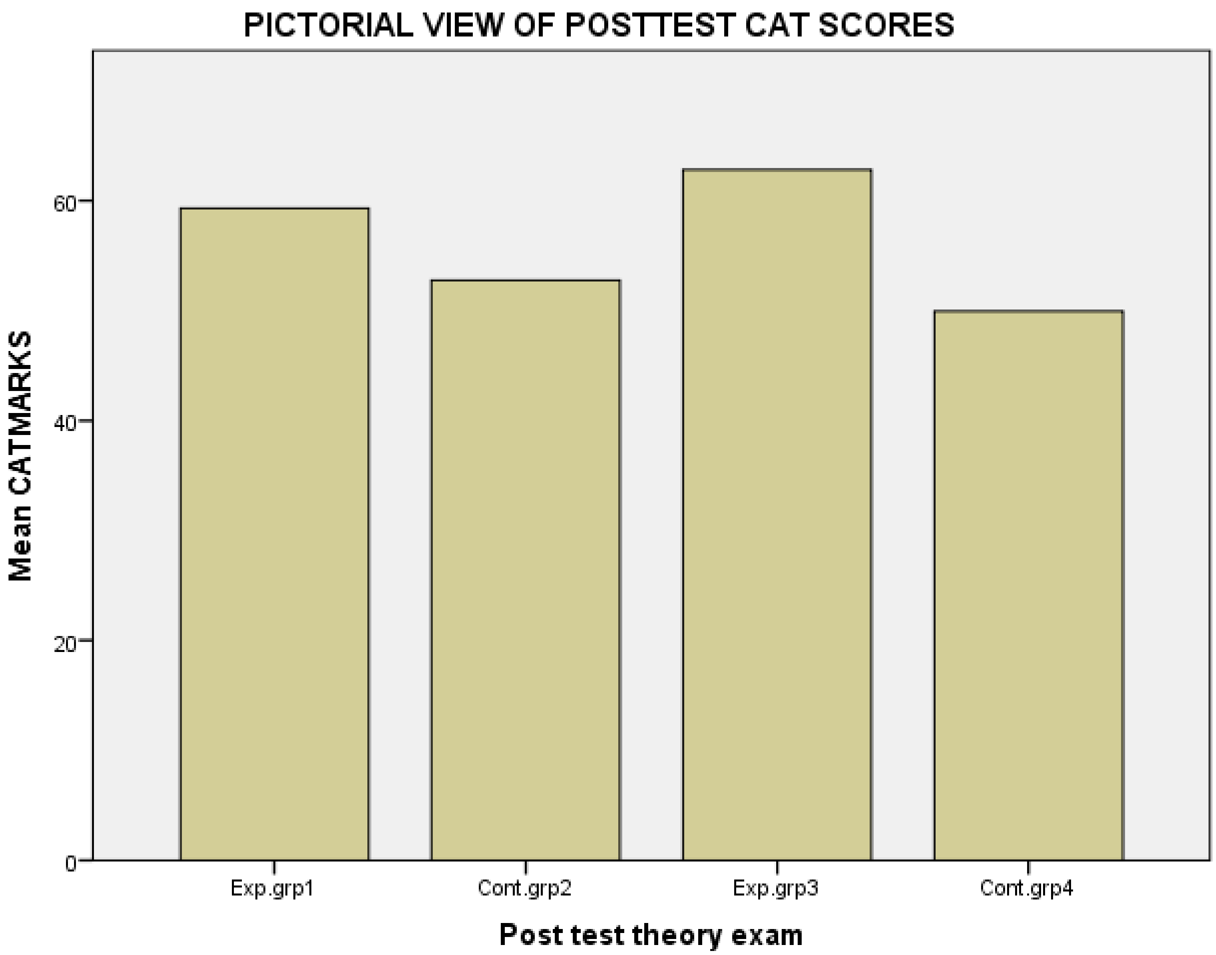


Figure 4.1: pictorial view of learners’ post test scores in CAT

Table 4:3 shows the mean and standard deviations of learners’ post- test scores in CAT

**Table 4:3: 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 |

Source: field data

Table 4:3 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 4:4 shows the one way ANOVA test results for post-test scores in CAT according to groups.

**Table 4:4: 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 | | | |

Source: field data

Table 4:4 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 4:5.

**Table 4:5: 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 0.05 level.

Table 4:5 shows that the mean of group 1 was statistically significantly higher than that of group 2 and 4 (t = 6.527, P-value = 0.049 < 0.05 and t = 9.325, P-value = 0.01 < 0.05 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 = 0.001 < 0.05 and t = 12.862, P-value = 0.000 < 0.05 respectively) this shows that the students who were taught using SPSTA performed better in Chemistry theory 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 = 0.051 > 0.05), 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)

A comparison of the students' scores in the pre-test and post-test CAT was carried out. Table 4:6 shows the scores together with their mean gain.

**Table 4:6: Students' Scores and Mean Gain Obtained in the CAT**

| | Group1 N= 92 | Group2 N=90 | Overall |
|---|---|---|---|
| **Pre-test mean** | 20.21 | 19.09 | 19.65 |
| **Post-test mean** | 59.30 | 52.78 | 56.04 |
| **Mean gain** | 39.09 | 33.69 | 36.39 |

Source: field data

As indicated in Table 4:6, the mean gain between students' CAT pre-test and post-test scores was higher for the experimental group than the control group. This implies that the SPSTA resulted in higher achievement than the RT methods. A t-test for mean gain in CAT for group 1 and group 2 are presented in Table 4:7.

**Table 4:7: Independent samples t-test for mean gain between pre – test and post – test scores in group 1 and group 2**

| Variable | Group | Mean gain | Std. error | t-value | df | p-value |
|---|---|---|---|---|---|---|
| **CAT** | 1 | 39.09 | 1.4647 | 23.001 | 89 | 0.000 |
| | 2 | 33.69 | 1.4742 | | | |

Table 4:7 shows that there was a statistically significant mean gain difference between the mean gain of group 1 and group 2 (t(89) =23.001 and P=0.000 $\leq$ 0.05), hence group 1 gained significantly better from instruction using SPSTA than group 2 which was taught using RT methods.

ANCOVA was used since the study involved non-equivalent control group design. KCPE mean mark was used as covariate. 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 4: 8 shows the adjusted post-test CAT scores of ANCOVA with KCPE scores as covariate.

**Table 4:8: 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 |

Source: field data

From Table 4:8, 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 4:9.

**Table 4:9: 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 | 0.000 |
| **KCPE** | 552.668 | 1 | 552.668 | 3.914 | 0.022 |
| **Error** | 25133.714 | 178 | 141.201 | | |

Source: field data

Table 4:9 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 $F(3,178) = 9.418$, $P = 0.000 < 0.05$. Further ANCOVA pair wise comparisons of the adjusted means test are presented in Table 4:10.

**Table 4:10: 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 4:10, 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 0.041<0.05 and t=9.382, p-value = 0.001<0.05) respectively. This implies that experimental group 1 performed better in Chemistry theory 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= 0.001<0.05 and t= 12.764, p=0.000<0.05) respectively, however there was no statistically significant difference between the marginal means of experimental group 1 and group3 (t=3.382,p=1.000>0.05) and between control group 2 and group 4 (t=2.753,p=1.000).

Table 4:11 shows the effect of post – test scores on CAT based on the linearly independent pair wise comparisons among the estimated marginal means.

**Table 4:11: Univariate Tests**

| | Sum of squares | Df | Mean square | F | p-value |
|---|---|---|---|---|---|
| Contrast | 4739.680 | 3 | 1579.893 | 11.189 | 0.000 |
| Error | 25133.714 | 178 | 141.201 | | |

Source: field data

Table 4:11shows a statistically significant difference between the experimental and control group estimated marginal means (df= 3,178 F= 11.189 P= 0.000< 0.05).

A pre-test of the CAT was administered to group 1 and group 2. The pre-test helped to assess: whether there was any interaction between the pre-test and treatment conditions; the effect of pre-test to no pre-test and the similarity of the groups before administration of the instrument (Gall& Borg, 2007). Table 4:1 presents the means of the pre-test scores on the CAT a t-test on pre-test CAT scores was performed and results presented in Table 4:2. The t-test showed that the differences between the pre-test CAT means were not statistically significant at P$\leq$ 0.05 this implies that the groups were suitable for the study and that they had comparable characteristics.

In this study, students in the experimental groups were exposed to Science Process Skills Teaching Approach (SPSTA) in the learning of the content "salts" in the Form Two Chemistry syllabus while the control groups were taught the same content using Regular Teaching (RT) Methods, after instruction all the groups did a post-test CAT. The post-test CAT mean scores were presented in Table 4:3. A one way ANOVA on the post-test CAT mean scores for the four groups (Table4:4) shows that there was a statistically significant difference in the post-test mean scores. A comparison of the post-test CAT mean scores on the Least Significant Differences

(LSD) table (Table 4:5) shows that the experimental groups had a significantly different higher post-test CAT mean score than the control groups, while the post-test CAT mean score differences between experimental group 1 and experimental group 3 were not significantly different and the post-test CAT mean scores between the control group 2 and control group 4 were also not significantly different.

Experimental group 1 and experimental group 3 were found to be similar to each other in the post-test CAT, but not similar to the control group 2 and control group 4, the researcher was in a strong position to attribute the differences to the experimental condition (Mugenda & Mugenda, 2005). In this study, SPSTA was attributed to the differences between the experimental groups and the control groups in the post-test CAT scores. Further, Analysis of Covariance was performed to establish whether there were existing differences at learners' entry level, and the learners' KCPE scores were used as a covariate. The ANCOVA of the adjusted post-test mean scores on CAT results are presented in Table 4:10 and they indicate that there was a statistically significant difference in the adjusted post-test CAT mean scores with KCPE scores as a covariate.

The LSD Table 4:11 indicates that the adjusted post-test CAT scores with KCPE scores as a covariate for experimental group 1 and group 3 were significantly different from those of the control group 2 and control group 4 and since the groups were not different at entry level, the researcher strongly attributed the difference to the SPSTA. The post-test CAT results in this study did not indicate any interaction between the pre-test and the SPSTA treatment since there was no significant difference between experimental group 1 and experimental group 3 and between control group 2 and control group 4. If the Pre-test provided a practice effect, it should have resulted in significantly higher post-test CAT scores by group 1 and group 2 than by group 3 and group 4, but this was not the case in this study, hence the CAT pre-test was suitable for the study and the researcher attributed the significant mean gain between the pre-test and the post-test CAT scores to the use of SPSTA which resulted in higher students' achievement in Chemistry theory than the regular teaching methods since experimental group1 and experimental group 3 obtained statistically significant higher scores in the CAT than the control group 2 and control group 4.

Objective 1 was to find out whether there is a significant difference, statistically in the achievement scores of students who are taught using SPSTA and that of students who are taught using the regular teaching (RT) methods in Chemistry theory found that the difference in the achievement scores of students who were instructed using SPSTA and that of students who were taught using RT methods in Chemistry was statistically significant; 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 theory was therefore rejected.

These findings support a study by Nyakan (2008) who by using science process skills instructional approach to teach Form Two secondary school students in physics in Kenya, concluded that the attainment scores of learners instructed using science process skills instructional approach were higher as compared to that of learners who were instructed using other regular teaching methods. These differences in attainment scores were statistically significant.

Abungu (2014) too 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 Solomon four control group designs. The study covered two topics (volumetric analysis and qualitative analysis). Abungu's study revealed that science process skills teaching approach significantly effect on students' achievement in chemistry. The findings of the current study support science process skills teaching strategy in Chemistry.

These findings 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) SPSTA is a strategy through which knowledge is actively constructed by learners by being involved during a lesson.

Rade (2009) established that, when learners were instructed using experiments; they scored highly in Chemistry by 12$^{th}$ Grade female students in Tehran. Langrois (2013) got similar results. According to Sweeder and Jeffery (2013); when experiments are properly planned, they promote thinking skills and attitude towards Chemistry. Mwangi (2016) established that students using practical for learning performed well in Chemistry. SPSTA used experiments for teaching and from the findings; students using SPSTA improved their achievement in Chemistry theory.

The rationale for SPSTA founded on constructivist psychology, where the teacher organizes activities for learning with proof of hands-on activities, with application of correct investigation and analysis procedures and as consequence the understanding of developing science constructs. SPSTA basically enables learners to make generalizations about their investigation by considering the data collected (Khan& Zafar, 2011).Secondary school Chemistry teachers are therefore urged to apply SPSTA for instruction as it will help improve the students' achievement in KCSE Chemistry theory.

### 4.3 Influence of SPSTA on Students' Achievement in Chemistry Practical

Chemistry practical is an essential part of teaching which is examinable by the Kenya national examinations council in the Kenya Certificate of Secondary Education as Chemistry paper 3. The chemistry practical contributes 40% of the candidate's total score in Chemistry in the national examination. This study sought to find out whether there is a statistically significant difference between the achievement of students who are exposed to SPSTA and those who are not exposed to it in Chemistry practical. This was done by testing the second hypothesis for the study which was stated as:

**$HO_2$**: there is no statistically significant difference between the achievement of students who are taught using SPSTA and that of students who are taught using RT methods in Chemistry practical.

This hypothesis was derived from the second objective. It was tested using the CPT which was administered as a pre-test and as a post-test. The pre-test was administered to experimental group 1 and control group 2 the CPT pre-test mean scores and standard deviations are presented on Table 4:12

**Table 4:12: Mean and Standard Deviation of Learners' Pre-Test Scores in CPT**

| Pre-test CPT | N | Mean | Std. deviation |
|---|---|---|---|
| **Group 1** | 92 | 29.87 | 6.648 |
| **Group 2** | 90 | 29.72 | 6.701 |

Source: field data

From Table 4:12, the experimental group 1 attained a higher mean than control group 2 in the pre-test. This necessitated a t-test to be carried out on the CPT Pre-test scores to determine whether the mean differences between group 1 and group 2 in the pre-test scores were statistically significantly different. The results are presented in Table 4:13.

**Table 4:13: Independent Samples t-test for Pre-Test Scores on CPT**

| Variable | Group | Mean | Std. error | t-value | df | p-value |
|---|---|---|---|---|---|---|
| CPT | 1 | 29.87 | 1.399 | 0.123 | 89 | 0.902 |
| | 2 | 29.72 | 1.400 | | | |

Source: field data

From Table 4:13, the mean differences are not statistically significantly different (t= 0.123, P=0.902> 0.05. from the analysis of the pre – test of the CPT, there is evidence that the groups did not have a statistically significant difference at the start of the study hence the groups could be compared at the end of the study, since they had comparable characteristics. After the treatment, all the groups were subjected to a CPT as a post-test which was scored by the researcher and the data was keyed and coded for analysis. A pictorial view of the post-test scores in CPT are represented in figure 4.2.

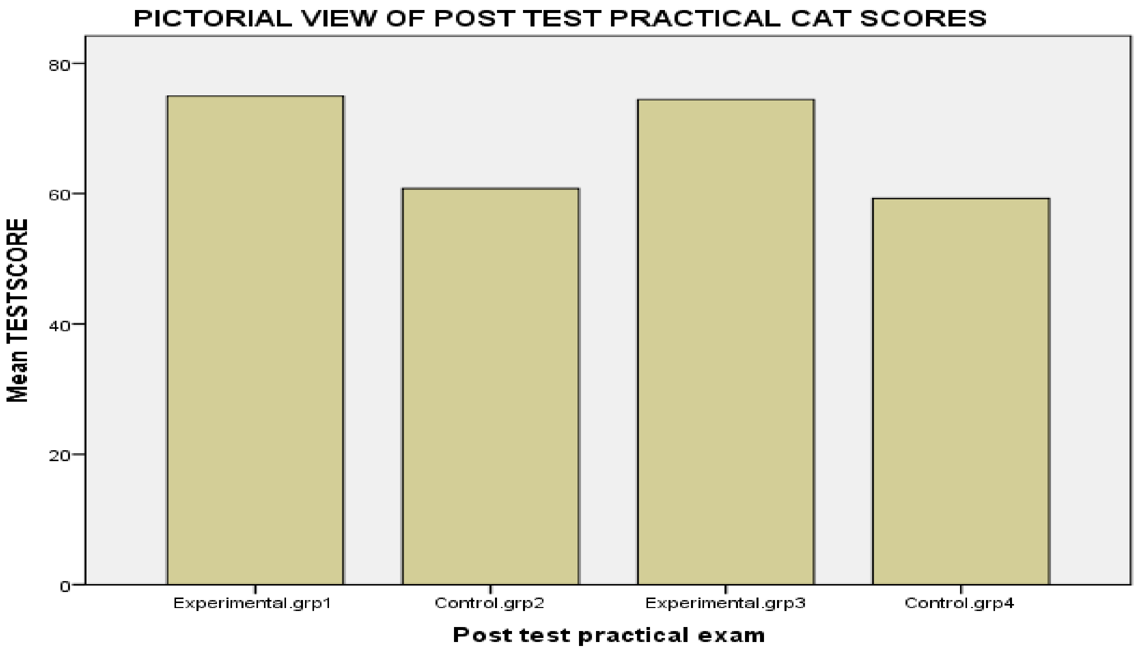


Figure 4.2: pictorial view of post test CPT scores

The means and standard deviations of learners' post -test scores in CPT are presented in Table 4:14.

**Table 4:14: Mean and Standard Deviations of Learners' Post-Test Scores in CPT According to Groups**

| | N | Mean | Std. Deviation | Std. Error |
|---|---|---|---|---|
| gourp1 | 92 | 74.98 | 3.605 | .532 |
| group2 | 90 | 60.80 | 3.202 | .477 |
| group3 | 88 | 74.45 | 4.060 | .612 |
| group4 | 96 | 59.29 | 3.364 | .486 |
| Total | 366 | 67.25 | 8.194 | .606 |

Source: field data

From Table 4:14, experimental group 1 posted the highest mean score in CPT, followed by Experimental group 3.control group2 and control group 4 followed in that order. The overall mean score for the four groups was 67.25. The experimental group 3 was the most dispersed around the mean followed by experimental group 1, then control group 4 and control group 2 was the least dispersed about the mean.

Since the means were different, a one way ANOVA test was carried out to determine whether the mean differences in CPT were statistically significantly different and the results are presented in Table 4:15.

**Table 4:15: One Way ANOVA Test for Post – Test Scores in CPT According to Groups**

| | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 9943.433 | 3 | 3314.478 | 260.558 | .000 |
| Within Groups | 2277.004 | 179 | 12.721 | | |
| Total | 12220.437 | 182 | | | |

Source: field data

From Table 4:15, the mean differences were statistically significantly different (df = 3, 179, F = 260.558, P=0.00< 0.05).

Since there was a statistically significant difference in the learners' mean scores in CPT, a post hoc analysis test was performed to determine the groups which were statistically significantly different and the results are presented in Table 4:16.

**Table 4:16: multiple comparison of post – test scores in CPT by group**

| (I) Post-test CPT | (J) Post-test CPT | Mean Difference (I-J) | Std. Error | Sig. |
|---|---|---|---|---|
| group1 | group2 | 14.178* | .748 | .000 |
| | group3 | .524 | .752 | .898 |
| | group4 | 15.687* | .736 | .000 |
| group2 | group1 | -14.178* | .748 | .000 |
| | group3 | -13.655* | .756 | .000 |
| | group4 | 1.508 | .740 | .178 |
| group3 | group1 | -.524 | .752 | .898 |
| | group2 | 13.655* | .756 | .000 |
| | group4 | 15.163* | .744 | .000 |
| group4 | group1 | -15.687* | .736 | .000 |
| | group2 | -1.508 | .740 | .178 |
| | group3 | -15.163* | .744 | .000 |

*the mean difference is significant at 0.05 level

Source: field data

From Table 4:16, there is a statistically significant difference in the mean scores of experimental group 1 and that of control group 2 and group 4 ($t=14.178$, $p=0.000<0.05$ and $t=15.687,p=0.000<0.05$) respectively. The mean difference between experimental group 3 and that of control group 2 and group 4 was also statistically significantly different ( $t=13.65,p=0.000<0.05$ and $t=15.163$, $p=0.000 <0.05$) respectively The mean difference between experimental group 1 and experimental group 3 was not statistically significantly different ($t= 0.524$, $p= 0.898>0.05$) and mean difference between control group 2 and control group 4 were not statistically significantly different (t=1.5808, p=0.178 >0.05) since experimental group 1 and 3 had a statistically significantly higher mean than the control group 2 and 4, SPSTA resulted in students performing better in Chemistry practical than the RT methods.

Having established that there was a statistically significant difference in the achievement of students who are taught using SPSTA and that of students taught using regular teaching methods in Chemistry practical, there was need to find out whether the groups were different before the study or the difference was as a result of instruction. To do this the learners' KCPE scores were used as a covariate. Table 4:17 shows the adjusted post-test CPT mean scores for ANCOVA with KCPE scores as covariate.

**Table 4:17: Adjusted Post -test CPT Mean Scores for ANCOVA with KCPE Scores as Covariate**

| Group | N | Mean | Std. Deviation |
|---|---|---|---|
| group1 | 92 | 64.30 | 13.715 |
| group2 | 90 | 55.78 | 9.813 |
| group3 | 88 | 68.84 | 16.752 |
| group4 | 96 | 51.98 | 11.950 |
| Total | 366 | 60.23 | 14.935 |

Source: field data

From Table 4:17, experimental group 3 had the highest mean followed by experimental group1 then control group 2 and control group 4 followed in that order. The ANCOVA of the post- test scores on the CPT are presented in Table 4:18.

**Table 4:18: ANCOVA on the Post -test CPT**

| | Sum of squares | df | Mean square | F | p-value |
|---|---|---|---|---|---|
| **Corrected model** | 5319.313 | 3 | 1729.828 | 9.528 | 0.000 |
| **KCPE** | 552.668 | 1 | 552.668 | 4.914 | 0.049 |
| **Error** | 27133.714 | 178 | 141.201 | | |

Source: field data

Table 4:18 shows there is a statistically significant difference between the means at $p < 0.05$. $F(3,178) = 9.528$, $p = 0.000 < 0.05$). The post hoc pair wise comparisons based on the ANCOVA are displayed in Table 4:19.

**Table 4:19: Pair Wise Comparisons Based on ANCOVA**

| (I)post-test CPT | (J)Post-test CPT | (I-J) | Std. Error | p-value |
|---|---|---|---|---|
| group1 | group2 | 8.52* | 2.492 | 0.034 |
| | group3 | -4.54 | 2.507 | 1.000 |
| | group4 | 12.32* | 2.452 | 0.001 |
| group2 | group1 | -8.52* | 2.492 | 0.034 |
| | group3 | -13.06* | 2.519 | 0.001 |
| | group4 | 3.8 | 2.466 | 1.000 |
| group3 | group1 | 4.54 | 3.307 | 1.000 |
| | group2 | 13.06* | 3.289 | 0.001 |
| | group4 | 16.86* | 2.481 | 0.000 |
| group4 | group1 | -12.32* | 2.452 | 0.001 |
| | group2 | -3.8 | 2.466 | 1.000 |
| | group3 | -16.86* | 2.481 | 0.000 |

*the mean difference is significant at 0.05 level

Source: field data

From Table 4:19, there is a statistically significant difference between experimental group 1 and control group 2 and 4 (t= 8.52, p=0.034<0.05 and t=12.32, p= 0.001<0.05) respectively. There is also a statistically significant difference between experimental group 3 and control group 2 and 4 (t= 13.06, p=.001<.05 and t=16.86, p=.000<.05) respectively. The mean differences between experimental group 1 and experimental group 3 were not statistically significant (t=4.54,p=1.000>.05) and the mean differences between control group 2 and control group 4 were also not statistically significant ( t=3.8, p=1.00>.05)

A comparison of the students' scores in the pre-test and post-test CPT for group 1 and 2 was carried out and the results together with their mean gain are presented in Table 4:20.

**Table 4:20: Students' mean gain in pre-test CPT and post-test CPT Scores**

| | Group1 N= 92 | Group2 N=90 | Overall |
|---|---|---|---|
| **Pre-test mean** | 29.87 | 29.72 | 29.80 |
| **Post-test mean** | 74.98 | 60.80 | 67.89 |
| **Mean gain** | 45.11 | 31.08 | 38.90 |

Table 4:20 shows that the mean gain for experimental group 1 was higher than that of the control group 2 yet they both did a pre-test, the other tests have shown that experimental group1 had a significantly different higher mean score that control group 2 in the post-test CPT mean score. This difference can only be attributed to the use of SPSTA. A t-test was performed to determine whether there was a significant mean gain between pre-test and post-test scores in CPT, the results are presented in Table 4:21.

**Table 4:21: Independent Samples t-Test for Significant Gain between Pre-test and Post – test in CPT (Group 1 and Group 2)**

| Variable | Group | Mean gain | Std. dev | t-value | df | p-value |
|---|---|---|---|---|---|---|
| **CAT** | 1 | 45.11 | 6.648 | 28.29 | 89 | 0.000 |
| | 2 | 31.08 | 6.701 | | | |

Source: field data

Table 4:21 shows there was a statistically significant gain in the mean between the pre-test and post-test in CPT (t=28.29, P= 0.00<0.05). The experimental group 1 had a statistically significant higher mean gain than the control group 2; these findings can be strongly attributed to the use of SPSTA.

Gall& Borg (2007) hold that a pre-test helps to, evaluate if there was any association between the pre-test and treatment conditions. It also assists to establish how pre-test influences outcome as compared to no pre-test and also the similarity of the groups before administration of the instrument. In this study CPT pre-test was administered to experimental group 1 and control group 2.The means of the pre-test scores on the CPT are presented in Table 4:12 which indicated that the control group 2 had a higher mean score than the experimental group 1 in the CPT. Further tests to determine whether the mean differences in the pre-test CPT scores were significantly different were performed.

A t-test on pre-test CPT scores showed that the mean differences were not statistically significant at $P \leq 0.05$ (Table 4:13).Since the means of the pre-test scores were not significantly different, the groups had comparable characteristics and hence appropriate for the study. The experimental group 1 and group 3 were exposed to Science Process Skills Teaching Approach (SPSTA) in the learning of the content “salts” in the Form Two Chemistry syllabus while the control group2 and group 4 were taught the same content using Regular Teaching (RT) Methods, after instruction a post-test CPT was administered to all the groups. The CPT was analyzed using SPSS in order to test hypothesis 2 for the study. A one way ANOVA on the post-test CPT mean scores for the four groups were presented in Table 4:15 and it showed that there was a statistically significant difference in the CPT post-test mean scores.

A comparison of the post-test CPT mean scores on the Least Significant Differences (LSD) table was presented in Table 4:16 and it shows that the experimental groups had a statistically significantly different higher post-test CPT mean score than the control groups, while the post-test CPT mean score differences between experimental group 1 and experimental group 3 were not significantly different and the post-test CPT mean scores between the control group 2 and control group 4 were also not significantly different.

Experimental group 1 and experimental group 3 were found to be similar to each other in the post-test CPT, but not similar to the control group 2 and control group 4, the researcher was in a strong position to attribute the differences to the experimental condition (Mugenda & Mugenda, 2005). SPSTA was attributed to the differences between the experimental groups and the control groups in the post-test CPT scores. Further, Analysis of Covariance was performed to establish whether there were existing differences at learners’ entry level, and the learners’ KCPE scores were used as a covariate. The ANCOVA of the adjusted post-test mean scores on CPT presented in Table 4:18 indicate that there was a statistically significant difference in the adjusted post-test

CPT mean scores with KCPE scores as a covariate. The LSD Table 4:19 indicates that the adjusted post-test CPT scores with KCPE scores as a covariate for experimental group 1 and group 3 were significantly different from those of the control group 2 and control group 4 and since the groups were not different at entry level, the researcher strongly attributed the difference to the SPSTA.

The post-test CPT results in this study did not indicate any interaction between the pre-test and the SPSTA treatment since there was no significant difference between experimental group 1 and experimental group 3 and between control group 2 and control group 4. If the Pre-test provided a practice effect, it should have resulted in significantly higher post-test CPT scores by group 1 and group 2 than by group 3 and group 4, but this was not the case in this study, hence the CPT pre-test was suitable for the study and the researcher attributed the significant mean gain between the pre-test and the post-test CPT scores to the use of SPSTA which resulted in higher students' achievement in Chemistry Practical than the regular teaching methods since experimental group1 and experimental group 3 obtained statistically significant higher scores in the CPT than the control group 2 and control group 4.

Objective 2 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 Practical 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 Practical with the students taught using SPSTA posting  higher achievement scores in CPT post-test relative to the students who were taught using RT methods hence $HO_2$ 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 Practical was rejected.

Findings of this study are in line with Akpa (2002) who argues that giving learners the freedom to come up with their intentions by stating goals, then planning on how to achieve their goals by following their own laid down procedure to satisfy their curiosity to develop own learning amidst challenges and allowing the student to suggest practical alterations and improvements could result in a significant positive impact on student's ability to learn both the intended practical skill and the theory behind the investigation.

Current dynamics in the setting of KCSE chemistry practical show that**;** learners ought to have manipulative skills which makes it possible to handle it. Endlamaw et al (2017) showed that many learners were not exposed to physics practical in Nigeria. A similar case was reported in Ethiopia (Tsai, 2003). Ajaja (2009) reported that in Nigeria there was a poor performance in practicals, a fact associated with lack of skill from learners to handle apparatus since they did not have exposure. SPSTA on the other hand provided an opportunity for the acquisition of the needed skills; hence the good performance in Chemistry practical.

Teachers should ensure that learners experience both the high and low order process skills of science (Abrahams & Millar, 2008). Further, Watts (2013) argues that when learners develop these skills and abilities during the lesson of Chemistry, which can be improved through Chemistry practical. Results of current study are attributed to the fact that In SPSTA, there was learner involvement which facilitated personal growth and skills development which resulted from the fact that learners had the privilege to learn the syllabus content through science process skills teaching approach, which enhanced development of a varied skills such as manipulating apparatus, asking questioning, making accurate observations, predicting, inferring and critical thinking.

SPSTA helped to improve the quality of Chemistry practical and when practical are of good quality, they enhance learner's appreciation of concepts and process skills of science (Dillon, 2008) this led to better scores in Chemistry practical by the learners who were taught using SPSTA. SPSTA made the practical of Chemistry to boost learning, and the learning experiences played an important role in improving students' achievement in Chemistry practical, a view held by The House of Commons Science Technology Committee (UK, 2002).

In SPSTA, the role of the teacher was to create a learning environment where learners were compelled to look for research steps in identifying learning problems, to come up with questions which require to be addressed. This was followed by the learner making use of the scientific method of inquiry, to establish relevant explanations, predictions and descriptions to the concern that necessitated an investigation. This contributed to high performance in Chemistry practical. Science process skills exercises provide an opportunity for learners to develop manipulative skills (Wilke & Straits, 2005).

SPSTA improves students' performance in for example, finding answers to their concerns, evaluating their performance to be able make conclusions and generalizations. These qualities are fundamental, if learners are required to achieve highly. If secondary schools in Kenya implement SPSTA for instruction in Chemistry, there is a likelihood that that the students' achievement scores at KCSE in Chemistry Practical examination will significantly improve. Secondary school Chemistry teachers are therefore encouraged to use SPSTA in their teaching.

### 4.4 Achievement of Girls and Boys Exposed to SPSTA in Chemistry Theory

Trumper, (2006) explains that girls and boys of approximately the same age exhibit different perceptions towards the same method of instruction. Kibirige and Tsamango (2013) however established a contradictory opinion that, learners who are girls and boys did not show a difference in attitude towards similar strategies of instruction. Based on 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 instructed using SPSTA in Chemistry theory. This was determined by testing the third hypothesis for the study which stated; **$HO_3$**: there is no statistically significant difference between the achievement of girls and boys exposed to SPSTA in Chemistry theory. 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 took a pre-test and the means of the pre-test scores on CAT for experimental group 1 boys and girls are presented in Table 4:22.

**Table 4:22: Means and standard deviations of Pre-test Scores on CAT for experimental group 1 boys and girls**

| Pre-Test CAT | Mean | N | Std. Deviation |
|---|---|---|---|
| Group1Boys | 18.09 | 46 | 4.111 |
| Group 1 Girls | 20.09 | 46 | 4.804 |
| Total | 19.09 | 92 | 4.535 |

Source: field data

Table 4:22 shows that the girls scored a mean of 20.09 while the boys had a mean of 18.09. The girls' mean score was higher than that of the boys in the pre-test in the CAT. However from earlier analysis these mean differences were not statistically significant. This means that the boys and girls in group 1 had comparable characteristics hence suitable for the study. After treatment, the experimental group 1 did a CAT post-test. The CAT post-test mean scores for experimental group1boys and girls are presented in Table 4:23.

**Table 4:23: CAT Post-test Mean Scores for Experimental Group 1 Boys and Girls**

| Post-test CAT | Mean | N | Std. Deviation |
|---|---|---|---|
| group1Girls | 58.57 | 46 | 14.795 |
| group1Boys | 60.04 | 46 | 9.088 |
| Total | 59.30 | 92 | 12.715 |

Source: field data

From Table 4:23, the boys had a mean of 60.04 while the girls' mean score was 58.57 in the post-test CAT. Experimental group 3 did a post-test CAT and the CAT post-test mean scores for experimental group 3 boys and girls are presented in Table 4:24.

**Table 4:24: CAT Post-test Mean Scores for Experimental Group 3 Boys and Girls**

| Post-test CAT | Mean | N | Std. Deviation |
|---|---|---|---|
| group3 Girls | 62.17 | 46 | 12.567 |
| group3 Boys | 62.95 | 44 | 16.961 |
| Total | 62.84 | 90 | 14.752 |

Source: field data

From Table 4:24, the boys had a mean of 62.95 while the girls' mean score was 62.17. 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 4:25.

**Table 4:25: Means and Standard Deviation of Experimental Group 1 and Group 3 in Post-test CAT**

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

Source: Field data

From Table 4:25, 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 4:26.

**Table 4:26: 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 | | | |

Source: field data

From Table 4:26, the mean differences between groups are not significant at $P< 0.05$ $F = 1.599$, $P= 0.195> 0.05$ 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 instructed throughSPSTA perform equally well in Chemistry theory. A t-test between the girls and the boys exposed to SPSTA was conducted and the results are presented in Table 4:27.

**Table 4:27: 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 | 0.983 |
| | Girls | 60.37 | 4.594 | | | |

Source: field data

Table 4:27 shows that the mean differences between the boys and the girls exposed to SPSTA were not statistically significant( t=0.022, p= 0.983> 0.05). 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 theory if SPSTA is used.

Having established that the mean differences between the girls and boys exposed to SPSTA were not statistically significant (Table 4:26 and Table 4:27), hypothesis **$H0_3$** 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 hypothesis **$H0_3$** was retained .

From Table 1:1 showing that the boys attain a higher mean in Chemistry KCSE examination than girls over the years may be addressed by implimenting teaching strategies, that are appealing to girls' interests in Chemistry. This will greatly assist in overcoming the gender gap that exist in the performance of girls and boys (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 styles of learning by students studying technology, pharmacy, Chemistry, technology and design majors. He discovered that learners who are doing chemistry and pharmacy are attracted towards styles of learning which are characterisedactive styles which are visual and sensitive 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 to find out how medical students in their first year in university would enjoy to learn. They used'turkish version questionnaire' which contains ( kinestatic,visual, read - write and auditory styles) and reported that there was no difference in learning styles preffered by both male students 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 theory and address the gender gap thatis exhibited in the performance of Chemistry in the KNEC KCSE theory.

## 4.5 Achievement of Girls and Boys Exposed to SPSTA in Chemistry Practical

Chemistry practical is a crucial part of Chemistry learning in secondary school. This is because it consists of 40% of the overall grade of the student at KCSE, hence there is need to design a teaching strategy which can boost the self-confidence in the ability to perform Chemistry practicals in the learners. KCSE results indicate that the boys score higher grades in Chemistry than the girls. The study used SPSTA and there was need to find out whether the achievement in chemistry practical was significantly different between the boys and girls exposed to SPSTA since studies indicate that girls and boys in the same class may have a difference in opinion towards the same instructional strategy. This was achieved by analysing hypothesis which stated; **$HO_4$**: there is no statistically significant difference between the achievement of boys and girls exposed to SPSTA in Chemistry practical.

$HO_4$ was tested by analysis of the CPT post test of experimental group 1 and experimental group 3 according to gender. Table 4:28 shows the means and standard deviations of the students' achievement in the CPT post- test by experimental group1boys and girls.

**Table 4:28: CPT post-test mean scores for experimental group 1 boys and girls**

| Post-test CPT | Mean | N | Std. Deviation |
|---|---|---|---|
| group1Girls | 75.00 | 46 | 4.101 |
| group1Boys | 74.96 | 46 | 3.126 |
| Total | 74.98 | 92 | 3.605 |

Source: field data

From Table 4:28, the experimental group 1 girls posted a mean of 75.00 while the experimental group 1 boys scored a mean of 74.96 in the CPT. Table 4:29 presents the CPT post-test scores for experimental group 3 boys and girls.

**Table 4:29: CPT Post-test Scores for Experimental Group 3 boys and girls**

| Post-test practical exam | Mean | N | Std. Deviation |
|---|---|---|---|
| group3Girls | 73.87 | 46 | 4.246 |
| group3Boys | 75.10 | 44 | 3.846 |
| Total | 74.45 | 90 | 4.060 |

Source: field data

Table 4:29 shows that the boys of experimental group 3 attained a mean of 75.10 while the girls posted a mean of 73.87 in the CPT. Experimental group 1 and experimental group 3 were analysed and the means in CPT post-test are presented in Table 4:30.

**Table 4:30: Means and Standard deviations of the Students' Achievement in CPT Post-test According to Gender**

| Group | Mean | N | Std. Deviation |
|---|---|---|---|
| group1Boys | 74.96 | 46 | 3.126 |
| group1 Girls | 75.00 | 46 | 4.101 |
| group3 Boys | 75.23 | 44 | 3.804 |
| group3 Girls | 73.68 | 46 | 4.247 |
| Total | 74.72 | 182 | 3.822 |

Source: field data

From Table 4:30, the means were different for all the groups and a one way ANOVA was carried out to determine whether the means were statistically significantly different and the results are in Table 4:31.

**Table 4:31: One way ANOVA on the Post-test Scores on CPT Accordiong to Gender**

| | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 32.463 | 3 | 10.821 | .734 | .534 |
| Within Groups | 1267.593 | 86 | 14.739 | | |
| Total | 1300.056 | 89 | | | |

Source: field data

From Table 4:31, there is no statistically significant difference between the achievement of boys and girls exposed to SPSTA in Chemistry practical at $P < 0.05$, $F = (3, 89) = 0.734$, $P = 0.534 > 0.05$. Having established that the mean differences among the girls and boys reported in Table 4:30 were not statistically significant from the ANOVA test in Table 4:31 then the study found out that the achievement of boys and girls exposed to SPSTA in Chemistry practical is not statistically significantly different. A t-test on the CPT post-test scores for the experimental group1 and experimental group 3 boys and girls are presented in Table 4:32.

**Table 4:32: CPT Post-test Scores for the Experimental Group1 and Experimental Group 3 Boys and Girls**

Boys, N= 90 Girls, N= 92

| Variable | Gender | Mean | Std. dev. | t-value | df | p-value |
|---|---|---|---|---|---|---|
| **CAT** | Boys | 75.10 | 4.535 | 1.059 | 89 | 0.295 |
| | Girls | 74.34 | 4.594 | | | |

Source: field data

From Table 4:32, (t= 1.059 and P= 0.295>0.05 ), the mean differences between the boys and girls exposed to SPSTA were not statistically significant. This implies that the boys and girls exposed to SPSTA perform equally well in Chemistry practical. **$H0_4$**: there is no statistically significant difference between the achievement of boys and girls instructed using SPSTA in chemistry practical was therefore retained since the ANOVA results (Table 4:31) and t-test (Table 4:32) show that there is no statistically significant difference between the achievement of boys and girls exposed to SPSTA in Chemistry practical. This implies that girls and boys exposed to SPSTA will perform equally well in Chemistry practical.

The outcome on the use of SPSTA, concur with findings by (Mwangi, 2016), who studied how Chemistry practical instruction affected the performance of both female students and male students in chemistry in public secondary schools in Kenya. He found no significant difference in Chemistry scores of boys and girls who took part in instruction using practical.

These findings are in support of the study by Oluwatosin and Ogbebu (2017). They looked at how hands on activities impacted on secondary school boys' and girls' performance in stoichiometry. They established that the attainment scores of boys and girls who participated in hands on activities in stoichiometry did not have a statistically significant difference. Cooperative class experiment (CCE) is another strategy that enables both male and female students to perform equally well. This was reported from a study of using CCE to instruct students in Chemistry (Wachanga, 2004). Cooperative project based learning (CPBL) also showed that when girls and boys are engaged in projects for learning chemistry, they improve in their performance with no statistically significant gender difference between them (Okero, 2010).

Ssempala, (2008) studied differences in performing Chemistry practical skills based on gender among students in Kampala District, Uganda. He established that both boys and girls performed well with no statistical difference in manipulative skills in handling apparatus, making observations, accuracy in reporting, recording data, ability to interpret, analyze and compute data collected. Both boys and girls admitted that the skill of data analysis and interpretation pose a challenge to either gender, while handling and manipulating apparatus were termed as easy skills by both boys and girls. It is worth noting that girls exposed poor self confidence in carrying out the practical and that boys were good at reporting, recording, analyzing and computing data as compared to girls. These skills carry a lot of weight when testing practical Chemistry by the Uganda National Examinations Board examiners (UNEB) and the study attributed this to the better performance of boys than girls in UNEB Chemistry practical examinations.

Busolo, (2010) study on gender differences in students' achievement in Chemistry in secondary schools in Kenya reported that boys had a strong attraction and positive attitude towards Chemistry as compared to girls and recommended that strategies to develop interest in Chemistry for girls should be developed. A study on what contributes to gender disparity in academic performance in science subjects in Kenya Certificate of Secondary Education in Kenya recommended that there was need to implement strategies to awaken the interest of girls in science subjects with the aim of eliminating the difference in performance between boys and girls (Mackatian, 2018) SPSTA on the other hand was able to stimulate the girls' interests in Chemistry and develop the girls' self confidence in their ability to perform Chemistry practicals that is why there was no statistically significant difference in the achievement of boys and girls exposed to SPSTA in Chemistry practical. If teachers of Chemistry adopt SPSTA in their teaching, the achievement of students in Chemistry practical will improve and the gender gap in the achievement in Chemistry practical will be alleviated.

# CHAPTER FIVE

# SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Introduction

This chapter has given a summary, based on the findings of the study. Conclusions and recommendations are presented, to help improve Chemistry teaching in Kenyan secondary schools. Suggestions for further research are provided.

The purpose of this study was to explore the influence of science process skills teaching approach (SPSTA) on secondary school students' achievement in Chemistry. The study determined whether there was a significant improvement in performance of secondary school students' achievement in both chemistry theory and chemistry practical due to the application of SPSTA for instruction. Objectives which guided the study are:

(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 theory.

(ii) To determine whether the achievement of students who are taught using SPSTA is statistically significantly different from that of students who are taught using the RT methods in Chemistry practical.

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

(iv)To find out whether there is a statistically significant difference in the achievement of the boys and the girls taught using SPSTA in Chemistry practical.

The following null hypotheses were generated:

$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 theory test.

$H_0$2: There is no statistically significant difference in the achievement of students exposed to SPSTA and those who are exposed to RT methods in Chemistry practical test.

$H_0$3: There is no statistically significant difference in achievement between boys and girls who are taught through SPSTA in Chemistry theory test.

$H_0$4: There is no statistically significant difference in achievement between boys and girls who are taught through SPSTA in Chemistry practical test.

The review of literature focused on science process skills teaching approach; the science process skills teaching activities, the implementation of science process skills teaching approach and chemistry instruction in secondary schools. The study made use of quasi- experimental, Solomon Four non-equivalent control group pre-test-post-test design. The accessible population was Form Two chemistry students in Kisii South Sub- County of Kenya. 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. Simple random sampling was further used to select two schools from the sampled schools to form the experimental groups while the two remaining schools formed the control groups. A sample of 366 students in the four schools was selected for the study. 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' which is part of the Form Two syllabus. Chemistry Achievement Test (CAT) and a Chemistry Practical Test (CPT) were used for data collection. Data was analyzed using SPSS version 21. ANOVA, t-test and ANCOVA was used to test the hypotheses.

## 5.2 Summary of Findings

The study came up with the following findings:

### (i) Influence of SPSTA on students' achievement in chemistry theory

The experimental group1 had a mean of 59.30 while control group 2 had a mean of 52.78, experimental group 3 had a mean of 62.84 and control group 4 had a mean of 49.98 in the post-test CAT. Further analysis using ANOVA, F= 11.072 with P= 0.00 and the LSD table showed that the mean differences were significant between experimental group 1 and control group 2 and control group 4 and between experimental group 3 and control group 2 and control group 4. ANCOVA further revealed that the mean differences were significant at $P \leq 0.05$ level, this shows that the use of Science Process Skills Teaching Approach (SPSTA) had a significant positive influence in the achievement of secondary school students in Chemistry Theory and therefore it is better method of teaching and learning Chemistry.

### (ii) Influence of SPSTA on students' achievement in Chemistry practical

The experimental group1 had a mean of 74.98 while control group 2 had a mean of 60.80, experimental group 3 had a mean of 74.45 and control group 4 had a mean of 59.29 in the post-test CPT. Further analysis using ANOVA showed F= 260.558 with P= 0.00 and the LSD table showed that the mean differences were significant between experimental group 1 and control group 2 and control group 4 and between experimental group 3 and control group 2 and control group 4. ANCOVA further revealed that the mean differences were significant at $P \leq 0.05$ level, this shows that the use of Science Process Skills Teaching Approach (SPSTA) had a significant positive influence in the achievement of secondary school students in Chemistry Practical and therefore it is better method of teaching and learning Chemistry.

**(iii) Achievement of girls and boys exposed to SPSTA in Chemistry Theory**

Experimental group 1 boys had a mean of 60.04 while experimental group 1girls had a mean of 58.57. Experimental group 3 boys had a mean of 62.95 while the experimental group 3 girls had a mean of 62.17 in the post-test CAT. Further analysis using ANOVA shows F= 1.599 and P= 0.195. this shows that when SPSTA is used for instruction, both male and female students will benefit equally and that both boys and girls taught using SPSTA will perform equally well in Chemistry theory and SPSTA is a better method of teaching and learning Chemistry for both boys and girls as it will help improve the students' achievement in Chemistry theory.

**(iv) Achievement of girls and boys exposed to SPSTA in Chemistry practical**

Experimental group 1 boys had a mean of 74.96 while experimental group 1girls had a mean of 75.00 Experimental group 3 boys had a mean of 75.23 while the experimental group 3 girls had a mean of 73.68 in the post-test CPT. Further analysis using ANOVA shows F= 0.734 and P= 0.534, this shows that when SPSTA is used for instruction, both male and female students will benefit equally and that both boys and girls taught using SPSTA will perform equally well in

Chemistry Practical and SPSTA is a better method of teaching and learning Chemistry for both boys and girls as it will help improve the students' achievement in Chemistry Practical.

## 5.3 Conclusions

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 Theory as compared to Regular Teaching methods. (2) Science Process Skills Teaching Approach positively influences secondary school students' achievement in Chemistry Practical more than Regular Teaching methods. (3) Both boys and girls will improve their achievement in Chemistry Theory when they are taught using Science Process Skills Teaching Approach. (4) Both boys and girls will improve their achievement in Chemistry Practical when they are taught using Science Process Skills Teaching Approach.

The findings of this study confirm that the use of SPSTA for teaching helps in improving secondary school students' achievement in both Chemistry Theory and Chemistry Practical regardless of their gender. This implies that exposure to SPSTA had a positive influence in the achievement of learners in both Chemistry Theory and Chemistry Practical. This is attributed to the fact that SPSTA increases students' interest and abilities in science subjects as well as their achievement in science subjects since SPSTA helps students to understand theories and chemical principles which are difficult to understand as it offers several opportunities to students to develop scientific inquiry and enthusiasm to Chemistry and develops basic manipulative and problem solving skills.

To improve on the use of SPSTA, there should be enough resources for Chemistry teaching and learning, that is enough teachers, well equipped laboratories and classrooms. Ensure that both male and female students are actively involved with equal opportunity to enhance students' interest during learning since SPSTA is not gender biased.

## 5.4 Recommendations

The outcomes of the study indicate that SPSTA exerted a positive influence on the secondary school students' achievement in both Chemistry theory and Chemistry practical than the RT methods. This implies that the problem of poor performance in Chemistry may be addressed by incorporating the SPSTA in the teaching at secondary school level; this can be achieved through subject seminars to sensitize teachers on SPSTA. SPSTA should be used to supplement, but not replace other teaching methods and for SPSTA to be more effective the number of teachers should be increased in order to reduce the size of the classroom and there should be well equipped laboratories. It is also essential that the pre-service and in-service training of teachers prepare teachers on the use of SPSTA so that the teachers will be able to effectively use SPSTA for the teaching of Chemistry.

The gender gap in the performance of Chemistry in KCSE may be related to instructional practice. It seems that SPSTA has the potential of maintaining the comparable abilities between boys and girls throughout the secondary school course since the study revealed that there was no statistically significant difference in the achievement of boys and girls exposed to SPSTA. Therefore wide spread implementation of SPSTA would be beneficial to students. Anchored on these findings, the study recommends the following:

(i) Heads of schools to provide resources to teachers of Chemistry to enable them to implement SPSTA in teaching.

(ii) Quality, assurance and standards officers in service delivery to check and advice teachers of Chemistry to adopt learner centred pedagogy in teaching which are mainly experiment in nature like SPSTA.

(iii) Heads of Science department of schools ensure that teaching of science subjects in their department embraces expository methods of teaching and one of such methods is SPSTA.

(iv) Heads of subjects of Chemistry of schools to see to it that teachers of Chemistry use SPSTA as a learner centred approach for teaching.

(v) Teachers of Chemistry to practice the use of SPSTA as an expository method in the teaching of Chemistry. This will improve the secondary school students' achievement in Chemistry theory and Chemistry practical.

(vi) The in-service courses organized by CEMASTEA for practicing teachers of Chemistry should encourage teachers of Chemistry to use practical oriented techniques to teaching such as SPSTA.

## 5.5 Areas for Further Research

The present study has shown that SPSTA can help improve Chemistry instruction; however there are areas which need further investigation such as:

(i) A study aimed at determining the influence of SPSTA on secondary school students' achievement in Chemistry in different school environments such as boys' only and girls' only schools.

(ii) A study on the influence of SPSTA on the acquisition of science process skills by secondary school students.

(iii) A study on the effect of SPSTA on secondary school students' motivation towards chemistry.

(iv) Studies on how to make the quality of SPSTA worthwhile to implement better and more efficient practices.

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# APPENDICES

## APPENDIX A

## TEACHER'S MANUAL

The learner is expected to be able to do the following by the end of instruction in this area of study.

a) Choose the most suitable method which can be used to prepare a required salt.

b) Give the meaning of words such as; a solution which is saturated solution. crystallization, neutralization and the method of precipitation

c) Balance well written equations involving ions in reactions.

d) Classify salts based on type.

e) Identify salts which dissolve in water and those which do not.

f) Explain based on experimental observations how heat affects different salts

g) Identify applicability of salts to real life.

**FORMATION OF GROUPS**

Divide students into small learning groups. At this stage of forming groups for use; adhere to the following guidelines;

i) Distribute work among five members of each group so that everybody is active they should work together in the following activities:

a) Planning the experiment

b) Performing the experiment

c) Recording the experimental results

d) Analyzing the results and making conclusions

e) Writing reports

Each group member should be in charge of an activity i.e.

a) Assembling the apparatus and performing the experiments

b) Recording the observations

d) Analysis of the results

e) Checking literature in the text books

f) Conclusions and equations.

-Each group should aim at a score of 60% in the practical and CAT

-Each student should write the experimental report. Once a teacher has marked the reports, an individual as well as a group score should be given.

-In order to promote individual accountability, the teacher should:

a) Keep the size of the group small. A group of five students is optimum.

b) Every member of the group should be given a task to perform individually.

c) Give an oral examination. This can be done by asking a learner at random to come forward and give the individual or group's laboratory report before the entire class.

## SALTS (20 lessons)

Lesson1

lesson objectives;

From this lesson; the learner is required to:

i) Give the meaning of the word salt

ii) Describe different salts based on ‘type’

iii) Identify types of salts

Teacher/ learner activities

Provide learners with normal type salts, examples of acid type salts, basic nature salts and some double type salts in their groups. Learners are expected to place salts of the same type in the same group. Each group to show case their findings for other groups to compare their results. Tell learners the appropriate definition of‘salt’, ‘normal salt’, ‘acid salt’, ‘basic salt’ and ‘double salt’. Learners to come up with examples of these salts from the list they presented in class in their co-operative groups.

Teacher/ learner resources

Sodium chloride, potassium sulphate, sodium carbonate, calcium nitrate, sodium hydrogen carbonate, potassium hydrogen sulphate, basic magnesium chloride, basic lead carbonate, basic zinc chloride, basic copper II carbonate, hydrated potassium aluminium sulphate, hydrated ammonium iron II sulphate, trona.

Lesson 2&3

This lesson should help the learner to;

i) use water to classify salts in terms of 'solubility'

ii) Carry out an experiment to determine soluble and insoluble salts

Teacher/ learner activities

Provide learners with worksheets on the solubility of salts in water in their co-operative groups. The learners follow the procedure given in the worksheet to come up with a summary of the soluble and insoluble salts. Each group presents their finding on the soluble and insoluble salts. Learners are given an assignment to give a summary on the soluble and insoluble sulphates, chlorides, nitrates and carbonates.

Resources

Potassium salts, sodium salts, calcium salts, magnesium salts,ammonium salts aluminium salts, zinc salts, iron salts, lead salts, copper salts, barium salts, water, test tubes

Lesson 4

The lesson intends to achieve the following in a learner:

i) Identify salts which are dissolvable in water(soluble) and insoluble bases in water

ii) Carry out an experiment to determine soluble and insoluble bases

iii) Record accurate observation of their experiment

iv) Make their findings available to all class members

Teacher/ learner activities

Provide learners with worksheets on the solubility of bases in water in their co-operative groups. The learners follow the procedure given in the worksheet to come up with a summary of the soluble and insoluble bases in water. Each group presents their results to the whole class. Learners are given an assignment to give a summary on soluble and insoluble bases

Resources

Oxides and hydroxides of calcium, potassium, aluminium, sodium, magnesium,copper and zinc.

Note: zinc, copper and aluminium hydroxide can be pre-prepared by precipitating the hydroxide by double decomposition.

Lesson 5

Lesson objectives:

At the end of the lesson, the learner should:

i) Give the definition of‘saturated solution’ and‘crystallization’

ii) Prepare copper II sulphate crystals; from saturated copper II sulphate solution

Teacher/learner activities

Provide learners with worksheets on the preparation of copper II sulphate crystals in their co-operative groups. The learners follow the procedure given in the worksheet to prepare copper II sulphate crystals. Each group presents their copper II sulphate crystals to the whole class.

Discuss with the learners the meaning of a saturated solution and crystallization. Give learners an assignment to answer questions on page 87 KLB students' book for form 2 in their co-operative groups.

Resources

Provide each group with the following:

100ml water, one spatulafull of copper II sulphate crystals, beaker, stirring rod, evaporating dish, source of heat, glass rod, filter paper.

Lesson 6 & 7

This lesson is intended to help the learner to:

i) Follow steps which lead to the formation of zinc sulphate

ii) Write a balanced chemical equation showing how chemicals interact during the experiment.

Teacher/ learner activities

Provide learners with worksheets for the preparation of zinc sulphate in their co-operative groups. Learners follow the procedure in the work sheet to prepare zinc sulphate. Every group present their zinc sulphate to the entire class. Discuss with learners other soluble salts which can be prepared by reacting a metal with an acid. Let the learners illustrate reactions using chemical equations in their groups. Give learners an assignment to balance chemical equations for the discussed cases of reactions involved in preparing salts.

Resources

20 $cm^3$ dilute sulphuric acid, 2g zinc powder, glass rod, spatula, beaker, filter paper, filter funnel, evaporating basin

Lesson 8

Lesson objectives:

At the end of the lesson, the learner shall:

i) Prepare ‘copper II sulphate’

ii) Represent the experiment stoichiometrically.

Teacher/ learner activities

Provide learners with worksheets for the preparation of copper II sulphate in their groups. Learners follow the procedure in the work sheet to prepare copper II sulphate. Every group presents their copper II sulphate to the entire class. Discuss with learners other soluble salts which can be prepared by reacting a metal oxide with an acid. Let the learners provide balanced chemical equation for the reaction which took place in their groups. Give learners an assignment to write stoichiometric equations for the reactions involved when the salts discussed in class are prepared

Resources

20 $cm^3$ dilute sulphuric (VI) acid, 4 g copper (II) oxide, 2 glass beakers, glass rod, spatula, 3 filter papers, conical flask, filter funnel, evaporating basin, water, source of heat

Lesson 9

The objective of this lesson is to make the learner to be able to:

i) Come up with sodium chloride

ii) Show how the reaction takes place using equations.

Teacher/ learner activities

Provide learners with worksheets for the preparation of sodium chloride in their groups. Learners follow the procedure in the work sheet to prepare sodium chloride. Every group presents their sodium chloride to the entire class. Discuss with learners; other soluble salts which can be prepared by reacting a metal hydroxide with an acid. Let the learners generate balanced chemical equations for the reactions in the experiment. Give learners an assignment to illustrate their experiments using stoichiometry.

Resources

$25cm^3$ 1M HCl, $25cm^3$ 1M NaOH, universal indicator paper, phenolphthalein indicator, evaporating basin, source of heat.

Lesson 10 & 11

This lesson will enable the learner:

i) To prepare lead (II) nitrate

ii) To write an equation to show the reaction which has occured

Teacher/ learner activities

Provide learners with worksheets for the preparation of lead (II) nitrate in their groups. Learners follow the procedure in the work sheet to prepare lead (II) nitrate. Every group presents their lead (II) nitrate to the entire class. Discuss with learners other soluble salts which can be prepared by reacting a metal carbonate and an acid. Let the learners show the reaction using an equation in their groups. Give learners an assignment on the salts discussed during the lesson.

Resources

25 $cm^3$ dilute nitric acid, lead (II) carbonate, glass rod, glass beaker, filter paper, filter funnel, conical flask, evaporating basin, spatula, source of heat

Lesson 12

This lesson is aimed at helping the student to:

i) Come up with iron (II) sulphide from an experiment

ii) Explain how ions interact during the experiment using equations

Teacher/ learner activities

Provide learners with worksheets for the preparation of iron (II) sulphide in their groups. Learners follow the procedure in the work sheet to prepare iron (II) sulphide. Every group presents their iron (II) sulphide to the entire class. Discuss with learners other salts which can be prepared by direct combination of elements. Let the learners illustratein their co-operative groups, how the ions combine during the experiment. An assignment on ionic equations for the saltsdiscussed should be given.

Resources

Spatulaful of iron fillings, spatulaful of sulphur, crucible, source of heat

Lesson 13

At the end of the lesson, the learner should be enabled to:

i) Follow a workable procedure to prepare lead (II) sulphate salt

ii) Elaborate the procedure followed using an ionic equation

Teacher/ learner activities

Provide learners with worksheets for the preparation of lead (II) sulphate in their groups. Learners follow the procedure in the work sheet to prepare lead (II) sulphate. Every group presents their lead (II) sulphate to the entire class. Discuss with learners other salts which can be prepared by precipitation/ double decomposition. Let the learners come up with ionic equations for the reaction which took place during the experiment. Give learners an assignment to show ionic equations for the reactions involving salts discussed.

Resources

10 $cm^3$ lead (II) nitrate, magnesium sulphate solution, glass rod, beaker, distilled water, 2 filter papers, a conical flask, filter funnel

Teacher/learner activities

Provide learners with worksheet on the effect of exposure to the atmosphere on salts in their groups in a day earlier before the lesson. Learners follow the procedure and set samples for the lesson overnight in the laboratory. During the lesson, learners make observation on the effect of the exposure to the atmosphere on salts and classify salts into deliquescent, hygroscopic and efflorescent salts. Learners present their report to the entire class. Discuss with learners deliquescence, hygroscopy, and efflorescence. Give learners an assignment to research and add to the list of the different types of salts observed in class.

Resources

Common salt, anhydrous calcium chloride, potassium nitrate, hydrated sodium carbonate, anhydrous iron (III) chloride.

Lesson 16

By the end of the lesson, the learner should be able to:

i) Explain how heat will affect carbonate salts

ii) show how carbonates decompose when heated by use of equations

Teacher/learner activities

Provide the learners with worksheets on the effect of heat on carbonates in their groups. Learners follow the procedure on the work sheet to fill the table on the effect of heat on carbonates. Each group shows their results to all groups in class. Discuss the results with learners and let the groups to write balanced chemical equations involved in the heating of carbonates.

Resources

Copper (II) carbonate,potassium carbonate, calcium carbonate, zinc carbonate, lead (II) carbonate,sodium carbonate, ammonium carbonate, sodium hydrogen carbonate, potassium hydrogen carbonate, source of heat, calcium hydroxide solution, boiling tubes, glass rod.

Lesson 17

This lesson should enable the learner to:

i) Identify the products obtained when nitrates are heated

ii) Illustrate the decomposition of nitrate salts using equations

Teacher/ learner activities

Provide the learners with worksheets on the effect of heat on nitrates in their groups. Learners follow the procedure on the work sheet to fill the table on the effect of heat on nitrates. Each group to show case their results to the class in turns. Discuss results presented with the class and let the groups give a summary of the decomposition of nitrate salts.

Resources

Nitrates of potassium, sodium, calcium, zinc, lead and copper

Lesson 18 & 19

By the end of the lesson, the learner should be able to:

i)Record accurately observations made when sulphates are heated.

ii) Explain how heat affects sulphates using chemical equations for reactions taking place in the experiment

Teacher/ learner activities

Provide the learners with worksheets on the effect of heat on sulphates in their groups. Learners follow the procedure on the work sheet to fill the table on the effect of heat on sulphates. Each group shares their observations in class. Discuss observations presented by groups and let the groups write balanced chemical equations involved in the heating of sulphates.

Resources

Sulphates, source of heat

Lesson 20

Guide the learner in a manner that the learner can:

i) Identify some practical application of the knowledge of salts in real life

ii) Respond to questions given on the content ‘salts’

Teacher/ learner activities

Each group presents their findings on the uses of some salts using well drawn charts. The groups present a summary of what they have learnt in the topic salts.

## APPENDIX B

## FORM TWO CHEMISTRY ACHIEVEMENT TEST (CAT)

SCHOOL ------------------------------------------------GENDER……………………

KCPE MARKS SCORED IN SCIENCE------------------------------------------

**Time: 2 hours**

**INSTRUCTIONS**

1. Kindly state your school's name and your gender (male or female) in the spaces provided.

3. The spaces provided under each question is meant for you to write your response

4. Answer all questions in this paper

**QUESTIONS**

1. Define the following terms:

a) A saturated solution (1 mark)

b) Crystallization (1 mark)

2. A student was provided with the following apparatus and reagents to prepare zinc sulphate crystals: - 20 $CM^3$ of dilute sulphuric (VI) acid, 5 grams of zinc powder, measuring cylinder, beaker, conical flask, filter funnel, stirring rod, evaporating dish, tripod stand, wire gauze, filter paper,Bunsen burner. Using appropriate diagrams outline the steps the student will follow in order to obtain zinc sulphate crystals (8marks)

3. Provide an example of:

i. Acid type of salt (1 mark)

ii. Double type of salt (1 mark)

iii. Normal type of salt used in homes (1 mark)

4. A spatulaful of iron was mixed with a spatulaful of sulphur in a crucible. The mixture was heated strongly until the reaction was complete and the products were allowed to cool.

a) Identify the name of the product formed (1 mark)

b) What is the name of the method of preparing salts represented in the above procedure? (1mark)

c) State the observations made in this experiment (2 marks)

d) Illustrate how the reaction occurred in the experiment using an equation (1 mark)

5. Which property of salts is exhibited when the following salts are exposed to the atmosphere overnight?

i. potassium hydroxide pellets (1 mark)

ii.anhydrous copper (II) sulphate (1 mark)

6.A form two student placed a salt of copper carbonate in a boiling tube. It was then heated by the student. Use this information to:

I State what the student observed during heating (1marks)

ii. Show the products formed in the experiment using an equation (1mark)

7. List two applications of salts in real life (2 marks)

i

ii

8. Use the reaction-- scheme below for subsequent sections of this question

WHITESOLID Q ⟶ YELLOW RESIDUE+BROWN GAS

↑

SOURCE OF HEAT

i. What name is given to white solid Q? (1 mark)

ii. Identify the yellow residue and give its name (1 mark)

9.By using an appropriate example; explain why some sulphate salts are not affected by heat (2 marks)

10. When a sulphate of barium and a carbonate of zinc react; a double decomposition reaction takes place. Show this reaction stoichiometrically(1mark)

11. K nitrate, M nitrate and L nitrate (K, M and L are not actual symbols of the elements) were heated over a non-luminous flame. The students recorded their observation in the following table.

| Nitrate | products |
|---|---|
| K nitrate | K nitrite and oxygen gas |
| M nitrate | M metal, oxygen gas and a red brown gas |
| L nitrate | L oxide, red brown gas, oxygen gas |

a) From the results' table, identify the most reactive metal in the reactivity series (1 mark)

b) Give the most likely identity for M. Show how the nitrate of M decomposes to give products shown (2 marks)

12. One of the precautions in preparing salts where an acid is involved; is that the solid reactant should be used in excess.

a) What isthe usefulness of this safety precaution? (1 mark)

b)Draw a well labeled diagram of the apparatus you will use to remove the excess solid reactant.(2 marks)

13. Fill blank spaces in the table by writing the formula of the products formed using reactants at the intersection. Indicate the state symbol of the product(s) using (s) for solid, (aq) if aqueous (L) for liquid and (g) when gaseous. The first box has been filled to serve as an example.

(10marks)

| **Solution** | **$Ag(NO_3)$** | **$Na_2SO_4$** |
|---|---|---|
| **NaCl** | **AgCl(s), $NaNO_3$(aq)** | |
| **$BaCl_2$** | | |
| **$Pb(NO_3)_2$** | | |
| **$CaCl_2$** | | |
| **$MgSO_4$** | | |

14Study the experimental steps below to answer the questions that follow.

(a) Burn magnesium in air

(b) Add $10cm^3$ of 0.5M $H_2SO_4$ to the product obtained in step (a) in a beaker. Stir the mixture and filter

(c) Add $20cm^3$ of aqueous $Na_2CO_3$ to the filtrate

(d) Filter

(e) Wash the residue with distilled water

(f) Dry residue between filter papers

(i) What is the name of the residue obtained in step (d)? (1 mark)

(ii) Name the chemical process taking place in step (c) (1 mark)

(iii) Draw a diagram to show how step (a) was performed (3 marks)

**APPENDIX C**

**CHEMISTRY PRACTICAL TEST**

**SCHOOL……………………………GENDER……………………………**

**TIME: 1HR 30 MIN**

**INSTRUCTIONS**

1. Write the name of your school and your gender (either male or female)

2. Spend the first 10 minutes of the practical to check the workability of your apparatus.

3. Read through all questions before you start carrying out the practical to understand what is required of you in the examination

QUESTION ONE.

Use solids X and Y provided in this question. Carry out the tests outlined and record your observations and inferences appropriately.

IExamine solids X and Y and give a description of their appearance (2 marks)

Appearance of Solid X

Appearance of solid Y

II scoop a spatulaful of solid X into a boiling tube. To the solid in the boiling tube; add $3cm^3$ of distilled water and shake to dissolve. To the solution of X prepared; drop a blue and a red litmus paper. Keep record of your observation and inference in the table below

| Observation | Inference |
|---|---|
| (1 mark) | (1 mark) |

III place one spatula of solid Y in a test-tube. Add enough water and shake well. With the resulting solution Y; use both blue and red litmus papers. Fill the following table based on your findings

| Observation | Inference |
|---|---|
| (1 mark) | (1 mark) |

IV Transfer the remaining solid X into a dry boiling tube. Heat the boiling tube containing solid X gently, and then strongly. Test the gases produced using:

-a glowing splint

-moist red litmus paper

- Wet blue litmus paper

-a glass rod dipped in calcium hydroxide solution.

Take note of what you observe and infer accordingly in the table provided

| Observation | inference |
| --- | --- |
| ( 1 mark) | (1 mark) |

V  Put the rest of solid Y in a dry test-tube and heat. Test for production of gases with:

A glowing splint, moist red litmus paper, Wet blue litmus paper and a glass rod dipped in calcium hydroxide solution. Record and infer appropriately.

| Observation | Inference |
| --- | --- |
| ( 1 mark) | ( 1 mark) |

QUESTION TWO

You are provident with the following reagents and apparatus

Aqueous $Pb(NO_3)_2$, $MgSO_4$solution, distilled water in a wash bottle, a measuring cylinder, an empty 50ml beaker, 2 filter papers, a filter funnel and a glass rod. You can also access a weighing machine. Carry out these steps and answer the questions that follow.

i )Measure accurately 10cm$^3$of $Pb(NO_3)_2$into the empty beaker

ii) Add 20cm$^3$ of $MgSO_4$ into the solution in the beaker

iii) Stir the solution you prepared in step ii and allow the solution to settle

iv) Filter, and then wash the residue with distilled water.

v) Dry the residue between filter papers

**Note**: retain both the filtrate and the residue to use them in answering the questions below:

a) What is the mass of the residue obtained in step v?

----------------------------------------grams (5 marks)

b) Identify the colourless of

Residue---------------------------------------------------

Filtrate---------------------------------------------------

(2marks)

c) Draw neat diagrams to show the apparatus you used for filtration (3 marks)

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**OFFICE OF THE REGISTRAR RESEARCH AND EXTENSION**

**Ref:** KSU/R&E/03/5/Vol.1/78 **Date:** 14th November, 2019

**The Head, Research Coordination**
**National Council for Science, Technology and Innovation (NACOSTI)**
**Utalii House, 8th Floor, Uhuru Highway**
**P. O. Box 30623 – 00100**
**NAIROBI - KENYA.**

Dear Sir/Madam

**RE: EVELYNE K. OKERO DED/00290/15**

The above mentioned is a student of Kisii University currently pursuing a Doctorate of Philosophy (PhD) degree in Curriculum and Instruction in the School of Education and Human Resource Development. The topic of her research is, **"Influence of Science Process Skills Teaching Approach on Secondary School Students' Achievement in Chemistry in Kisii South Sub-County, Kenya."**

We are kindly requesting for assistance in acquiring a research permit to enable her carry out the research.

Thank you.

Prof. Anakalo Shitandi, PhD
**Registrar, Research and Extension**
**Cc:** DVC (ASA)
Registrar (AA)
Director SPGS

REPUBLIC OF KENYA

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