EFFECTS OF SCIENCE PROCESS SKILLS TEACHING APPROACH ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT AND SELF-CONCEPT IN CHEMISTRY, NYANDO DISTRICT, KENYA

HESBON ELLY ODHIAMBO ABUNGU

A Thesis Submitted to the Board of Postgraduate Studies in Partial Fulfillment of the Requirements for the Doctor of Philosophy Degree in Science Education of Egerton University

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DECLARATION AND RECCOMMENDATION

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This thesis is my original work and has not been presented for a degree, diploma or other awards in this or any other university.

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Hesbon Elly Odhiambo Abungu

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This thesis has been submitted for examination with our approval as University Supervisors

Signature………………………………… Date …………………………

Prof. Samuel W. Wachanga
Department of Curriculum, Instruction and Educational Management,
Faculty of Education and Community Studies,
Egerton University, Kenya.

Signature…………………………………. Date………………………….

Prof. Mark O. Okere
Department of Curriculum, Instruction and Educational Management,
Faculty of Education and Community Studies,
Egerton University, Kenya.

DEDICATION

This work is dedicated to my wife Risper A. Odhiambo and my youngest daughter Pauline Akinyi Abungu.

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ABSTRACT

Science education is crucial for the understanding of our environment and an essential tool for technological development in any society. Hence nations all over the world continue to ensure that the teaching of science subjects should be done in a manner that enhances the achievement of intended objectives. Science process skills are central to the acquisition of scientific knowledge which is useful in solving problems in our society. In Kenya, students' achievement in Kenya Certificate of Secondary Education (KCSE) Chemistry is poor. The poor performance could probably be attributed to lack of exposure to science process skills, which may affect students' achievement and self-concept in chemistry. This study was intended to investigate the effect of the science process skills teaching approach (SPSTA) on students' achievement and self-concept in chemistry. It was also intended to find out the effect of gender and group composition on students' achievement and self-concept in chemistry when they taught using SPSTA. The study involved quasi-experimental research where the Solomon Four-Group Non Equivalent ControlGroup Design was employed. The target population consisted of students in the secondary schools in Nyando District. Purposive sampling was used to obtain four district secondary schools in Nyando District to ensure that the number of boys and girls in each school was about the same. The samples consisted of 153 Form Three students drawn from four district secondary schools located in Nyando District. The Form Three classes were randomly assigned to the experimental and control groups. The study covered two topics selected from the KCSE Chemistry syllabus, that is, Volumetric analysis (Titration) and Qualitative analysis. To determine students' entry point in terms of knowledge on the selected topics and chemistry self-concept, Chemistry Achievement Test (CAT) consisting of calculations, True and False items, Fill in blanks and SSCS questionnaire were used as pre-test. After the administration of treatment, which lasted five weeks, the same test (CAT) was administered to the four groups as post-test. Students' Self-Concept Scale (SSCS) questionnaire was also used to measure students' chemistry self-concept. The CAT and SSCS were adapted from the KCSE Chemistry practical past papers and Self-Descriptive Questionnaire II (SDQ) scale respectively. The reliabilities of the CAT and SSCS were estimated using Kuder-Richardson (K-R21) and Cronbach's alpha coefficient formulae respectively. The reliability coefficient of 0.88 (CAT) and 0.95 (SSCS) were established for the instruments and indeed were accepted as suitable. The instruments were validated by experts from science education and psychology areas of specialisation. The data generated were analyzed using descriptive statistics, t-test, ANOVA, ANCOVA, Pearson correlation coefficient and Multiple Regression. The level of significance for acceptance and rejection of the hypotheses was at $\alpha = 0.05$. The results revealed that SPSTA had significant effect on students' achievement and self-concept in chemistry. However, gender and group composition had no significant effect on students' chemistry self-concept.The outcome of this study may provide an insight for designing instructional strategies that aim to enhance students' performance and contribute to the improvement of teaching and learning of Chemistry in secondary schools in Kenya. This will be shown by achievements made by the students in practical activities. It is expected that the findings of the study may be used by Kenya Institute of Education, Education Administrators and Quality Assurance Standards' Officers, who are major stakeholders of the Ministry of Education to re-examine the instructional methodologies of teaching chemistry in the secondary school curriculum.

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LIST OF ABBREVIATIONS

AAAS	America Association for the Advancement of Science
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
APU	Assessment of Performance Unit
ASE	Association of Science Education
CASE	Cognitive Acceleration through Science Education
CAT	Chemistry Achievement Test
DES	Department of Science Education (UK)
GCSE	General Certificate of Secondary Education
GOK	Government of Kenya
ILEA	Inland Local Education Authority
KCPE	Kenya Certificate of Primary Education
KCSE	Kenya Certificate of Secondary Education
KIE	Kenya Institute of Education
KNEC	Kenya National Examinations Council
MOE	Ministry of Education
MOHEST	Ministry of Higher Education, Science and Technology
NCST	National Council for Science and Technology
QASO	Quality Assurance Standard Officer
ROK	Republic of Kenya
SMASSE	Strengthening Mathematics and Science in Secondary Education
SPSS	Statistical Package for Social Sciences
SPSTA	Science Process Skills Teaching Approach
SSCS	Students’ Self-Concept Scale
SSP	Schools Science Project
UK	United Kingdom

CHAPTER ONE

INTRODUCTION

1.1 Background Information

The need to include science education in the secondary school curriculum is mainly to enable students to develop scientific knowledge, skills and positive attitudes towards science and technology. This would enable the students to understand the role and value of science and technology in society and to gain knowledge on the interaction between science, technology and society. Science education creates awareness on the effect of scientific knowledge in everyday life, for example, its applications in society, the management and conservation of the environment, the utilization of resources and production of goods (KIE, 2002). The other reason for teaching science education at secondary school is to address the challenges of scientific literacy, so that students are encouraged to understand the scientific enterprise and how to benefit from it (Collette & Chiapetta, 1984). In addition, science education prepares students for adult and working life by drawing applications and issues relating to science and technology. In a nutshell, science education promotes technological and socio-economic development in society.

In the pursuit of scientific and technological development, there is need to enhance science education in the secondary school curriculum. Science as a practical subject provides students with an opportunity to engage in science process skills through practical work. This is an important approach to teaching science subjects in schools since it contributes to the understanding of abstract concepts in science, which would remain implicit if taught theoretically (Hodson, 1990). The practical activities carried out by students in class also motivate and prepare them for the pursuit of science related courses at higher levels. Hodson suggested that when students' interests are captured through hands-on activities, the consequence is that they will do better in the subject. Jenkins (1989) reinforced the foregoing statement by arguing that scientific knowledge presented through practical activities can be appealing and accessible to students.

The active participation of students in practical work gives them an opportunity to acquire science process skills that give rise to more meaningful and effective learning (Nwagbo & Uzoamaka, 2011). Science process skills are a set of transferable abilities, which students utilize during scientific investigations (Padilla, 1990). Keil et al. (2009) suggested that content is acquired more effectively when obtained via inquiring using the fundamental tools of science. In addition, the acquisition of science process skills may enable the students to tackle practical tasks in the informal sector and industry. The selected science process skills investigated in this study were observing, measuring, recording and interpreting.

Most students in secondary schools in Kenya find science concepts difficult to understand, this is reflected in the low scores obtained in KCSE by the candidates (KNEC, 2011), see Tables 3 and 4. Hodson (1990) reported that process skills would aid the understanding of the theoretical scientific knowledge if practical learning opportunities were put in place. The prospects of involving students in science practical activities may improve the mastery of science process skills and enhance the ability to understand the scientific concepts. Science education progammes throughout the world have given tremendous opportunity to young scientists in training in terms of the acquisition of knowledge and skills for solving problems.

At the global level, there is emphasis on the development of science process skills and scientific knowledge among young children as the major objectives of science education (Adeyemi, 1990; Urevbu, 1990). Therefore attempts have been made to re-examine the role of process skills in science teaching in the secondary schools. For example, the 1996 issue of International Journal of Science Education devoted most of its articles on the role of the school laboratory to science teaching (Donnelly, 1998). A greater portion of the Handbook of Research in Science Teaching highlights research on this topic (White, 1996). In England and Wales, Brotherton and Preece (1996) explored the effects of teaching science with a special emphasis on process skills. For example, the Cognitive Acceleration through Science Education (CASE) project provided evidence that having science process skills in science lesson activities based on Piagetian formal reasoning patterns lead to short term boost to cognitive achievement (Adey & Shayer, 1993). The American Association for the Advancement of Science (AAAS, 1967) study incorporated basic and integrated process skills in an intervention and the outcome revealed that enhanced science process skills in science lessons, raised the level of performance in science by boys. The findings of an investigation carried out by Preece and Brotherton (1997) on the effect of teaching science with an emphasis on process skills for promoting performance in science showed a positive result. These findings support interventions that involve process skills teaching strategy.

In the 1960s and the early 1970s most of the science curriculum developments promoted hands-on practical work as an enjoyable and effective form of learning (Hodson, 1990). The science 5-16 (Age group) Statement of policy (UK) recommended that science courses should provide appropriate opportunities for students to make observations, measurements and carry out experiments (DES, 1985). In the 1990s, the National Curriculum was a major government sponsored initiative in the UK, which was seen to emphasize the role of laboratory work in secondary schools. Science educators view laboratory activities as central in the science curriculum practices and have suggested that many benefits accrue from engaging students in science laboratory activities (Hofstein & Lunetta, 1982; 2004; Tobin, 1990; Hodson, 1993; Lunetta, 1998; Hofstein, 2004; Lunetta, Hofstein & Clough, 2007).

In Kenya, the secondary school curriculum has put in place similar initiatives, specifically to enhance practical work in the science lessons. For example, the syllabuses of science courses place emphasis on practical work (KIE, 2002). The need for students to engage in science process skills is clearly stated in the objectives of teaching Chemistry in secondary schools (KIE), Strengthening of Mathematics and Science in Secondary Education (SMASSE) programmes (Changeiywo, 2000). The secondary schools annual science congress and the emphasis put on students' projects in schools are initiatives intended to enable students acquire science process skills. The instructional methods adopted in science lessons are intended to promote problem solving activities, project work and use of local materials. The Kenya Vision 2030 proposes application of science and technology to raise productivity and accelerate economic development, which is intended to enable Kenya join the newly industrializing countries (GOK, 2007). Science process skills teaching approach in secondary schools in Kenya is intended to facilitate the acquisition of skills and application of scientific knowledge necessary for the economic take-off in the 21st century. The activities under this framework focus on a wide range of skills and processes and attest to the importance of experimental work in the secondary schools science. If all the secondary schools take up the challenge seriously then most of the graduates will be equipped with process skills necessary for technological development of this nation.

The present Kenyan secondary school curriculum is practical oriented and broad-based. It is designed to offer varied experiences to the students, which may lead to an all-round individual.

It aims at preparing children for vocational and commercial entreprises and also for the fulfillment of emotional, social and personality attributes (KIE, 2002). Okere (1986) observed that students who complete the secondary school education successfully should have attained appropriate psychomotor and affective skills. Besides, the students who terminate their education at secondary school level will have acquired adequate knowledge and skills to make them useful members of the society. Okere (1996) argues that the most important means of achieving the foregoing attributes is through the school curriculum, which incorporates practical activities in the learning of science. The view is supported by Maundu, Sambili and Muthui (1998) who suggested that a scientist must intellectually be able to solve problems in terms of cause and effect relationships and carry out activities that involve psychomotor skills.

Chemistry in particular, takes up a very significant place in the secondary school curriculum because of its applications in everyday life and the role it plays in enabling students to develop intellectual and practical skills. Haines (1992) suggests that through practical activities in Chemistry, students are able to develop science process skills necessary for solving problems in real life situations. The application of chemical knowledge has improved the life of mankind in the area of medicine, agriculture, transport and food industry (Okere, 1996). It also enables students to explore the world by understanding the chemical phenomena, procedures and its investigative nature. In this respect, many schools in Kenya and Nyando District in particular offer Chemistry to most of the candidates at KCSE level as compared to other science subjects as shown in Tables 1 and 2. Nyando District is the focus for this study.

Table 1:
Registered Number of Candidates for KCSE in Kenya.

Year	Chemistry	Biology	Physics
2001	181,238	176,954	54,645
2002	187,261	177,251	54,180
2003	198,016	184,438	55,877
2004	214,520	200,797	60,082
2005	253,508	234,975	69,424
2006	236,831	217,675	72,299
2007	267,719	248,519	83,162
2008	296,937	274,215	93,692
2009	329,730	299,302	104,883
2010	347,364	317,135	109,811

Source: KNEC (2002- 2011).

Table 2:
Registered Number of Candidates for KCSE in Nyando District.

Year	Chemistry	Biology	Physics
2002	1953	1833	510
2003	2181	2000	585
2004	2297	2117	633
2005	2643	2464	708
2006	2572	2367	779
2007	2758	2534	928
2008	3371	3150	1074

Source: MOE-District Education Office – Nyando (2009)

The secondary school Chemistry curriculum has put in place provisions to involve students in practical work. For example, the Chemistry syllabus (KIE, 2002) has inbuilt significant portion of practical work to be carried out in Chemistry lessons. The schools' timetables have a double lesson slot reserved for Chemistry practical activities in the laboratory. In addition, the Chemistry practical examination paper is an instrument for assessing student's ability to execute science process skills as part of KCSE (KNEC, 2004). This orientation is intended to give students an opportunity to practice science process skills in Chemistry and also prepare them for

KCSE Chemistry examination. The KCSE Chemistry syllabus emphasizes class experiments as one major method of teaching Chemistry in secondary schools. This approach introduces pupils to the scientific method, which utilizes inductive approach in generating knowledge (Millar, 1989). This is achieved by enabling the students to carry out experiments, make observations, which lead to the developing of hypotheses, which can be checked. When students do these activities, they have the opportunity to practice science process skills such as observing, measuring, experimenting, predicting, recording and interpreting.

In order to make students master science process skills, there is need to expose them to varied practical activities scheduled in the secondary school syllabus. One possible way of achieving this is for the Chemistry teacher to plan for a variety of experiments in the lessons. For example, students should be able to do in class such activities as preparation and testing of gases, titration reactions, qualitative and flame tests. Through these activities students will learn to use apparatus; instruments, assemble apparatus, make observations, read measuring instruments and interpret and apply gained knowledge. It is envisaged that going through these activities will enhance the ability of students to learn Chemistry. However, the overall performance of candidates in science subjects at KCSE between 1998 and 2010 has continued to be poor as compared to the arts-related subjects (KNEC 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011) (Table 3). This dismal performance in science subjects may be attributed to the practical nature of the subjects and students' lack of experience in carrying out experiments.

Table 3 shows the candidates overall performance in Chemistry, Physics and Biology in the KCSE in the period 1998 to 2010.

Table 3:
The KCSE Chemistry, Physics, Biology National overall Performance (1998-2010) Percentage Mean Score

Year	Chemistry	Physics	Biology
1998	19.0	21.6	29.8
1999	21.3	22.6	31.2
2000	22.0	23.0	27.8
2001	15.9	18.4	27.5
2002	18.0	22.0	23.0
2003	19.6	23.0	26.0
2004	20.8	25.1	30.6
2005	20.0	25.5	25.9
2006	24.9	40.3	27.4
2007	25.4	41.3	41.9
2008	22.7	36.7	30.3
2009	19.1	31.3	27.1
2010	24.9	35.1	29.2

Source: - KNEC (1999- 2011).

In the period 1998-2005, the average performance in Chemistry at KCSE was about 20%, which is lower than Physics and Biology during the same period. However, there was an improvement in performance in Chemistry in the year 2006 and 2007 though still dismal as compared to performance in Physics and Biology, this declined in 2008 and 2009.

Table 4 shows the candidates performance in the practical papers in Chemistry, Physics and Biology. The three subjects are compared because they are closely related and belong to one major area of knowledge with practical components in the curriculum.

Table 4:
Chemistry, Physics, Biology Practical Papers

Year	Percentage Mean Score Chemistry	Physics	Biology
1998	31.8	37.7	17.8
1999	39.5	41.6	28.0
2000	38.6	44.6	29.4
2001	32.6	36.4	29.0
2002	30.6	32.6	21.8
2003	36.4	40.4	25.9
2004	35.5	56.3	28.8
2005	33.9	53.1	22.3
2006	28.7	52.2	29.0
2007	29.7	64.6	54.2
2008	28.7	60.0	43.3
2009	27.2	38.1	39.7
2010	37.2	56.0	46.1

Source: - KNEC 1999 -2011)

The average performance in Chemistry practical paper during the period 1998-2005 was slightly better than the performance in biology practical paper but lower than the performance in physics practical paper (Table 4). While the performance in physics and biology practical papers improved substantially in the year 2006 and 2007, the performance in Chemistry practical paper remained low. The low percentage mean score of candidates in Chemistry practical paper (an average of 30%) may have substantially contributed to the overall low achievement in Chemistry.

In Nyando District the students' performance in Chemistry is equally poor. The students mean point/grade in Chemistry, Physics and Biology in KCSE in the district between the years 2002 and 2008 is shown in Table 5.

Table 5:
The KCSE Science Subjects' Performance in Nyando District.

Subjects	Chemistry		Physics		Biology	
Year	Total enrolment	Mean point/Grade	Total enrolment	Mean point/Grade	Total enrolment	Mean point/Grade
2002	1953	4.533	510	5.611	1833	5.214
2003	2181	4.153	585	5.435	2000	4.995
2004	2297	5.138	633	6.005	2117	6.816
2005	2643	4.915	708	6.154	2464	5.680
2006	2572	4.511	779	6.190	2367	6.190
2007	2758	4.637	928	6.179	2534	6.139
2008	3371	4.411	1074	6.415	3150	5.751

Interpretation of Mean Point with Equivalent Grade (maximum points = 12.000)

A = 12, A- = 11, B+ = 10, B = 9, B- = 8, C+ = 7, C = 6, C- = 5, D+ = 4, D = 3, D- = 2,

E = 1.

Source: Nyando District KCSE results analysis (2002-2008)

The district mean point index of 4.53 and 4.15 in Chemistry is equivalent to D+ grade in 2002 and 2003 respectively. There was a slight improvement in the mean grade in 2004 of C-. This reverted to a mean grade D+ in the subsequent years 2005, 2006, 2007and 2008. The low mean grade obtained in Chemistry by candidates in Nyando District shows that the achievement in the subject is poor and this prompted the investigation on the methods of teaching Chemistry employed by the teachers in the district. Therefore the main objective of this study was to find whether chemistry process skills teaching approach (SPSTA) would be a more suitable method of teaching Chemistry in improving the students' performance. White (1991), Brook, Driver and Johnstone (1989) suggest that exposing students to Chemistry experiments would serve as sources of experiences, which the learner links to the theoretical knowledge acquired under (didactic) teacher-centred lessons. It is argued that these experiences prepare students to find out and learn Chemistry knowledge more comprehensively. Atkinson (1980) also supports this view by highlighting a case in which a ninth-grade class had been taught gas laws and the main activity of the lesson was a demonstration using a large cylinder and plunger. When the apparatus for the experiment was shown again to the students the next day, about one third of the class said they had never seen it before. This scenario shows that demonstration lessons can be skewed towards teacher-centered approach, with very little student participation. The claim that some of the students in the class did not notice what happened in the demonstration experiment would reinforce the point that unless students are actively involved in the experiment then very little knowledge and skills are acquired. In other words, active involvement of students in carrying out experiments would focus their attention and enable them develop science process skills as well as Chemistry knowledge.

Colleta and Chiappetta (1984) point out that practical activity give students concrete learning experiences, which can be used to explore new ideas, improve their psychomotor skills, promote motivation, self-concept and interest in the learning of Chemistry. Self-Concept is vital in the field of psychology and education that is greatly valued as a desirable educational goal. Its relevance to SPSTA in this study was as a result of research findings, which showed that good academic achievement is highly correlated with academic self-concept (Marsh, 1990a; Sanchez & Roda, 2003). Self-concept is an evaluation which an individual makes and customarily maintains with respect to himself and herself in general or specific areas of knowledge (Bauer, 2005). It has a multidimensional hierarchy with well-differentiated components such as academic, physical, social and emotional (Marsh, 2006).

The study focused on the academic dimension particularly on the aspect, which relates to Chemistry self-concept. It examined the effect of SPSTA on multiple sub-scales of Chemistry self-concept. The sub-scales that measured students' Chemistry self-concept were adapted from Self Description Questionnaire II (SDQ II) (Marsh, 1989, 1990a). Although research findings reported by Byrne and Shavelson (1986); Marsh (1990a); Muola (2000) showed positive relationship between students self-concept and academic achievement, little work has been undertaken to investigate the relationship between students' Chemistry self-concept and their participation in the science process skills related activities. The reason for selecting observing, measuring, recording and interpreting skills for the study was that they are commonly tested by KCSE Chemistry practical paper and many candidates perform dismally on the same skills (KNEC, 2001, 2004, 2005, 2007, 2008 & 2010). The study also compared the effect of science process skills teaching approach on students' achievement and self-concept in Chemistry by gender and between mixed, boys' only and girls' only groups. Since the students worked in groups of mixed and single sex structure during treatment period, it was important to make the study reflect the effect of the two variables, as these may have an effect on students' achievement and self-concept in Chemistry.

1.2 Statement of the Problem

The acquisition of scientific knowledge and process skills is very pertinent in finding solutions to a myriad of problems facing mankind. Chemistry as a practical subject in the secondary school curriculum plays a central role in preparing students for the challenges in the immediate environment. Despite the importance attached to activity-based instructional methods by the chemistry teachers in Kenya, there is still poor performance in Chemistry as revealed by the analysis of KCSE results of 1998-2010. The poor performance could probably be attributed to lack of exposure of students to science process skills which are crucial to the enhancement of achievement and self-concept in chemistry. But it is not clear whether this exposure enhances their achievement and self-concept or not. Furthermore, not much research has been carried out in Kenya to investigate the effect of science process skills teaching approach, gender and group composition on secondary school students' achievement and self-concept. In Nyando District particularly, it is not known how teaching through SPSTA would affect students' achievement and self-concept in chemistry. The challenge therefore is to determine whether science process skills teaching approach improves students' achievement in chemistry and also to find out whether active participation in science process skills can enhance students' self-concept. It is on these bases that the study was designed to establish the effect of science process skills teaching approach on students' achievement and self-concept in Chemistry in Nyando District.

1.3 Purpose of the Study

The study was to investigate the effect of science process skills teaching approach on secondary school students' achievement and self-concept in Chemistry in Nyando District.

1.4 Objectives of the Study

The objectives that guided the study were as follows:-

1. To determine the effect of science process skills teaching approach on secondary school students' achievement in Chemistry.

2. To find out the effect of science process skills teaching approach on achievement in Chemistry with regard to gender.

3. To compare the effect of science process skills teaching approach on girls' achievement in Chemistry between mixed groups and single sex groups.

4. To compare the effect of science process skills teaching approach on boys' achievement in Chemistry between mixed groups and single sex groups.

5. To establish the hierarchical order of the selected science process skills in the contribution to the students' achievement (scores) in Chemistry when taught through SPSTA.

6. To establish the effect of science process skills teaching approach on secondary school students' self-concept in Chemistry.

7. To determine the effect of science process skills teaching approach on self-concept of secondary school boys and girls in Chemistry.

8. To compare the effect of science process skills teaching approach on girls' self-concept in Chemistry between mixed groups and single sex groups.

9. To compare the effect of science process skills teaching approach on boys' self-concept in Chemistry between mixed groups and single sex groups.

10. To find the relationship between the self-concept sub-scales in the attainment of students' self-concept in chemistry when taught using SPSTA.

1.5 Hypotheses of the Study

Ho1 There is no statistically significant difference in Chemistry achievement of students who are taught through SPSTA and that of those who are not exposed to it.

Ho2 There is no statistically significant difference in achievement between secondary school boys and girls who are taught Chemistry through SPSTA.

Ho3 There is no statistically significant difference in Chemistry achievement between girls exposed to SPSTA in mixed groups and girls in girls' groups.

Ho4 There is no statistically significant difference in Chemistry achievement between boys exposed to SPSTA in mixed groups and boys in boys' groups.

Ho5 There is no statistically significant relationship between the selected science process skills and students' achievement in chemistry when taught through SPSTA.

Ho6 There is no statistically significant difference in self-concept of students who are taught Chemistry through SPSTA and that of those who are not exposed to it.

Ho7 There is no statistically significant difference in self-concept between secondary school boys and girls who are taught Chemistry through SPSTA.

Ho8 There is no statistically significant difference in self-concept between girls exposed to SPSTA in mixed groups and girls in girls' groups during Chemistry lessons.

Ho9 There is no statistically significant difference in self-concept between boys exposed to SPSTA in mixed groups and boys in boys' groups during Chemistry lessons.

Ho10 There is no statistically significant relationship between the self-concept sub-scales and the students' self-concept in chemistry when taught using SPSTA.

1.6 Significance of the Study

The use of science process skills teaching approach contributed to the improvement of teaching and learning of Chemistry. This was shown by achievements made by the students in practical activities. The study offered valuable information to the Education Administrators and planners to supplement Government efforts in improving the Chemistry education in secondary schools. KIE and Quality Assurance Standards Officers (QASO) may also use it to review the Chemistry curriculum and supervision of classroom practice. The outcome of the research may also be used to empower the teacher training institutions, Colleges and Universities to make informed decisions in their task of producing effective Chemistry teachers. Lastly, the information obtained from the study may be used to improve the learning of Chemistry in secondary schools in Nyando District.

1.7 Scope of the Study

The study was confined to Form Three students drawn from the district schools in Nyando District. The students' activities were selected from the topics in the KCSE Chemistry syllabus and the experiments covered Volumetric analysis and Qualitative analysis. These topics were mainly selected to provide a wide range of practical activities, which enable the students to interact with science process skills under investigation.

1.8 Limitations of the Study

The quasi-experimental research has its limitations in that it involves the whole class as an intact group. The inability to randomly select individual students to treatment adds validity threats such as statistical regression, interaction between selection and testing and also limits generalization of the results to the target population. The school's reputation in past performance in Chemistry may have an influence on students' attitude towards the subject and this may affect achievement in Chemistry tests. The cultural experiences of students may also influence their conceptions on Chemistry ideas/concepts and this may lead to inappropriate/unscientific responses to Chemistry questions.

1.9 Assumptions of the Study

(i) The schools carried out their normal functions without any interference from external factors during the period of the study and therefore the learning atmosphere in the four sample schools was comparable.

(ii) The events taking place during the study other than the treatment did not cause any difference in the student's achievement and self-concept in Chemistry.

(iii) A cohort of students in the same class is assumed to have started school at the same time and therefore of the same age.

(iv) It is assumed that the teachers who were involved in the study will effect the intervention with due diligence and perform at the same level.

1.10 Definitions of Terms

Achievement – A successful completion of task/assignment. In this study, it is used to mean students learning outcome as reflected in the scores obtained from Chemistry Achievement Test (CAT).

Cognitive Skill- the ability of the student to use mental capacity to interpret/discuss information in Chemistry.

Conventional Approach to Teaching - Regular method of teaching which is common in most schools in Kenya and it consists of lectures and/or demonstrations.

District Secondary Schools – Category of schools in Kenya that admit students with average grades at KCPE from the same district.

Experimenting – Scientific investigations/tests that are conducted to find out the nature and behaviour of substances in certain conditions. In this study, experiments were referred to as practical activities in Chemistry, which were carried out by students to find out the nature and behaviour of chemical substances during acid-base reactions and chemical analyses.

Extraneous Variable- Are undesirable variables that influence the relationship between the variables that an experimenter is examing.

Gender- Socially determined duties and responsibilities performed at school, home and in the community associated with being male and female. In this study gender refers to any differences in achievement in Chemistry that occurs between boys and girls in secondary schools.

Group Composition- Practical-working groups during Chemistry lessons, which were composed of mixed (boys and girls) group and single sex groups (boys only group, and girls' only group)

Interpreting – Making an explanation of an occurrence, data/results obtained from a chemical reaction. In this study, students were expected to explain and make deductions from the observed data recorded from the experiments.

Measuring – Weigh, measure the quantity of a substance or measure temperature, time, and length of items. In this study, the students measured the volumes of substances for titration reaction.

Nyando District - Nyando Distict is situated within Kisumu County and neighbours Nyakach, Kisumu East and Muhoroni Districts.

Observing – Detecting/noting the changes that occur in chemical reactions. In this study, students were expected to note the changes taking place in titration reaction and the colour changes in qualitative chemical reactions.

Practical Skills- the abilities, which students acquire when they engage in psychomotor (sensory experiences) activities in Chemistry.

Recording – Students were expected to write down observations and measurements arising from Chemistry experiments undertaken; which could be in the form of statements, notes, diagrams, tables, graphs and chemical equations.

Science process skills – abilities which students utilize during scientific investigations. In this study they include observing, recording, measuring, and interpreting.

Science Process Skills Teaching Approach (SPSTA) - An inquiry-based instruction, which incorporates the use of science process skills in studying the nature and behaviour of matter in chemical reactions. In this study SPSTA were based on four selected science process skills.

Self-Concept – Students' feelings and perceptions in Chemistry. It focuses on the academic dimension that relates to Chemistry self-concept. In this study, it is viewed as students' perception of their abilities and skills in Chemistry, which were measured by the use of sub-scales adapted from the Self Description Questionnaire II (SDQ II).

Teachers' experience – Chemistry teachers who have taught for three or more years in a secondary school hence have appropriate experience; were involved in the study.

Teachers' qualification – Chemistry teachers involved in the study were either Diploma or Degree holders hence trained and qualified.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter includes brief historical account of the development of practical work in Chemistry, the appropriate methods of teaching Chemistry and the objectives of teaching Chemistry in the Kenyan secondary school curriculum. In addition, it highlights the influence of gender and the role of science process skills in the learning of Chemistry. Finally, it deals with students' self-concept and group composition during Chemistry practical work.

2.2 Historical Account of the Development of Practical Work in the Secondary School Chemistry Curriculum

Practical work in Chemistry picked impetus by the turn of the 19th century where renowned chemists (Priestly, Lavoisier & Dalton) carried out a number of experiments on the preparation of gases, chemical reactions and qualitative analyses (Jenkins, 1989). However, by mid 1850's, the practice was still regarded as a means of illustrating concepts and was carried out through demonstration by the teacher (Gott & Duggen 1996). As early as 1882, the Education Department in the UK declared that the instruction of students in science subjects should be given mainly by practical work (Hodson, 1990). About more or less the same time, Armstrong advocated direct experimentation by students in science lessons, an example of heuristic approach to teaching science. This method of doing science required the students to find out things for themselves and 'learning how' through first hand experiences. Thereafter a number of science syllabuses in the developed countries emphasized experimentation and hands-on activities by the students. Moore and Thomas (1983) linked this approach to the psychological theory of 'learning by doing', presumably based on the view that practice improves competence.

The secondary school curriculum in Kenya was tailored to reflect a similar trend as in the UK. Kenya as well as other British ex-colonies throughout the world embraced science education practices that reflected the British education system. The syllabi were borrowed with little attention to local realities. For example, they closely resembled London General Certificate Examination (GCE) type of science for secondary schools in the UK. In the early 1960s, immediately after Kenya attained independence science education was necessitated by the need to industrialize, localize expatriate cadres and make more control of production technologies. Hence, there was need to equip secondary school students with scientific knowledge and skills needed for manpower and national development. But science at secondary school level was generally taught to selected groups of secondary age students because of the belief that only small proportions of the school population with a special aptitude for science could benefit. The science programmes were predominantly academic, prescriptive, knowledge based and inspired by ‘grammar’ school traditions (Karamustafaoglu, 2011). Only in very exceptional cases were students taught Chemistry as a subject, otherwise the majority of the secondary school students were taught general science syllabus.

The aim of teaching Chemistry was mainly to prepare students for A-level and University chemistry (Okere, 1996). The instructional strategies employed were didactic, rote learning coupled with memorization of facts. The teaching did not reflect applications of chemistry concepts in everyday life and needs of the Kenyan society. In view of this, physics with chemistry syllabus was introduced to address the challenges but the programme was later re-packaged to produce physical science syllabus. The purpose of introducing physical science in the secondary schools was partly to prepare the secondary school students for further education in the sciences and to train technicians who were needed to fill the vacuum left by the expatriates. This syllabus was introduced in the schools, which were well equipped because it was practical oriented. Towards the end of 1960s, the science curriculum developers based at Kenya Institute of Education (KIE) in conjunction with the experts from the UK introduced the School Science Project (SSP) in a few secondary schools on a pilot basis (Wachanga, 2005). The project was an East African version of the British Nuffield Science courses of 1962, which placed a lot of emphasis on students’ participation in practical work and thereby complementing the teaching of theoretical aspects of science (Millar, 1989; Okere, 1996; Wachanga, 2005). However, the initiative was nipped in the bud before large-scale dissemination to all secondary schools due to the immense costs involved in the production of science equipment, worksheets and other materials required for carrying out experiments by individual students. In the 1970s, pure chemistry syllabus was introduced in the Kenyan secondary schools in well resourced schools. This syllabus was practical oriented; however, it dealt with the content to more depth compared to physical science syllabus. The three syllabi, namely pure chemistry, physical science and general science were offered concurrently in Kenyan schools until in the 1980s when the latter two were phased out.

The secondary cycle of 8-4-4 curriculum introduced in Kenya schools, following the recommendation of Mackay Report in 1981 emphasized a greater orientation to practical education (Shiundu & Omulando, 1992). The system addressed the weaknesses of the previous system and responded to the challenges of national development and effective participation of the school leavers in development. With the emphasis on practical education, the 8-4-4 system ensured that the school leavers at all levels had some scientific and practical skills that could enable them acquire salaried employment, skills needed in the informal sector of the economy and/or for further training (Okere, 1996). The 8.4.4 curriculum laid emphasis on practical work/investigations in school Chemistry as is exemplified by the Chemistry syllabus where the topics have in-built practical activities, suggestions on applications and project work (KIE, 2002). However, this initiative was riddled with shortcomings during the formative years. There were limited funds to provide facilities, laboratories, workshops and adequate qualified personnel to implement the programme. However, the issue of educational relevance has been at the centre of curriculum development initiatives in Kenya since independence in 1963. The implementation of new science programmes introduced in Kenya was intended to replace the teacher centred pedagogy and the teaching of science as an accumulation of facts by more involvement of students in their learning, greater amounts of practical activity, less dependence on traditional textbooks and more concern for the intellectual and practical skills. All the foregoing efforts were instituted to improve the image of practical work in the school Chemistry curriculum; however, the scenario in Chemistry lessons in Kenya secondary schools leaves a lot to be desired. For example, the practical activities in Chemistry undertaken by the students in most schools are teacher demonstrations and deductive methods intended to illustrate previous knowledge learned or according to the prescribed instructions in the Chemistry textbook or worksheet (Millar, 1991; Hodson, 1990; Lock, 1990). The practice does not allow a free hand in ‘doing science’ – a philosophy characterized by ‘hands on’ experiment, which is destined to enable students’ develop science process skills.

2.3 Science Process Skills

Science process skills are a set of transferable abilities, which students utilize during scientific investigations (Padilla, 1990). The importance of teaching science process skills is that they allow students to describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge and communicate their ideas to others (Opara, 2011). Science process skills enable students to experience hands-on engagement with science materials and also learn to solve problems using practical approaches. Teachers often use the term ‘science processes’ during practical science lessons, at the science congress meetings, during educational seminars and workshops in secondary schools in Kenya. Students acquire science process skills when they engage in scientific investigations during science lessons. The emphasis on process-based activities in science lessons cannot be doubted, as this is clearly evident in the objectives and instructional programmes in science subjects at the secondary schools. Millar (1989) draws reference to the variations in terminology used in the classroom set up, for example, processes, skills and process-skills. However, there is common ground in the usage of these terms, for instance, many of the processes occur on their own right while some are subsumed into broader categories.

The proponents of process-based approach uphold the teaching of process-skills and advocate for the skills to be developed through experimenting (ILEA, 1987). Raven and Calvey (1977) investigated the effect of a process-oriented science programme with the elementary school children on the achievement of Piaget’s operative comprehension. The findings of the study showed that eighth grade students achieved higher scores on operative items than the eighth grade students in a more traditional science programme. The interaction with process-skills is evident throughout the students’ daily lives and also in science lessons when they engage in practical activities. During the activities, the students may be instructed to measure and heat different amounts of water for the same time and measure the temperature of water before and after heating, make observations, record and interpret the results. The activities carried out by the students under this framework will enable them to practice and utilize process-skills. This set of intellectual abilities is referred to as science process skills, which scientists use (Bentley, Ebert & Ebert, 2007).

Besides promoting the acquisition of the process-skills, practical work in science does contribute to the preparation of students for adult and working life (Gott, 1987). There are a number of science process skills provided for in the secondary school Chemistry syllabus. However, the study will focus on four selected process skills commonly practiced in the Chemistry lessons and tested by KCSE Chemistry practical paper; namely, observing, measuring, recording and interpreting.

2.3.1 Observing

The process-skill of observation involves the use of ones senses to perceive objects and events; their properties and behavior. It requires that the students pay close attention to some aspects of what is being observed. An observation entails the description of phenomena, for example, during titration experiment the students would be required to observe and state the colour change of the substance formed in the conical flask, measure and record the volume of titre used to effect the change. In this respect, observation as a process-skill would bring into play other process-skills.

In Chemistry lessons, students should be taught to observe closely and make relevant observations. This pre-supposes some kind of prior expectations to enable one to make decisions on what to observe. This supposition concurs with the view that all observations are theory-laden (Millar, 1989). Gott (1987) reinforces the point by adopting the idea that when we observe something, we do so in the light of our experience of observing similar things in the past. In essence students will make a selection from the myriad of possible things to observe. For instance, if students are asked to describe the nature of precipitate formed when carbon dioxide gas is passed through calcium hydroxide solution, some will describe it as ‘milky’ or ‘cloudy’ while others would say a white precipitate (Mbaka & Wamae, 2004). In this case, observation tasks play an important role in revealing the students’ perception on phenomena. In other words, the responses students elicit reflect their experiential view. Kempa (1986) reiterates that observation skill is relevant to the practice of science and is useful to the students in their everyday life. And that careful observation of experiments would lead to interpretation and application of science (Chemistry) knowledge.

Practical activity in Chemistry lessons could be utilized to improve students' powers of observation by using all the senses to make deliberate and selective observations. The secondary school Chemistry syllabus emphasizes the practice of observation skill not simply for their immediate appeal and the wonder of excitement that they bring to the classroom setting but also to enable the students to develop science process skill of observation. Practical work in Chemistry presents to the students a variety of experiments, which give them plenty of opportunities to observe phenomena. For example, when copper metal is heated in air, it turns black. But when carbon dioxide is passed through a solution of calcium hydroxide, a white precipitate is formed, which dissolves in excess solution. Similarly, when zinc carbonate is heated in a test-tube, fumes are given off, and a solid which is yellow when hot and white when cold remains in the test-tube. These are some of the potential areas where students would be asked to carry out activities, which require the use of the senses.

The KCSE Chemistry Syllabus highlights the making of accurate observations during class experiments as one of the major objectives of practical work in Chemistry (KIE, 2002). Other 'O' level Chemistry syllabuses from the UK put emphasis on the development of observation process-skill as a major reason for doing Chemistry experiments. For example, the Northern Examination Association Syllabus, the Midland Examining Group Syllabus and the London and East Anglia Examining Group (UK) emphasize the practice of observation skill in Chemistry practical sessions (Gott, 1987). They argue that observation process-skill is a fundamental tool that would be required by the students of Chemistry to gain scientific knowledge and survive in technological and everyday life. In this study, students were asked to observe and describe the reactions taking place during acid-base titration and identify the cations and anions in the qualitative analysis experiment.

2.3.2 Measuring

Most students are introduced to elementary measurement through science and mathematics lessons in the primary school, for instance, measuring length, weights, time, temperatures and volumes of substances (Kellington et al, 1980; Bentley et al, 2007). But when they enter secondary school, this skill is built on through the use of more accurate tools. It is at this stage that students come in contact with measuring instruments in a practical situation. In Chemistry lessons at secondary school level, the students' abilities to measure are extended further through a variety of experiments. The tasks set would require them to read and use instruments and apparatus, for example, weighing a sample of substance using a balance and/or measuring the volume of a substance in a burette (KIE, 2002). The tasks of this nature are very common in KCSE Chemistry practical examinations (KNEC, 2006; KNEC, 2007; KNEC, 2008; KNEC 2010). Therefore, the main objective of including such tasks in the Chemistry secondary school syllabus is to enable students develop the process-skill of measuring and eventually prepare for KCSE Chemistry examination. In this study, the students measured the volumes of solutions required to react in the titration experiment involving a base and an acid.

2.3.3 Recording

Most practical work in Chemistry involve recording observations, measurements, drawing experimental set-ups and tabulating readings in titration and rate of reaction experiments. Recording is a science process-skill that represents a view of presenting experimental results, which can be in a table-form, written form, graphical manner and through drawing. The students' ability to communicate the results of an experiment is of great importance. Okere (1996) underscored the foregoing statement by suggesting that tabulation of results could make it easier for a student to recognize a pattern in the data recorded and also an average value of the quantity measured can be obtained from a set of two or more readings made. The records made by the students reflect the accuracy of the observed results. The students' abilities to record results accurately need to be emphasized in Chemistry practical lessons because lack of it would reveal the inability to perform other science process skills satisfactorily. In this study, students were asked to record observations made during titration of a base with an acid, draw a table showing the number of titrations made, the volume of the acid used in each titration. The students were also required to record the observations made during the qualitative analysis experiment.

2.3.4 Interpreting

Interpretation is an example of a cognitive skill, which enables students to make sense of data obtained from a practical test. There are usually many interpretations made from the data obtained from an experiment, some of which may be correct while others could be inadequate. However, interpretations are statements made from observations; some of these may be influenced by theoretical paradigms. In Chemistry, students interpret data using experience and information learnt during practical work to enable explanations of what is observed (Tomkins & Tunncliffe, 2001). Students' interpretative comments influence subsequent understanding and thinking on scientific concepts. The interpretations will be productive when students discuss what they observe thus leading to the development of conceptual growth (Tomkins & Tunnicliffe, 2001). In cooperative learning, group discussion informs us about students thinking and interpretation which would shed light on the understanding of the science concepts (Acar & Tarhan 2007; Keraro et al, 2007; Wachanga 2002). In this study, the students interpreted the observations made from the reactions in the qualitative analysis experiment and made calculation on moles of the reacting substances.

2.4 Teaching of Chemistry in the Secondary School Curriculum.

The Kenya Secondary School Chemistry syllabus (KIE, 2002) spells out the reasons for engaging students in practical work. For example, students should be able to

(i) Make and record accurate observations.

(ii) Use appropriate apparatus for experimental investigations.

(iii) Recall safety precautions and follow correct experimental procedures.

It is important therefore to investigate the extent to which these objectives are receiving attention in Chemistry classrooms.

Allsop (1989) suggests that one reason for doing practical work in school science is learning practical skills and techniques. He argues that practical skills are learned through practical based tasks, which require students to make observations, measurements and conduct experiments. If the students are given opportunities during Chemistry lessons to conduct experiments then they would be in a position to learn how to observe, measure and record information. This view is supported by an American study, which reviewed three teaching methods. The result revealed that only in respect with the acquisition of laboratory skills did practical work show any significant advantages over other methods (Hodson, 1990). Studies by the Assessment of Performance Unit (APU) show that by the age of 15, it cannot be guaranteed that students' discrete skills can be harnessed in the service of conducting practical investigations (DES, 1983).

Notwithstanding the arguments put forward by Hodson and APU, Allsop contends that one of the justifications of including practical work in the teaching of Chemistry is to teach the processes of science. It is therefore the responsibility of the Chemistry teachers to plan for practical activities to enable the students develop science process skills. For example, organizing experiments to determine the presence of specific ions in a solution and testing of gases generated from a chemical reaction may require the students to link their activities with observation, measurement and recording skills. This compares very well with the arguments put forward in support of students' experimental activities in Chemistry as the basis for future technology, industrial development and needs of students in everyday life.

Chemistry subject has some complex and abstract concepts, which if taught theoretically may not be understood by students. It is therefore important for students to engage in practical activities that would resolve the complexities created by the nature of the subject. Therefore, the learning of abstract concepts in Chemistry needs to be supported by hands on experience. However, Shayer (1978) argues that a child's level of cognitive development almost wholly determines his or her acquisition of (Chemistry) concept. In other words, the experimental activities carried out by the students during primary and early secondary education could add to the understanding of Chemistry concepts if they are taken at the right level of ability.

Despite Shayer's assertion, there are other special dimensions where practical activities can be argued to foster learning in Chemistry. One case in point is that carrying out practical work in Chemistry lessons creates an opportunity for the students to engage in activities that would promote the development of process skills (Wellington, 2000). In so doing, the students' face challenges when using the process-skills and thereby enhancing their competence in those skills. The experiments allow the pupils to work together in groups and thus provide an avenue for sharing of ideas and skills. Furthermore, the experience of practical work creates a situation where students exchange naïve ideas and beliefs about phenomena to elicit scientific knowledge. For example, in a practical session on the nature of matter, students should be able to resolve the alternative conceptions held by young children that matter is continuous as opposed to the accepted scientific view of matter as particulate (Nussbaum 1985).

The theories underpinning Chemistry practical lessons as outlined in the Kenyan secondary schools chemistry syllabus (KIE, 2002) concur with the views presented by Moore and Thomas (1983), Denny and Chennell (1986), Hodson (1990), and Lock (1990). Though the objectives appear similar, the practice in Kenyan schools may be different due to other factors associated with contextualization. According to Woolnough and Allsop (1985) observations, measurement, interpretation and recording process skills are fundamental to Chemistry investigations and students encounter these skills under the framework of practical work in Chemistry.

2.5 Methods of Teaching Chemistry

Teaching Chemistry is aimed at bringing about desirable behavioural changes among students. In order to make students learn Chemistry effectively the teacher has to adopt the right method of teaching. In selecting the right method in a given situation the teacher has to be familiar with different methods of teaching and the nature of the subject (Kumar, Krishna & Rao, 2004). Structurally, Chemistry knowledge consists of formulae, principles, theories, concepts and processes that require an intellectual ability to comprehend. Though some of these would appear difficult, chemistry can still be made appealing to students through practical activities and procedures in the classroom, which would enable them to learn Chemistry through their senses.

The teaching approach that utilizes both auditory and visual perspectives is likely to create an impact on learning of Chemistry. Moore and Thomas (1983) cite the psychological theory of 'learning by doing' as one of the effective ways of learning Chemistry. The class experiments, which students do, accord them opportunities for hands-on activities, which constitute direct experiences in learning. Practical work in Chemistry allow students to participate in investigations either in groups or individually, gives them concrete learning experiences, which may not be attained through theoretical instructions and promote development of science process skills (Collette & Chiappetta 1984). It is through this type of instruction that students may be able to make observations, measurements, and records in Chemistry lessons. The interactions with these activities are essential for cognitive development (Lunetta & Hofstein, 1991).

It is therefore necessary for the Chemistry teacher to adopt an appropriate method of teaching, which would benefit and expose the learners to experimental activities. The activities planned for in class are expected to relate to the cognitive ability of the learner and therefore providing a rich set of experiences that would assist and promote the development of science process skills (Fensham, 1984). This argument is supported by Piaget’s theory of cognitive development where age and adaptation to their environment influence children’s mental development. However, Summers (1982) and McClelland (1982) emphasized Ausubel’s constructivist theory, which puts significance to what the learner ‘already knows’ as a contributing factor in enabling the learner to acquire new knowledge. In effect, Ausubel (1968) suggested that the teaching strategies that alert the learners to the prior knowledge be required to promote new learning. It is therefore necessary to plan for teaching strategies, which take care of the students past experiences and mental abilities to enable them acquire new knowledge and process skills.

2.5.1 Questioning Approach

The main activity under this approach is discussion. The teacher asks questions, invites comments, which are responded to by the students thereby presenting an interactive atmosphere. New demands and challenges in students’ daily life require the use of questioning skill. The provision of questions in the learning sessions promotes classroom interactions and this can generate learning experiences for many students and may result in greater achievement in learning (Pedrosa de Jesus, 2003). Practical activities in Chemistry lessons emphasize learners’ contributions by promoting social interactions, which are expected to promote understanding of Chemistry knowledge. Questioning technique accompanies all other methods of teaching Chemistry, for example, class experiments, demonstrations, and informal exposition. Through questions, students are encouraged to make a verbal commitment to the learning process. This approach is used during practical lessons in Chemistry at the time of consolidating the results obtained by each group. At the time of reporting the findings to the whole class by group leaders, questions are raised by the teacher and students to interrogate the findings. This session provides an opportunity for active participation in the discussion and this would enable the students to clarify and extend their ideas on the task at hand. The interactive activity session would improve the students thinking and imagination on the subject matter (Das, 1985).

2.5.2 Constructivist Approach

Research studies have described a wide range of students' alternative or naïve conceptions of scientific knowledge, such that at any stage of schooling, the scientific concepts are not deeply understood by students (Havu- Nuutinen, 2005). This perspective has resulted into many science educators considering science learning as a process of conceptual change, which holds learning as a process in which students reorganize their existing knowledge in order to understand concepts and processes of science more completely.

From a constructivist perspective, learning is a social process that involves linking new ideas and experiences with what the learner already knows (Ausubel, 1968; Liang & Gabel, 2005). The approach holds the view that learners construct knowledge through interaction with each other, the physical and social environment. The understanding of scientific concepts is shaped by the learners' everyday experiences. The learner, in the process of constructing knowledge, generates links between his/her existing knowledge and the new materials, which are taught (Ishii, 2003). Emanating from this viewpoint, learning models, which promote social interactions amongst the students, may be proposed to add value to the students understanding of science concepts. It implies therefore that students require opportunities to experience what they are to learn in a direct way and time to think and make sense of what they are learning (Tobin, 1990).

Practical activities in Chemistry involving science process skills encourage social interactions during the learning process. These provide opportunities for students to restructure the views they hold on a particular phenomenon. Havu-Nuutinen (2005) argues that students' processes of reconstruction, which occur in an instructional context, happen mostly in social interaction with peers and the teacher. The students personal conceptual structures based on their everyday experience interact with the views of other students and the teacher. This type of orientation enables them to actively construct knowledge that can provide viable explanations of experience. Besides following prescribed instructions during Chemistry practical work, students need to be given time to think over the results obtained through group discussions, so that they are able to arrive at meaningful outcomes and construct viable explanations from the results. Constructivism holds collaboration among students in great regard since group interactions provide an opportunity for the negotiation of meaning and arriving at consensus (Wheatley, 1991). This approach of teaching is relevant in this study because during group practical activities the students are engaged in discussions and thereby providing an opportunity where their alternative frameworks on chemistry knowledge may be exposed. The teacher may use this opportunity to allow the students to clarify and extend their ideas and in so doing the correct conceptual framework may be established.

2.5.3 Practical Based Approach to Teaching Chemistry

An enormous amount of time and money is invested in making practical work an element of secondary school science. In this era of economic meltdown, it is inevitable for science teachers to justify the expense incurred in the provision of practical work in school science in preference to other teaching methods available in the school curriculum, which emphasize acquisition of content through expository approaches. Ker (1963) carried out a survey with science teachers to find out why they did practical work in school science and established the following purposes:

i) To encourage observation and careful recording
ii) To promote scientific methods of thought
iii) To be part of the process of finding facts by investigation

Woolnough and Allsop (1985) stated that teachers and curriculum developers gave four types of purposes for doing practical work in school science.

i) To motivate and interest students
ii) To enable students develop science process skills
iii) To be able to simulate the work of a real scientist
iv) To support or elucidate theoretical work

Their views on the purposes of practical work in school science, which are shared by Millar (1991) were,

i) Developing practical skills and techniques
ii) Being a problem-solving scientist
iii) Getting a feel for phenomenon

Gunstone (1991) suggested a constructivist approach to practical work, which includes P-O-E (Predict-Observe-Explain) pattern. The purpose of doing practical work under this framework emphasizes science process skills but with the later stage that attempt to explain, or reconcile any conflict between prediction and observation. Wellington (2000) suggests that these purposes are still relevant today in school science. Practical Chemistry lessons provide students with opportunities to apply science process skills through involving in measuring, observing, recording activities. It incorporates a wide range of skills, which students normally encounter as they take up Chemistry experiments. It is widely acknowledged that Chemistry has an empirical basis and therefore involves practical activities (Kempa, 1986). In most cases, the experiments carried out in Chemistry lessons tend to be illustrative, for instance, laboratory preparation of gases, qualitative analyses, and titration reactions. These are mainly used to illustrate the production of gases, products of reactions and detecting end-point of neutralization reactions. However, notwithstanding the foregoing statement, when students engage in the above cited experiments they are in no doubt provided with opportunities to develop science process skills, illustrate theory, motivate and challenge students (Wellington, 2000). In essence, while doing practical work, students participate in activities, which encourage the acquisition of science process skills.

2.5.3.1 Class Experiment

Chemistry is essentially practical oriented subject and it should be taught using demonstration and class experiments. Students' participation in practical exercises with scientific apparatus, usually in a science laboratory, has influenced the science teaching of many countries. Class experiment activity involves individual students or groups of students working on an experiment which requires handling of apparatus, observing, measuring volumes, weighing masses, and interpreting results. These activities provide opportunities to practice the science process skills. In groups or amongst themselves, students discuss or share ideas freely during their investigation. In such situations, students are more relaxed and usually cooperate and assist each other.

Class experiments help in broadening students' experiences and initiative, resourcefulness and cooperation (Kumar et al, 2004). Wellington (2000) suggested that when planning class experiments, students should be given a free hand in recording their results individually or in groups and later on consolidate the results centrally through discussion and making interpretations so that the students can learn from others work. The laboratory set-up helps students to focus on the task at hand and offers many opportunities for satisfying natural curiosity for individual initiative and for independent work (Tamir, 1991). Practical experiences are especially effective in inducing conceptual change and students' participation in class experiments through process-skill procedures is an essential component of learning Chemistry (Tamir, 1991). This will give the students an opportunity to develop science process skills and scientific knowledge. This study investigated the extent of students' involvement in Chemistry practical work and find out if this has any bearing on their achievement in Chemistry.

2.5.3.2 Project Work

These are activities carried out outside the class hours. Due to the nature of the tasks involved, these activities cannot be accomplished in the usual eighty minutes of the practical sessions in class. The activities give the students an opportunity to explore and extend the investigations to areas of concern in the community. A project may be designed as a learning process in which students learn through association, activity and cooperation, thereby enabling them to develop process and social skills (Das, 1985).

2.5.3.3 Problem Solving Approach

This entails an investigation where the students use their own experiences. Lock (1990) suggests that students use and apply the knowledge and skills learned in Chemistry lessons to improve their abilities of solving problems. The students work with real life constraints and yet have to produce workable solutions. Through brainstorming sessions, the students decide on what to measure, identify the variables to control as they go about solving the problems. In effect, students have an opportunity to develop science process skills when they engage in problem solving activities.

2.5.3.4 Process Approach

This approach emphasizes the methods of doing science (procedures of understanding) as opposed to the product approach. Screen (1986) argues that knowledge-led curriculum has little relevance but advocates for the science education, which will be of value when the facts are out of date, that is, the development of generic skills that are transferable. These skills should form a substantial proportion of the learning/teaching process of young people.

Process-led science courses are not new; the origin can be traced from the American Association for the Advancement of Science (AAAS) (1967), – a process approach, which was concerned with broadening the clients for school science towards ‘science for all’. The central role of this approach is to prepare students for a world that needs not only scientists but also citizens capable of dealing with the political and socio-economic impact of ongoing scientific progress. There are six basic and five integrated skills, which are taught in science to promote hands- on- learning (Padilla, 1990). Haury and Rillero (1994) argue that teachers who embrace hands-on-learning in science seem to recognize certain desirable outcomes and endorse student-centered instructional approaches. In this respect students will remember the material better, feel a sense of accomplishment when the task is completed and be able to transfer that experience easier to learning situations. It is through the use of process-skills during an investigation that the students develop scientific knowledge.

2.6 Gender and Science Education

The influence of gender on students’ achievement in science has for a long time been a concern to many researchers and science educators. Studies carried out in the United States overwhelmingly show the image of a scientist as a white, bespectacled male wearing a laboratory coat and holding a test tube. Most of the illustrative diagrams and pictures in the science textbooks show males doing experiments (Bazler & Simons, 1991; Blubaum, 1994; & Edgar, 1999; 2004). Even girls who had been taught by a female science teacher rarely drew a female figure when asked to address the masculine stereotype of scientists (Kahle, 1987). In fact the messages conveyed about science as male preserve may demoralize the girls and make them switch off from science. For instance, during experiments in science lessons, boys may dominate girls in carrying out the activities thereby acting as though boys have monopoly of apparatus. Boys tend to gain more than their share of teachers’ attention and ridicule girls’ attempts to work, to the extent that girls act as boys’ helpers/assistants. These behavioral attitudes and representations reinforce the masculine image of science (Versey, 1990). However, many studies have been carried out to find whether male superiority is real, but the results obtained are varied. Shaibu and Marri (1997); Ahiakwo (1988) concluded that girls performed better than boys in chemistry. Trigwell (1990) and Opara (2011) in their findings revealed that male subjects were superior over their female counterparts in achievement in chemistry and biology respectively.

The investigation carried out by Dawson (2000) on gender imbalance revealed that the gap between boys’ and girls’ interests in the physical sciences had widened, with boys’ interest in this area being far greater than that of girls. Jones, Howe and Rue (2000) Research report concurs with Dawson findings in that little change has taken place in girls' and boys' attitudes and perceptions towards science, with boys reporting a wider range of science interests and out-of-school experiences with science than girls. Adamson, Foster, Roark and Reeds (1998) found that, there was a significant gender difference in the area of science, which students selected for projects, that is, girls chose to work in the area of social and biological sciences, and boys in the physical sciences. Dawson advocates for the need to change the direction of science teaching from preparing science specialists to that of science for all.

In response to this disparity, the curriculum review panels, publishers and textbook authors have made attempts to counter the damaging notion of science as male preserve. The Hertfordshire (Secondary School Curriculum Review) Working Party Statistics indicate that attention paid to materials put in context can change girls' attitudes towards science (Versey, 1990). The statistics for Suffolk Co-ordinated Science indicate improved uptake of "A" level science by girls following their active learning approaches. There is need therefore to demystify the perception of girls from this attitude. Adopting teaching strategies that stimulate girls' interests in science could alleviate this gender imbalance. For example, can the girls' interests be stimulated through the development of new approaches to the teaching of certain topics and new instructional materials for use in the topics? Can the science teachers include experiments in class that reflect the role girls' play in their everyday life? As a result many studies have shown that gender has no significant effect on the secondary school students' achievement in science and particularly in chemistry and physics (Shaw & Doan, 1990; Inyang & Jegede, 1991; Balogun, 1994; Wachanga, 2002; Wambugu & Changeiywo, 2008).

Much of the discussion about gender issues and science has focused on physics as this is the area that attracts the least number of girls but most of these issues are also relevant to Chemistry. For example, KNEC (2001) report shows that the take-up of Chemistry by girls in the KCSE examination indicates that 43% of the total number of candidates who registered for Chemistry in 2000, were girls compared to 58% who took biology, 29% who took physics. However, the number of candidates who took physical science was fifty-fifty. The scenario begs for a number of questions that we need to ask ourselves. Why is science in general and Chemistry in particular less popular with girls in secondary schools? How do we get more girls to do Chemistry? How do we set about developing and fostering the interest of girls in Chemistry?

In the UK, right from primary school to GCSE level, Chemistry does appear to offer girls and boys a more gender-fair approach than is offered by physics, that is, Chemistry is the science subject that shows the least sex differentiation in terms of candidates' enrolment (Whitelegg, 1992). However, in Kenya, girls' and boys' attitudes to science in general influence their view of Chemistry in particular.

The 8.4.4 curriculum has popularized Chemistry to girls by encouraging active learning approaches and use of relevant contexts. Planning activities that involve girls in related chores and everyday activities may influence girls' attitudes towards Chemistry. Some publishers have produced Chemistry textbooks, which display on their covers and inside pages, pictures showing girls as well as boys doing the experiments. A close examination of Chemistry textbooks authored locally display illustrations depicting girls as showing more active roles (Mbaka & Wamae, 2004; KIE, 2001). The other recommended strategy that may influence girls interests in Chemistry involve the non-use of gender biased illustrations in class showing girls performing less conventional tasks. The need to establish an appropriate teaching method, which would encourage active participation of girls in the learning of Chemistry is relevant in this study because a lot of literature show disparities in the performance of science in general and chemistry in particular between boys and girls in secondary schools.

2.7 Self-Concept

Self-concept comprises people's attitudes, feelings, the perceptions that the individual assigns to himself or herself and characteristics. It is one's ideas of the self in relation to others and the environment (Bauer, 2005; Marsh, 2006). The individual perception of who one is, the perception of others about an individual and what one would like to be, do define what self-concept is (Muola, 2000). Andrews (1966) conceives the concept of self as the picture, an individual has of himself or herself from the interactions and experiences with the environment. The definition considers interactions and experiences as important factors that determine one's self-concept. Students come to Chemistry class with diverse interests, background and perceptions on the subject. The practical activities carried out in Chemistry lessons, through science process skills teaching approach provide interactions and experiences, which may shape the direction in which the students' Chemistry self-concept may take. Bauer (2005) views self-concept as multidimensional, which comprises academic, physical, social and emotional dimensions. The academic dimension includes other components of self-concept, for example, chemistry self-concept, mathematics self-concept. Chemistry self-concept refers to a person's perceptions and knowledge about the self in chemistry achievement, for example, I solve chemistry problems easily. This study focuses on Chemistry self-concept of the students and was measured using the following sub-scales.

i) Cognitive ability
ii) Psychomotor ability
iii) Ability to use mathematical applications
iv) Overall academic ability in Chemistry
v) Enjoyment in learning Chemistry
vi) Creativity

Research based on the three SDQ instruments show relationship between specific aspects of academic self-concept and corresponding measures of academic achievement in terms of test scores, for example, good chemistry achievement is highly correlated with chemistry self-concept (Young, 1998; Marsh, 1990a; Sanchez & Roda, 2003). It is argued that if students are given opportunities to interact actively in class then they have higher chances of enhancing their academic achievement. The practical activities in chemistry lessons do offer opportunity for interaction and that may spur positive development of students' chemistry self-concept (Muola, 2000). However, the effect of chemistry practical interactions upon students' self-concept has not been established. This study sought to investigate the effect of SPSTA on students 'chemistry self-concept as illustrated in the SDQ II Manual (Marsh, 1990b). The manual details the specific dimensions of chemistry self-concept that were measured.

2.8 Group Composition during Practical Work in Chemistry.

Besides finding out the effect of SPSTA on the achievement and self-concept of boys and girls in Chemistry, the study also compared the effect of SPSTA on achievement and self-concept in Chemistry between mixed groups and single sex groups of students. Much of the work involving inquiry-based learning involves students working together in small groups on a collective task. It has been reported in some research studies that there are significant learning benefits for students who work together on learning activities (Johnson & Johnson, 1981; 1989). Similarly in other related research studies Barron (2000a; b ;) compared individual and cooperative teams and found that groups outperform individuals and that individuals who work in groups do better. It is on this premise that the study sought if the nature of these groupings could affect the achievement and self-concept of students in chemistry.

In most secondary schools in Kenya, practical work in Chemistry is organized in small groups of four, five up to eight students working on specific or a circus of experiments in the laboratory or classroom. This is to enable students talk to each other, question and think about the results, share and discuss coherently (Argyle, 1983). Myra (2000) suggests group size of 5-6 members as convenient for working on practical tasks. When students do experiments, they may observe and record the results. They may be required to measure the volumes and masses of substances used in the reaction. Once the results/observations are recorded, the students are expected to interpret and discuss the results obtained from the experiments. The experiences of group work may be characterized as lively, stimulating and full of learning (Brown & Atkins, 1988). The patterns of interaction in group work may give the students an opportunity to talk to each other freely, exchange ideas and this may influence greater participation in discussion and promote the development of intellectual and discussion skills (Argyle, 1983). Muir (2006) asserts that the social interaction experienced in group work encourages individuals to take responsibility for their learning through problem solving tasks and sharing of information. The Chemistry teacher sometimes determines the composition of the groups basing the selection of group members on ability or gender considerations.

In this study, the groups were made up of boys, girls and mixed sex. The main objective was to compare the effect of science process skills teaching approach on achievement and self-concept in Chemistry between mixed groups and single sex groups of students. The purpose of organizing practical groups along gender lines was to get students to talk to each other and enhance co-operative skills. This arrangement may enable students to communicate with one another freely and handle the language of the subject which consists of symbols, formulae, concepts, processes effectively, thereby socializing them into the values and perspectives of the subject (Argyle, 1983). Brown and Atkins (1988) argue that questioning skill and sharing of each other's views are embedded in group work.

2.9 Theoretical Framework

One method of learning science is based on discovery approach associated with Bruner's psychological theory of learning (Bruner 1961; Bichler & Snowman, 1982). Learning by doing advocated by Bruner, which encompasses searching; exploring and analyzing activities are consistent with science process skills. These process skills are cognitive or practical and pedagogical processes involved in the learning of science in the classroom and are used by students to investigate the natural world (Jenkins, 1989). They include such activities as observing, measuring and recording. This study focused on the exploration and analytical aspects of the Bruner's psychological theory of learning. This theory involves exploration, investigation/experimenting, analytical and elaboration of activities and information. It puts the learner at the centre of doing, one who is supposed to find out for himself (Moore & Thomas, 1983). Hodson (1990) argues that when students get involved in hands-on activities, they perform better in the subject. Students' practical and past experiences influence what they learn (Ausubel, 1968). White (1991), Brooke et al. (1989) argue that exposing students to process skills in science lessons could serve as sources of experience (prior knowledge), which the learner links with what is being taught to enhance meaningful learning. Driver and Bell (1985) support the argument by stating that laboratory activities have been found to offer opportunity for identifying misconceptions and inducing conceptual change. Young (1998); Marsh (1990a); Sanchez and Roda (2003) show that research based on SDQ instruments relate positive academic self-concept to good academic achievement. The Cognitive Acceleration through Science Education (CASE) provided evidence that having science process skills in science activities based on Piagetian stages of intellectual development lead to a boost in cognitive achievement (Brotherton & Preece, 1996).

2.10 Conceptual Framework

Figure 1 shows the relationship between the independent, dependent and extraneous variables.

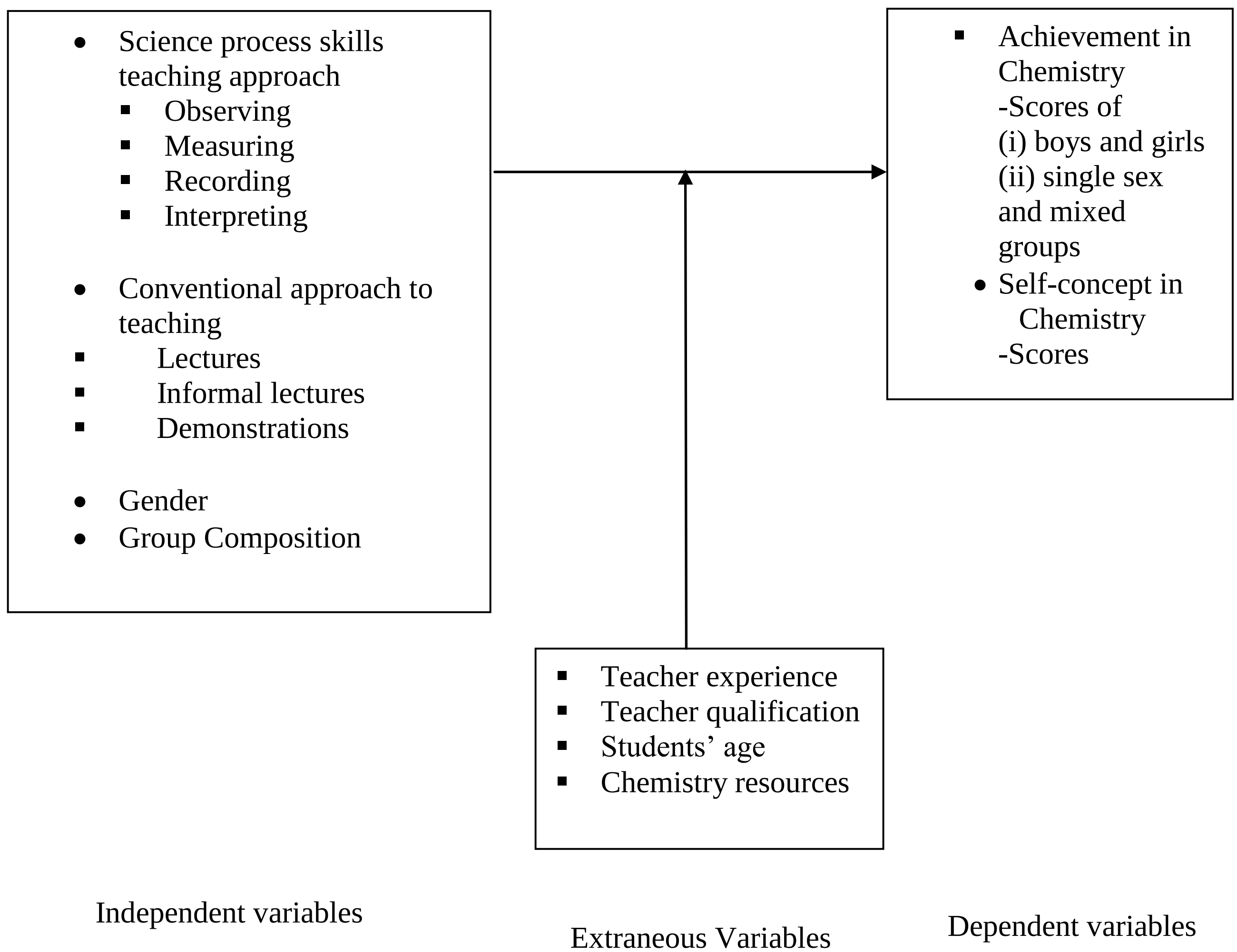

Figure 1: Conceptual framework showing the relationship between variables of the study.

In this study the independent variable was science process skills teaching approach and the dependent variables were achievement and self-concept in Chemistry. The effect of gender and group composition on students' achievement and chemistry self-concept was also examined. The extraneous variables were learning resources, students' age, teacher qualification and experience. These variables were controlled by selecting secondary schools with adequate Chemistry learning resources and trained graduate or diploma holders with a minimum of three years experience.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter contains the methodology employed in the study and describes the research design, population and sampling procedures. It also describes the nature of the treatment applied, the nature and administration of the instruments used in collecting data. Lastly, it outlines the procedures for data analysis.

3.2 Research Design

The study involved quasi-experimental research using the Solomon's Four-Group Non-Equivalent Control Group Design (Gall, Borg & Gall, 1996). The design was preferred because the Form Three classes involved in the study remained intact, as the school authorities would not allow randomization process by reconstituting and disrupting classes during the administration of the treatment (Coolican, 1999). However, it was possible to randomly assign the classes as either experimental and control groups. Although the use of intact/non-randomized groups and pre-test arrangement is capable of sensitizing and creating unequal groups, the ANCOVA statistic is able to adequately address this at the post-test level. Furthermore, the 2 x 2 factorial analysis used in Solomon Four-Group Non Equivalent Control Group Design was able to reveal whether the treatment was effective and/or if there was an interaction between the pre-test and the treatment. The design used is given in figure 2.

Group I	0_1	X	0_2	Experimental group
Group II	0_3		0_4	Control group
Group III		X	0_5	Experimental group
Group IV			0_6	Control group

Key: - Pre-tests 0_1 and 0_3

Post-tests 0_2, 0_4, 0_5 and 0_6

Treatment X

--------- Dashed lines show that the experimental and control groups were not equated by randomization hence non-equivalent.

Figure 2: Solomon's Four-Group Non-equivalent Control Group Design

Source: Cohen and Manion (1994), Gall, Borg and Gall (1996) and Wiersma and Jurs (2005).

The students in the two experimental (treatment) groups received instructional practical sessions on two-selected topic areas using SPSTA, while the two control groups followed their regular learning practices (conventional teaching approach) at the school. The treatment consisted of four practical sessions distributed over a period of five weeks of the school term. The selection and maturation biases were controlled by administering pre-test to groups I and II (see Figure 2). The pre-test was used to determine the knowledge level of the participating groups at the starting point. This was to indicate whether the two groups were equal or unequal (Gall, Borg and Gall, 1996).

3.3 Location of the Study

The study was conducted in Nyando District in Kisumu County, Kenya. The district has a total number of seventy-six secondary schools, out of these; sixty- three are district schools. Nyando District was selected because of the high number of district schools as compared to the provincial and private schools and justified from the perspective that the students' performance in Chemistry in KCSE is generally low and therefore there is a need to improve it by using appropriate teaching strategies. Nyando District is located in a rural setting where agricultural activities take centre stage. The occupation of most residents is farming and because they belong to one ethnic group, the culture, social and economic backgrounds are more or less homogenous. This has a bearing on the students' abilities and performance in the schools.

3.4 Population of the study

The target population for the study was about 3500 students of the Form Three classes in the secondary schools in Nyando District. The accessible population was composed of Form Three students in the sixty-three district schools. The Form Three students were used because they had an opportunity to do practical work in Chemistry in the first two years of secondary education.

3.5 Sampling Procedures and Sample Size

A list of sixty-three (63) district secondary schools in Nyando District formed the sampling frame. The sample consisted of Form Three students drawn from four district schools purposively sampled. Purposive sampling technique was preferred to enable selection of schools with about the same number of boys and girls and adequate resources for teaching Chemistry. The schools were located far apart from each other to eliminate diffusion of information from the experimental groups to the control groups. The district secondary schools were preferred for use in this study because; all the schools were mixed and operate as Day schools. The students admitted to these schools have comparable academic abilities arising from the selection process after KCPE. The schools were randomly assigned to the experimental and control groups. Each school provided a Form Three class to participate in the study but in cases where a school operates double or multi-streams, simple random sampling was used to pick one stream. The total number of students who took part in the study was one hundred and fifty three (153), with each school having approximately forty students (see Table 6). This provided a reasonable sample size whose findings may easily reproduce the salient characteristics of the accessible population to an acceptable level (Mugenda & Mugenda, 1999).

The optimum sample size required for each participating group in an experimental research as recommended by Coolican (1999), Gall, Borg and Gall (1996) is thirty respondents. This number compared very well with the proposed sample size employed in this study. The recommended class size for secondary schools in Kenya is approximately forty students. Table 6 shows the number of schools and students that participated in each group as outlined in Figure 2.

Table 6:

Assignment of sample schools and students to the experimental and control groups

Groups		School	Boys	Girls	Total
I	Experimental Group 1(with treatment)	1	39	11	50
II	Control Group 1 (without treatment)	1	19	11	30
III	Experimental Group 2 (with treatment but not pre-tested)	1	24	16	40
IV	Control Group 2 (without treatment and not pre-tested)	1	19	14	33
	Total	1	81	52	153

A total of 153 students participated in the study.

3.6 Instrumentation

Chemistry Achievement Test (CAT) was developed and used as a pre-test and post-test, this was mainly to determine students' knowledge in Chemistry with respect to selected topics. It had 60 items consisting of simple calculations, True and False, and Fill in blanks. It covered two topic areas, that is, Volumetric analysis (Titration) and Qualitative analysis selected from Form Three KCSE Chemistry syllabus. After an instructional intervention, the same CAT was reorganized by shuffling the items and then administered to the experimental and control groups as post-test. The test was scored on the basis of correct or incorrect responses. Each correct and incorrect response was scored one and zero marks respectively. Student's Self-Concept Scale (SSCS) was used to measure the students' Chemistry self-concept. It included six subscales of the chemistry self-concept inventory. The instrument was adapted from the SDQ II scale (Marsh, 1990a; Muola, 2000). A questionnaire consisting of forty (40) items developed to measure specific aspects of Chemistry self-concept was administered to the students. The numerical numbers listed below show the corresponding items measuring a particular aspect of chemistry self-concept (Appendix C).

i) Cognitive ability	1, 2, 3, 4, 5, 6, 7.
ii) Psychomotor ability	8, 9, 10, 11, 12.
iii) Ability to use mathematical applications	13, 14, 15, 16, 17, 18, 19.
iv) Overall academic ability in Chemistry	20, 21, 22, 23, 24, 25, 26.
v) Enjoyment in learning Chemistry	27, 28, 29, 30, 31, 32, 33.
vi) Creativity	34, 35, 36, 37, 38, 39, 40.

The students were expected to choose the response which best described the extent to which he or she perceived himself or herself in regard to Chemistry. A five-point (1-5) likert-type rating scale (Appendix C) modified from Marsh (1990a) and Muola (2000) self-scales was used to measure the students' Chemistry self-concept. The items marked SA (strongly agree) scored 5 points and SD (strongly disagree) scored 1 point.

3.6.1 Validation of the Instruments

Five experts from science education and psychology areas of specialization validated the Chemistry knowledge tested and the Chemistry self-concept items in the questionnaire. They comprised senior members of the departments of Curriculum, Instruction and Educational Management, Educational Psychology, Egerton University and two examiners in Chemistry registered with KNEC. The exercise was to ascertain the content validity of the items used in the instruments. The outcome from pilot testing was also used to find out the content validity of the items in order to establish if they were functional.

3.6.2 Reliability of the Instruments

Pilot testing was done in two district secondary schools in Nyando District, which were not part of the sample schools. The information gathered from piloting was used to estimate the reliability of the instruments. The purpose of reliability was to ensure that the results obtained when using a measuring tool in research, was consistent and could be replicated in another situation (Sapsford & Evans, 1984; Wallen & Fraenkel, 2000). Kuder-Richardson 21 formula (K-R21) was used to calculate the reliability coefficient of the CAT instrument. The use of K-R21 was recommended because the test items were scored dichotomously and were of equal difficulty level (Wiersma & Jurs, 2005; Bailey, 1982). It was to improve the accuracy of prediction of results by considering individual items hence generating greater reliability (Gall, Borg & Gall, 1996).

Kuder-Richardson 21 formula is as follows:

$$K - R21 = \frac{K}{K-1}\left[1 - \frac{\overline{X}\left(K - \overline{X}\right)}{KS^2}\right]$$

Where K = number of items in the test

$\overline{\chi}$ = mean of the set of scores

S = standard deviation of the set of scores

The reliability coefficient of the CAT instrument was found to be 0.76 at the piloting stage when calculated using K-R21. After the application of treatment, the discrimination indices, facility value of the items were calculated and those found to be having a discrimination index below 0.20 were discarded from the test. The reliability coefficient (K-R21) of the achievement test improved to 0.88 at the post-test stage. This was an improved value as compared to the value obtained during piloting.

Cronbach’s alpha coefficient was used to determine the reliability of SSCS instrument. The method was suitable because the test items had a range of 1-5 possible answers with a maximum weighting of 200 points. At the piloting stage, the reliability coefficient was calculated and found to be 0.95 which was accepted as suitable for the instrument since it conformed to the recommendations of Wallen & Fraenkel (1991), Coolican (1999), and Borg & Gall (1989). According to Wallen & Fraenkel, a reliability measure of above 0.70 was considered appropriate and showed that the instrument was adequately reliable and therefore suitable for this study. The cronbach coefficient formula is shown below.

$$\propto = \frac{K}{K-1}\left[1 - \frac{\sum Si^2}{S_x^2}\right]$$

Where α = reliability coefficient of the test

K = number of items in the test

Si^{2} = Variance of scores of the individual items

S^2 = Variance of the total scores of the test

3.6.2.1 Item Analysis of CAT

Research studies employ two factors to judge the efficiency of test items and these are; discrimination index (D.I) and facility value (F.V).

(a) Discrimination Index

Item discrimination indicates the extent to which success on an item corresponds to success on the whole test. The discrimination index (D) is computed from equal-sized high and low scoring groups on the test. It is calculated by obtaining the difference between the % mean score of the upper one-third or 27% and lower one-third or 27% of sample group size of pupils on a question divided by the number of pupils in each group (Kelley et al., 2002).

The discrimination index (D) formula is shown below.

D = U-L/N

Where; U = the % mean score of the upper group (one-third or 27%) of the pupils in the sample

L = the % mean score of the lower group (one-third or 27%) of the pupils in the sample

N = the number of pupils in the sample.

A positive value of the D.I shows that the question discriminates between pupils in the desired direction. The D.I values of 0.4 and above are regarded as high and values less than 0.2 are regarded as low (Ebel, 1966). This recommendation formed the basis of selecting the test items in the main study.

(b) Facility value

The facility value (F.V.) of a test item is a measure of its difficulty level. The difficulty of a question can be thought of as the proportion of students who get the question correctly. In order that students are separated out as much as possible it is desirable for assessments overall to have a difficult level of about 0.5; so that the mean mark is roughly half of the marks available.

In this study the selection of CAT items was done on the basis of the values of discrimination index (D.I) and facility value (F.V) of the individual items. The items with facility value lying within the range of 0.15 to 0.85 and discrimination index of 0.2 and above were considered appropriate (Frazer & Sleet, 1975) and therefore selected for this study.

3.7 Intervention/Treatment

The experimental groups received treatment conducted by the Chemistry teacher for a period of five weeks. Four sessions of practical work were organized, each session lasting eighty minutes. The students carried out experiments on the following content areas.

(i) Volumetric analysis (Titration of a base with an acid)
(ii) Qualitative analysis (detection of cations and anions)

During the practical sessions, the students were divided into five groups with about eight students each. The groupings were made up of mixed sex groups, boys' only groups and girls' only groups. Before the beginning of each session, the teacher informed and instructed the students on the objectives and procedures of working. The materials, apparatus and instructions for the experiment for each practical session were provided. The students did all the activities and the teacher visited the groups and posed guiding questions intended to lead them to an appropriate direction. The treatment was also administered to the other streams of Form Three class in the same school but the information obtained was not used in the study. This was mainly to eliminate anxiety amongst the students who were not involved in the research and also to conform to professional ethics. The control groups were asked to cover the same topics during the period of study but were free to follow their regular/conventional methods of teaching Chemistry in their schools.

3.8 Data Collection Procedures

The researcher sought permit from Board of Postgraduate Studies, Egerton University and the National Council for Science and Technology (NCST) in the Ministry of Higher Education, Science and Technology (MOHEST) to conduct the study in Nyando District. The researcher visited the sample schools to brief the Principals and the Chemistry teachers on the nature and purpose of the study. An induction course was offered to the Chemistry teachers who administered treatment to the students in the experimental groups for one day. The pre-tests (CAT; SSCS) were administered to the students in Experimental Group I and Control Group I to measure their initial Chemistry knowledge and self-concept levels before treatment (Table 6). The post-tests (CAT & SSCS) were administered to all the four groups (experimental and control) at the end of treatment period. CAT and the questionnaire (SSCS) were used to obtain students' achievement in Chemistry and students' Chemistry self-concept respectively. The students' scores from the tests were recorded and used for data analysis.

3.9 Data Analysis

The data were analyzed using both descriptive and inferential statistics. The mean and standard deviation were used to describe and compare students' self-concept and achievement in Chemistry from the experimental and control groups. The hypotheses were tested using the following statistical tests for significance, t-test, ANOVA, ANCOVA, correlation coefficient and multiple regression. ANOVA and t-test were used to determine if there were any statistical significant differences on students' self-concept and achievement in chemistry between experimental and control groups, boys and girls and mixed and single sex groupings. ANCOVA was used for statistical adjustment to enhance control if variation was evident in the experimental and control groups at the time of pre-testing. The post-test results were correlated with the co-variate, using KCPE results. The level of significance was set at $\alpha = 0.05$ to guide in the rejection or acceptance of null hypotheses. Summary of data analysis is given in Table 7.

Table 7:
Summary of Data Analysis

	Hypotheses	Independent Variables	Dependent Variables	Statistical methods for Data Analysis
Ho1	There is no statistically significant difference in Chemistry achievement between students taught through SPSTA and that of those who are not exposed to it.	Science process skills teaching approach (SPSTA) -Observation -Measurement -Recording -Interpretation	Achievement in Chemistry	t-test ANOVA ANCOVA
Ho2	There is no statistically significant difference in achievement between secondary school boys and girls who are taught Chemistry through SPSTA.	Gender	Achievement in Chemistry	t-test ANOVA ANCOVA
Ho3	There is no statistically significant difference in Chemistry achievement between girls exposed to SPSTA in mixed groups and girls in girls' only groups.	Group composition	Achievement in Chemistry	t-test ANOVA ANCOVA
Ho4	There is no statistically significant difference in Chemistry achievement between boys exposed to SPSTA in mixed groups and boys in boys' groups.	Group composition	Achievement in Chemistry	t-test ANOVA ANCOVA

Ho5	There is no relationship between the selected science process skills and students' achievement in chemistry when taught through SPSTA.	Science process skills	Achievement in Chemistry	Pearson's (r) Correlation. Multiple Regression (R-Square)
Ho6	There is no statistically significant difference in self-concept of students who are taught Chemistry through SPSTA and those who are not exposed to it.	Science process skills teaching approach (SPSTA)	Self-concept in chemistry	t-test ANOVA ANCOVA
Ho7	There is no statistical significant difference in self-concept between secondary school boys and girls who are taught Chemistry through SPSTA.	Gender	Self-concept in Chemistry	t-test ANOVA ANCOVA
Ho8	There is no statistically significant difference in self-concept between girls exposed to SPSTA in mixed groups and girls in girls' only groups during Chemistry lessons.	Group composition	Self-concept of girls in chemistry	t-test ANOVA ANCOVA
Ho9	There is no statistically significant difference in self-concept between boys exposed to SPSTA in mixed groups and boys in boys' only groups during Chemistry lessons.	Group composition	Self-concept of boys in chemistry	t-test ANOVA ANCOVA
Ho10	There is no relationship between the chemistry self-concept sub-scales and students' chemistry self-concept when taught when taught using SPSTA.	Chemistry self-concept sub-scales	Chemistry self-concept	Pearson's (r) Correlation.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The research findings on the effect of science process skills teaching approach on students' achievement and self-concept in chemistry in Nyando District are presented and discussed in this chapter. The results were analysed using descriptive and inferential statistics and presented in the form of graphs and tables. The following inferential statistics were used analyse data: t-test, ANOVA, ANCOVA, Pearson's (r) Correlation and Multiple Regression.

4.2 Results of the Pre-Tests

The research design employed in this study (Solomon Four Non-Equivalent Control Group Design) allowed the use of two groups to sit for pre-tests. Experimental Group 1 and Control Group 1 sat for the pre-tests CAT and SSCS. Experimental Groups 1and 2 received treatment; Control Group 2 was neither treated nor pre-tested. This arrangement was preferred because it enabled the researcher to:

(i) find out if there was any interaction between the pre-test and the treatment application.

(ii) find out the effect of pre-test on the pre-tested groups

(iii) find out if the groups were similar/equivalent before the administration of treatment.

The maximum score for the CAT in this study was 60 marks, which was converted to 100%. However, the grand mean score for each group shown in the tables below was calculated out of 1 unit which was equated to 100%. The grand mean score shown translates to percentage mean score by multiplying it by 100.

Table 8 shows the t-test of the Pre-test mean scores on CAT for Experimental Group 1 and Control Group 1.

Table 8:
Independent Samples t-test of the Pre-test Scores on CAT

Variable	Groups	N	Mean	Std. Deviation	df	t	Sig. (2-tailed)
CAT	Experimental Group 1	50	.43	.16	78	5.03	.000
	Control Group 1	30	.26	.14			

Tcal =5.03, Tcrit = 2.00, df = 78, $p<0.05$

The mean score value calculated for chemistry achievement in each group represented the grand mean, that is, the mean score was calculated out of a possible 1 unit. Therefore the percentage mean scores for the Experimental Group 1 and Control Group 1 could be represented as 43% and 26% respectively.

The results of the pre-test showed that students in Experimental Group 1 had a higher mean score than those in Control Group 1. There is statistically significant difference between the mean scores of the two groups t (78) = 5.03, $p<0.05$; hence the groups were treated as unequal. This is an indication that the students in Experimental Group 1 and Control Group 1 were not equal in chemistry ability at the starting point. The lack of similarity in academic ability exhibited by the two groups could possibly be due to the selection of the schools, however, the KCPE mean scores for the students in the two groups and the performance of the two schools in the KCSE in the previous years were comparable. Since the difference between Experimental Group 1 and Control Group 1 was statistically significant at $p<0.05$, it was necessary to use ANCOVA with KCPE and pre-test results as covariates to adjust the post-test results of the four groups and thereby compensating for the lack of initial equivalence.

4.3 Effect of Science Process Skills Teaching Approach (SPSTA) on Secondary School Students' Achievement in Chemistry.

Hypothesis one (Ho1) was derived from objective one of the research study and it stated that there is no statistically significant difference in Chemistry achievement of students who are taught through SPSTA and that of those who are not exposed to it. To test this hypothesis an analysis involving ANOVA and ANCOVA was carried out on the students' post-test scores to determine the effect of science process skills teaching approach on students' achievement in chemistry.

Table 9 shows the CAT post-test mean scores obtained by the students when the four groups were compared. This was mainly to find out if there are differences in the mean scores and the extent of dispersions of each group.

Table 9:

CAT Post-test Mean Scores Obtained by the Students in the Four Groups

	N	Mean	Std. Deviation	Std. Error
Experimental Group 1	50	.59	.11	.02
Experimental Group 2	40	.45	.14	.02
Control Group 1	30	.33	.14	.02
Control Group 2	33	.31	.13	.02
Total	153	.44	.17	.01

The means of the four groups were different, with Experimental Group 1 registering the highest mean score, followed by Experimental Group 2 then Control Group 1 and lastly Control Group 2. The students in Experimental Group 1 and 2 were exposed to SPSTA and their mean scores were higher than those in Control Groups 1 and 2. This could be due to their exposure to SPSTA. A comparison of the gain in mean scores between post-test and pre-test of Experimental Group 1 (treatment) and Control Group 1 (no treatment) (Tables 8 & 9) was double in favour of Experimental Group 1. At the post-test level it was also evident that the gain in the mean scores between the experimental and control groups was large. This was an indication that the treatment had a greater effect on the mean scores as compared to the effect that might have been attributed to the pre-test. The large positive gains in the mean scores of the experimental groups attributed to treatment outweighed any possible effect that might have been caused by the pre-test. Similarly if there was an interaction between the pre-test and treatment condition, the post-test mean scores of the Experimental Group 1 and the Control Group 1 should have indicated a much bigger difference due to the pre-test sensitization.

Table 10 shows the outcome of one-way Analysis of Variance (ANOVA) based on the post-test mean scores on the CAT. This was intended to show whether the difference in the mean scores between and within groups were statistically significant.

Table 10:
Analysis of Variance (ANOVA) of the Post-test Mean Scores on the CAT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.03	3	.68	41.53	.000
Within Groups	2.43	149	.02		
Total	4.46	152			

Fcal = 41.53; Fcrit = 2.67; $F (3, 149) = 41.53$; $p<0.05$

The difference between and within groups is statistically significant $F (3,149) = 41.53$, $p<0.05$, leading to the rejection of Ho1.Since there was significant difference between the means of the groups; it was necessary to carry out post-hoc comparisons test of CAT mean scores to establish where the differences occurred. The tests were carried out using Scheffe procedure at $p<0.05$ level.

Table 11 shows the results of the Scheffe post-hoc comparisons of CAT mean scores. The Scheffe post-hoc procedure is applicable in situations where the composition of the groups tested is not equal in number.

Table 11:
Post Hoc Comparisons of the Post-test of CAT Means for the Four Groups

Scheffe

(I) groups	(J) groups	Mean Difference (I-J)	Std. Error	Sig.
Experimental Group 1	Experimental Group 2	.14*	.03	.000
	Control Group 1	.26*	.03	.000
	Control Group 2	.28*	.03	.000
Experimental Group 2	Experimental Group 1	-.14*	.03	.000
	Control Group 1	.11*	.03	.005
	Control Group 2	.14*	.03	.000
Control Group 1	Experimental Group 1	-.26*	.03	.000
	Experimental Group 2	-.11*	.03	.005
	Control Group 2	.03	.03	.886
Control Group 2	Experimental Group 1	-.28*	.03	.000
	Control Group 1	-.03	.03	.886
	Experimental Group 2	-.14*	.03	.000

The post-hoc comparisons showed that the mean differences between Experimental Group 1 and Control Group 1(.26), Experimental Group 1 and Control Group 2 (.28), Experimental Group 1 and Experimental Group 2 (.14), Experimental Group 2 and Control Group 2 (.14) and Experimental Group 2 and Control Group 1 (.11) groups were statistically significant at $p<0.05$ level. In other words, Experimental Group 1 showed statistically significant difference with the Control Groups 1 and 2, Experimental Group 2 also showed statistically significant difference with Control Groups 1 and 2. This was expected if the treatment (SPSTA) had an effect on the students' chemistry achievement. But surprisingly the Experimental Group 1 showed statistically significant difference with Experimental Group 2. This could have resulted due the fact that the two groups were distinct and drawn from different locations within the district. However, the mean difference between them (.14) was small compared to the difference observed between Experimental Group 1 and the control groups. Since the Experimental Groups 1 and 2 received treatment, the results of post-hoc comparisons confirmed that SPSTA had a positive effect on students' achievement in chemistry, thus, leading to the rejection of the null hypothesis (Ho1).

It is also important to note that the mean difference between Control Groups 1 and 2 was not statistically significant. Since this study engaged non-equivalent control group design, which involved distinct/intact groups in the exercise, by the very nature of the groupings, it is possible that the significant differences shown on the post-test mean scores of the groups could have resulted from the pre-existing group differences other than the treatment effect. Therefore it was necessary to carry out analysis of covariance test (ANCOVA) to adjust the post-test mean scores of the groups using the students' Kenya Certificate of Primary Education (KCPE) and the Pre-test as covariates, in an attempt to reduce the effect of the initial group differences (Coolican, 1999).

Table 12 shows the adjusted CAT post-test mean scores for ANCOVA using KCPE as covariate.

Table 12:
Adjusted CAT Post-test Mean Scores for ANCOVA with KCPE as Covariate

Groups	N	Mean	Std. Error
Experimental Group1	50	.55[a]	.02
Experimental Group2	37	.46[a]	.02
Control Group 1	30	.36[a]	.02
Control Group 2	31	.33[a]	.02

a. Covariates appearing in the model are evaluated at the following values: KCPE covariate = 293.48.

The results from the pre-test (see Table 8) showed that the mean scores of Experimental Group 1 and Control Group 1 were different (non-equivalent), which meant there was need to adjust the post-test mean scores by performing the analysis of covariance (ANCOVA) using the students' KCPE and Pre-test scores as covariates. This was done to overcome threats of internal validity of non-equivalent control groups on the post-test scores, which might have occurred due to pre-existing group differences rather than the treatment effect. The adjusted CAT post-test mean scores with KCPE as covariate for the four groups are shown in Table 12.

The variation in the number of students in Experimental Group 2 and Control Group 2 (see Tables 9 & 12 concurrently) was occasioned by the information received from the school administration that some students joined the affected schools either in Form 2 or 3 and therefore their KCPE results could not be found. The cases were treated as missing values and therefore could not be computed for ANCOVA. When the adjusted CAT post-test mean scores of the experimental groups were compared to those of the control groups, the outcome showed that the groups which received treatment had better mean scores over the control groups despite Control Group 1 being pre-tested. This suggested that the pre-test did not influence the achievement of the students who were pre-tested. In such circumstances the only plausible explanation for the enhanced students' achievement in chemistry was the exposure to SPSTA.

Table 13 shows Analysis of Covariance (ANCOVA) of the post-test CAT mean scores with KCPE scores as covariate.

Table 13:
Analysis of Covariance (ANCOVA) of the Post-test Scores on CAT

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.28[a]	4	.57	40.54	.000
KCPE	.34	1	.34	24.30	.000
Groups	1.04	3	.35	24.55	.000
Error	2.02	143	.01		
Total	33.44	148			
Corrected Total	4.31	147			

a. R Squared = .531 (Adjusted R Squared = .518)
Fcal = 24.55; Fcrit = 10.13; $F(3, 143) = 24.55$; $p<0.05$

When the CAT post-test mean scores were adjusted using the KCPE scores, the mean score difference of the groups were statistically significant, $F(3, 143) = 24.55$), $p<0.05$. Since there was statistically significant difference between Experimental Group 1 and Control Groups 1 and 2, the same trend was also evident between Experimental Group 2 and Control Groups 1 and 2, it can be deduced that SPSTA had an effect on students' achievement in chemistry.

Table 14 shows post-hoc pair wise comparisons based on ANCOVA for CAT mean scores for the four groups.

Table 14:
ANCOVA Pair wise Comparisons on CAT Mean Scores for the Four Groups.

(I) groups	(J) groups	Mean Difference (I-J)	Std. Error	Sig.[a]
Experimental Group 1	Experimental Group 2	.09*	.027	.001
	Control Group 1	.19*	.030	.000
	Control Group 2	.22*	.029	.000
Experimental Group 2	Experimental Group 1	-.09*	.027	.001
	Control Group 1	.10*	.029	.001
	Control Group 2	.13*	.029	.000
Control Group 1	Experimental Group 1	-.19*	.030	.000
	Experimental Group 2	-.10*	.029	.001
	Control Group 2	.03	.031	.279
Control Group 2	Experimental Group 1	-.22*	.029	.000
	Experimental Group 2	-.13*	.029	.000
	Control Group 1	-.03	.031	.279

Based on estimated marginal means

*, The mean difference is significant at $p<0.05$ level.

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustment).

The post-hoc pair wise comparisons based on ANCOVA show statistically significant difference between Experimental Group 1 and Control Groups 1 and 2, similarly the same trend was observed between Experimental Group 2 and Control Groups 1 and 2. These results are supported by the data in Table 9, which show that the mean scores of Experimental Groups are higher than that of Control Groups. The results of ANCOVA pair wise comparisons relate very closely to that of post-hoc ANOVA (see Table 11); this confirms that SPSTA employed in the study had an effect on the students' achievement in chemistry as compared to the regular teaching approach used on the control groups. However, there was observed significant difference in the mean scores between Experimental Group 1 and Experimental Group 2. This could have been occasioned by the fact that the two experimental groups were not equal in abilities at the starting point. Hence, the trend persisted despite the positive effect caused by the treatment on each of the groups.

Table 15 shows the adjusted CAT post-test mean scores for ANCOVA with CAT Pre-test results as covariate.

Table 15:
Adjusted CAT Post-test Mean Scores for ANCOVA with Pre-test CAT as Covariate

Groups	Mean	Std. Deviation	N
Experimental Group 1	.59	.11	50
Control Group 1	.33	.14	30

The adjusted post-test mean scores of the Experimental Group 1 and Control Group 1 using ANCOVA with CAT pre-test results as covariate were the same as the post-test mean scores of the Experimental Group 1 and Control Group 1 (see Table 9). The findings showed that the use of CAT pre-test as covariate did not affect the post-test mean scores of the two groups.

Table 16 shows Analysis of Covariance (ANCOVA) of the CAT post-test mean scores using Pre-test as covariate.

Table 16:
Analysis of Covariance of the CAT Post-test Scores (CAT Pre-test as Covariate)

Source	Sum of Squares	df	Mean Square	F	Sig.
CAT (Pre-test)	.54	1	.54	69.20	.000
Groups	.36	1	.36	45.28	.000
Error	.61	77	.01		

The results showed significant difference between the mean scores of Experimental Group 1 and Control Group 1, $F(1, 77) = 45.28$, $p<0.05$. Since Experimental Group 1 was taught using SPSTA, it is reasonable to infer that the students who were exposed to SPSTA performed better in chemistry than those who were taught through regular teaching method, therefore, Ho1 is rejected.

Table 17 shows comparisons of the mean scores of CAT in the Pre-test and Post-test and also the mean gain obtained by the students.

Table 17:
Comparison of the Mean Scores and Mean Gain obtained by Students in the CAT

	Overall	Expt.al Group 1	Control Group 1
	N = 80	N = 50	N = 30
Pre-test	.34	.43	.26
Post-test	.46	.58	.33
Main Gain	.12	.15	.07

Each item had a maximum of one mark; therefore, the results shown indicate the grand mean score of each group. There was a larger gain in mean score obtained by Experimental Group 1 (15%) than by Control Group 1 (7%). The mean gain in experimental Group 1 was twice as much as the mean gain experienced by Control group 1. Since the students in Experimental Group 1 were exposed to SPSTA, it is reasonable to suggest that SPSTA had a positive effect on students' achievement in chemistry. However, it is important to note that both groups gained from the respective teaching approaches but the group which was exposed to SPSTA had a higher gain than the group that followed the regular teaching approach.

4.3.1 Discussion

After five weeks of science process skills based instruction, the researcher found that the students in the Experimental Groups attained significantly higher scores in chemistry than did the students in the Control Groups. It may be argued that students exposed to the SPSTA had the opportunity to observe, measure, record and interpret data as they were involved in the investigative activities. It can further be suggested that the science process skills emphasized in this study might have assisted the experimental groups to perform better in chemistry than the control groups. Studies carried out by Wambugu and Changeiywo (2008); Khan et al. (2011); Mao & Chang (1998); Alexander (2001); Ertepinar and Geban (1996) and Opara (2011) showed that inquiry-based teaching approaches enhanced students' achievement in science subjects, which are in agreement with the findings of this study. Mandor (2002) and Ibe (2004) research findings were also in agreement with the findings of this study by indicating that active participation of the students in science lessons contributed to effective learning. Aktamis and Ergin (2008) carried out a study to investigate the effect of science process skills with elementary school students in Buca District, Turkey, on scientific creativities, academic achievement and attitude towards science, the results were consistent with that of this study that science process skills teaching approach is most effective in enhancing learning of chemistry than regular teaching approach. Tobin (1986) studied the students' tasks involvement and achievement in process-oriented science activities in the elementary schools in Australia and the results indicated that students' engagement in planning and collecting tasks were positively related to achievement.

Feyzioglu (2009) carried out a study at the university level and the outcome indicated a positive relationship between science process skills and university students' achievement. Hykle (1994) studied the relationships among gender, science content achievement and science process skills and found that science process skills and the achievement in science were significantly related. A study carried out by Foley and McPhee (2008) in elementary science schools in America showed that students who used hands-on science curriculum had an advantage in achievement over those who followed the traditional textbook curriculum. Foley and McPhee (2008) reported the results of an investigation carried out by Stohr-Hunt (1996) on the effect of hands-on experience and science achievement that showed significant differences in science achievement between the students who engaged in hands-on activities everyday a week and those who never engaged in hands-on activities. Wachanga and Mwangi (2004) investigated the effect of cooperative class experiment (CCE) teaching method on secondary school students' achievement in chemistry and found that students who were taught through CCE achieved significantly higher scores in the CAT than those who were not taught through it. Class experiment method is an example of inquiry –based approach to teaching which emphasizes the use of science process skills. The positive results generated from Hykle, Wachanga and Mwangi, Foley and McPhee, and Stohr-Hunt investigations imply that an approach of teaching that lays more emphasis on science process skills is indeed effective in enhancing students' achievement than the regular teaching method. It may be further observed that chemistry teachers who use content approach to teaching in an expository manner tend to encourage memorization or rote learning as opposed to the teachers who embrace process instructional strategy tend to guide students through investigations and in problem solving activities. Therefore, process skills may be the desired instructional approach to teaching chemistry.

This study gives support to the fact that achievement of students in chemistry could be greatly improved if they are exposed to science process skills teaching approach. However, it is important to note that the success of the approach may depend on the competence, enthusiasm and confidence of the chemistry teacher and the ability of the students in making use of the opportunity provided.

4.4 Effect of Science Process Skills Teaching Approach on Boys and Girls Achievement in Chemistry.

Table 18 shows the t-test of the pre-test mean scores on CAT based on students' gender for Experimental Group 1.The purpose was to establish if the boys and girls in this group were of the same abilities in chemistry at the starting point.

Table 18:

Independent Samples t-test of the Pre-test Mean Scores on CAT based on Students Gender in Experimental Group 1

Expt 1	N	Mean	Std Deviation	t	df	Sig.(2-tailed)
Boys	39	.45	.16	1.47	48	.148
Girls	11	.37	.13			

The results showed that in the Experimental Group 1 the boys obtained higher mean score than the girls in the CAT pre test, but there was no statistically significant difference in the pre- test mean scores between the boys and girls in the Experimental Group 1; $t\ (48) = 1.47$, $p>0.05$. This means that the boys and girls were of equal abilities in chemistry at the starting point.

Table 19 shows the t-test of the post-test mean scores on CAT based on gender for Experimental Groups 1 and 2 combined. The two groups were exposed to SPSTA and an independent samples t-test was carried out to test Ho2, which stated that there is no statistically significant difference in achievement between secondary school boys and girls who are taught Chemistry through SPSTA.

Table 19:

Independent Samples t-test of the Post-test Mean Scores on CAT Based on Gender for Experimental 1 and 2 Groups Combined.

Gender	n	Mean	Std Deviation	t	df	Sig.(2-tailed
Boys	63	.55	.14	2.62	88	.010
Girls	27	.47	.12			

After the application of SPSTA, an instructional intervention, there was an improvement on the performance of boys and girls on CAT as compared to the performance on the pre test. But generally the boys performed slightly better than the girls. There was statistically significant difference in the mean scores between boys and girls in the experimental groups; $t(88) = 2.62$, $p<0.05$. From the results of the independent samples t-test there was significant difference between the achievement of boys and girls who were taught Chemistry through SPSTA, therefore Ho2 is rejected.

Since this study involved non-equivalent control group design, it was necessary to carry out analysis of covariance with KCPE score as covariate, to take into account any pre-existing differences that might have occurred due to other factors.

Table 20 shows the adjusted post-test mean scores of CAT based on gender for Experimental Groups 1 and 2 combined using KCPE as covariate.

Table 20:

Adjusted Post-test Mean Scores of CAT based on Gender for Experimental Groups 1 and 2 combined using KCPE as covariate.

Gender	N	Mean	Std. Error
Boys	62	.54[a]	.02
Girls	25	.50[a]	.03

a. Covariates appearing in the model are evaluated at the following values: covariate = 303.47.

The adjusted CAT post-test mean scores of boys and girls in the ANCOVA showed that boys performed better than the girls.

Table 21 shows the analysis of covariance of the Post-test mean scores of Boys and Girls in Experimental Groups 1 and 2 combined using KCPE as covariate.

Table 21:
Analysis of Covariance (ANCOVA) of the Post-test CAT Mean Scores of Boys and Girls for Experimental Groups 1 and 2 Combined.

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.45[a]	2	.22	15.07	.000
KCPE	.36	1	.36	24.18	.000
Gender	.02	1	.02	1.36	.248
Error	1.24	84	.02		
Total	26.02	87			
Corrected Total	1.69	86			

a. R Squared = .264 (Adjusted R Squared = .247)

The findings of ANCOVA test showed that there was statistically significant difference between the mean scores of boys and girls in experimental groups, $F (1, 84) = 1.36$, $p<0.05$ (Table 21). These results compare very well with the findings of the Independent Samples t-test of the Post-test Mean Scores on CAT Based on Gender for Experimental Groups 1 and 2 Combined (see Table 19); therefore (Ho2) is rejected.

4.4.1 Discussion

The t-test showed no significant difference between the pre-test mean scores of boys and girls in Experimental Group 1. However, the boys and girls' post-test mean scores on CAT in the experimental groups showed significant difference $t (1, 88) = 2.62$, $p<0.05$, when subjected to t-test. The results from ANCOVA showed the same trend. It should also be noted that KCPE contributed significantly in predicting achievement. Other research studies have reported findings, which agree with the results in this study. Studies carried out in Nigeria with secondary school students by Nwosu and Okeke (1995), Alexoponlou (1997), Okpala and Onocha (1998) and Adeoye (2000) found that there was gender difference in favour of boys in relation to practical skills in science. Shaibu and Marri (1997), Ahiakwo (1988) findings showed that girls performed better than boys in chemistry. Trigwell (1990) and Opara (2011) found that boys performed better than the girls in chemistry and biology respectively. However, these studies were done in different contexts. The former investigated the abilities of the students to solve quantitative problems in chemistry when exposed to an alternative science degree programme in Australia while the latter was carried out with secondary school students in River State in Nigeria. Studies carried out by International Evaluation of Educational Achievement (IEA) from a cross cultural survey revealed that sex differences have been found in every subject area in the written test, and that boys outperformed girls in Biology, Chemistry and Physics at all levels (Amunga et al., 2011). In Uganda the trend in academic excellence in the secondary schools final examination has shown that boys perform better than girls in Chemistry (Ssempala, 2005).

In Kenya similar results are evident as shown by a study carried out by the Institute of Policy Analysis and Research (IPAR) (2003) as reported in Amunga et al., (2011) that boys performed better than girls in Chemistry, Physics and Biology in KCSE. A study carried out by Amunga et al. in secondary schools in Western Province, Kenya, indicated that boys performed better than girls in Chemistry. The outcome of a study carried out by Nyakan (2008) in Kenya revealed that there was significant difference between the performance of boys and girls in physics. This finding was not surprising considering that physics is the least popular with secondary school girls.

However, studies carried out by Shaw and Doan (1990); Inyang and Jegede (1991); Balogun (994) showed no significant difference on the achievement of boys and girls in chemistry. The outcome of Wachanga's (2002) investigation on the effect of cooperative class experiment (CCE) on the achievement of boys and girls in chemistry disagree with the findings of this study. It showed that there was no significant difference between the achievement of boys and girls who were taught chemistry through CCE methods. Other studies carried out by Wambugu and Changeiywo (2008) in Kenya, Nwagbo and Uzoamaka (2011) in Nigeria with secondary school students showed similar results in Physics and Biology subjects respectively. Oludipe (2012) carried out a study to investigate the influence of gender on junior secondary school students' academic achievement in basic sciences using cooperative learning-teaching strategy. His findings revealed that there was no significant difference in academic achievement of male and female students. A study carried out by Olatoye, Aderogba and Aanu (2011) in Ogun State, Nigeria, on the effect of cooperative and individualized teaching methods on senior secondary school students' achievement in organic chemistry showed no significant difference between the achievement of boys and girls.

Nonetheless the findings of this study have indicated that boys and girls exposed to science process skills teaching approach show significant difference in chemistry achievement. This is supported by a research study carried out by Iroegbu (1998) in Nigeria with secondary school students, which reported gender differences among students that were exposed to practical oriented activities in the classroom. Therefore, science process skills teaching approach does enhance the achievement in chemistry by both boys and girls but at different levels. Most of the studies reported in this study indicate that there are disparities in boys and girls achievement in chemistry in secondary schools. The information obtained from this study reinforces the notion of male dominance in science learning and the view that science careers being predominantly male preserve.

4.5 Effect of Science Process Skills Teaching Approach on the Achievement of Girls in Girls' only Groups and Mixed sex Groups.

The experimental groups were organized in away that some girls were given treatment in girl's only groups while others received treatment in mixed sex groups during chemistry practical lessons. Hypothesis Ho3 sought to establish whether there is statistically significant difference in the achievement in chemistry between girls who were exposed to SPSTA in mixed groups and girls in girls' only groups. The CAT post-test mean scores obtained by the girls were analyzed and the results of the independent samples t-test of the mean scores are shown in Table 22.

Table 22 shows the t-test of the post-test mean scores of girls on CAT based on girls' only and girls in mixed group composition. The experimental groups were organized into working groups that consisted of girls only and girls mixed with boys.

Table 22:

Independent Samples t-test of the Post-test Scores on CAT for Experimental Groups 1 and 2 Combined, Based on Group Composition

Group Composition	N	Mean	Std.Deviation	t	df	Sig.(2-tailed)
Girls in girls only group	12	.45	.13	-.73	25	.47
Girls in mixed group	15	.48	.11			

The mean score of girls in mixed groups in chemistry was slightly better than that of girls in girls' only groups. The dispersion range was slightly smaller in girls in mixed groups compared to those of girls in girls' only groups. The findings showed no significant difference in achievement in chemistry between girls in mixed groups and girls in girls' only groups, $t(25) = -0.73$, $p>0.05$. In other words, SPSTA does not make significant difference in the performance of girls when they do chemistry experiments in girls' only groups or in mixed groups. The outcome confirms Ho3, that there is no significant difference in chemistry achievement between girls exposed to SPSTA in girls' only groups and girls in mixed groups, therefore Ho3 is retained.

4.5.1 Discussion

Studies reported in the literature on girls' classroom set up have shown varied information regarding the girls' achievement in science in single sex and mixed schools (Gillibrand et al., 1999; Kessels & Hannover, 2008; Shapka & Keating, 2003). Some research findings indicated that girls tended to have higher academic achievement levels in single sex classes than in mixed classes (Deem, 1984; Riordan, 1985; Malacova, 2007; Sullivan et al., 2010). Spielhofer et al. (2002) analyzed the effects of single sex and co-educational schooling in private Roman Catholic Secondary Schools in the USA and found that girls benefited from single sex schooling particularly in science, and that mixed schools had a negative impact on girls' achievement. Studies carried out in the USA, England and Australia showed that girls achieved higher in single sex schooling compared to mixed sex schools (Lee & Lockheed, 1989; Frazer &Young, 1990; Stables, 1996; Streitmatter, 1999; Dartnow and Hubband, 2002). Carter (2005) carried out an investigation to find whether girls attained better results in Physical Science in single sex environments or in co-educational classes. The tests were administered in 2000, 2001 and 2002; the outcome indicated that girls' achievement in single sex schools was significantly better in Physical Science than girls in mixed schools. However, the same tests carried out in 1999 and 2003 showed no significant difference in the results. But when the study was repeated in 2004, girls were found to perform significantly better in single sex schools. Similarly, she reported the findings of another study carried out by Nuttal et al. in 1992 on the patterns of examination performance of 15 and 16 year olds students, which showed no significant difference between the achievement of girls in single sex schools and mixed schools. Spielhofer et al. (2002) reported that other factors such as students' prior achievement, socio-economic and parental support, which might have contributed to higher achievement in science in single-sex schools, were not controlled.

Other studies have also found no significant difference in the achievement of girls in science between single sex and mixed groupings (Marsh, 1989; Goldstein et al., 1993; Thomas et al., 1994 ;). Elwood and Gipps (1999) and Carpenter and Hayden (1987) reported that much of research studies indicated that single sex schooling had very small impact or none at all on girls' achievement in science. Some other studies have also shown that students attending single sex schools tend to achieve better results, although the results do not differ significantly from those in mixed schools (Carter, 2005). Wachanga (2002) compared the effect of single sex and mixed sex schools on the achievement of girls in chemistry. The outcome showed that having girls in their own groups during practical based instruction did not enhance their achievement in chemistry as compared to when they were mixed with boys.

Most of the studies reported here support the findings of this study that no significant difference was found between the achievements of girls in girls' only and girls' in mixed groups. The results obtained in this study may have strong credibility because the other factors which may have had an effect on students' achievement were controlled. For example, students who get admitted to district secondary schools in Kenya obtain average marks at KCPE level and that most of them come from the same locality where the inhabitants belong to the same socio-economic class. Furthermore, the findings of this study demystify the perception held among some educators that girls operating in mixed groups during science lessons are likely to be sexually intimidated, dominated or serve as boys' helpers in practical activities and these contribute to their underachievement. Similarly the teachers belief that girls do better academically when they work in their own groups (Streitmatter, 1999), simply because they experience few distractions from the boys, have all the teachers attention, are more focused and are more empowered to ask and answer questions without the risk of being ridiculed is questionable. If anything the girls tend to be encouraged to do well in chemistry when they work together with boys as exemplified by the small difference in the mean scores observed in Table 22.

4.6 Effect of Science Process Skills Teaching Approach on Boys' Achievement in Chemistry in Boys 'only Groups and Boys in Mixed Sex Groups.

An intervention was carried out during the study to find out the achievement of boys in Chemistry when they were taught using SPSTA in boys' only and in mixed sex groups. Hypothesis Ho4 sought to establish whether there is statistically significant difference in the achievement in chemistry between boys in boys' only groups and boys in mixed sex groups.

Table 23 shows the t-test of the post-test mean scores on CAT based on group composition.

Table 23:

Independent Samples t-test of the Post-test Scores on CAT for Experimental Groups 1 and 2 Combined, Based on Group Composition

Group Composition	N	Mean	Std. Deviation	t	df	Sig.(2-tailed)
Boys only	33	.58	.14	1.68	61	.09
Boys in mixed group	30	.52	.15			

The mean score of boys in boys' only group was higher than the mean score of boys in mixed groups, however, the difference between the mean scores was not statistically significant, t (61) = 1.68, p>0.05, therefore Ho4 was accepted. This was an indication that science process skills teaching approach did not make a difference in the boys' achievement in chemistry in single sex or mixed sex groupings during chemistry practical lessons.

4.6.1 Discussion

The findings of this study indicated that there was no significant difference in achievement in chemistry between the boys in boys' only groups and the boys in mixed groups when taught using science process skills teaching approach. Spielhofer et al. (2004) in a study carried out in England agreed with the findings of this study, that average academic achievement levels for boys do not differ significantly between single-sex and mixed groups' settings. Similarly Riordan (1985) found no significant difference in the achievement of boys in single sex education set up as compared to mixed groups. However, some studies reported that while single-sex groups have the potential to raise the achievement levels of boys and girls (Hamilton, 1985; Arnot et al., 1998; Rowe & Rowe, 2002; Spielhofer et al., 2002; Younger & Warrington, 2006; Malacova, 2007), other findings have shown that mixed grouping is more effective in improving the achievement of boys only (Jimenez & Lockheed, 1989). Research studies carried out by Askew and Ross (1988); Howe (1997); Francis (2004) showed that boys in mixed groups contributed more to classroom interactions and dominated in hands-on activities in the laboratory. This is supported by the higher mean score obtained by boys in boys' only group (see Table 23). In this study science process skills teaching approach did not make a difference in the achievement of boys in chemistry whether they did chemistry experiments in the groups composed of boys' only or when they were mixed with girls. This suggests that in a chemistry practical situation students can be organized into their experimental groups without due reference to gender.

4.7 Students' Achievement on the selected Science Process Skills in Chemistry

This study also intended to find the level of students' achievement in each of the selected science process skills in chemistry when taught using SPSTA. The purpose of this objective was to establish the relationships between the selected science process skills and the contributions they make and in what order to the students' achievement in chemistry. Pearson's moment- product (r) was used to test Ho5, which stated that there is no relationship between the selected science process skills and students' achievement in chemistry when taught through SPSTA. The mean scores attained by the students in the experimental groups are shown in Table 24.

Table 24 shows the students' mean scores on the selected science process skills on CAT at the post-test level for Experimental Groups 1 and 2 Combined.

Table 24:

Post test Mean Scores of Students on Science Process Skills, based on CAT for Experimental Groups 1 and 2 Combined.

Science process skills	N	Mean	Std. Deviation
Interpreting	90	.51	.21
Observing	90	.55	.21
Measuring	90	.59	.15
Recording	90	.52	.21

The results showed that the students mean score was better in the measuring skill, followed by observing skill, recording skill, interpreting skill in that order. The mean score for the selected science process skills were above the 50% mark, which suggested that students recalled a lot on what they had seen, measured and recorded. They were also able to interpret the data collected through observation and measurement correctly. However, the students experienced challenges on activities relating to recording skill particularly when presenting the titration table and the writing of the chemical and ionic equations. The challenge in writing and balancing the chemical equations contributed to the low achievement attained on the items related to the recording skill. The students mean score in the selected science process skills is presented in a bar graph, (see Figure 3).

Figure 3 shows a bar graph for the post-test mean scores of students in Experimental Groups 1 and 2 combined on individual science process skills based on CAT. The labels on x-axis represent the individual science process skills.

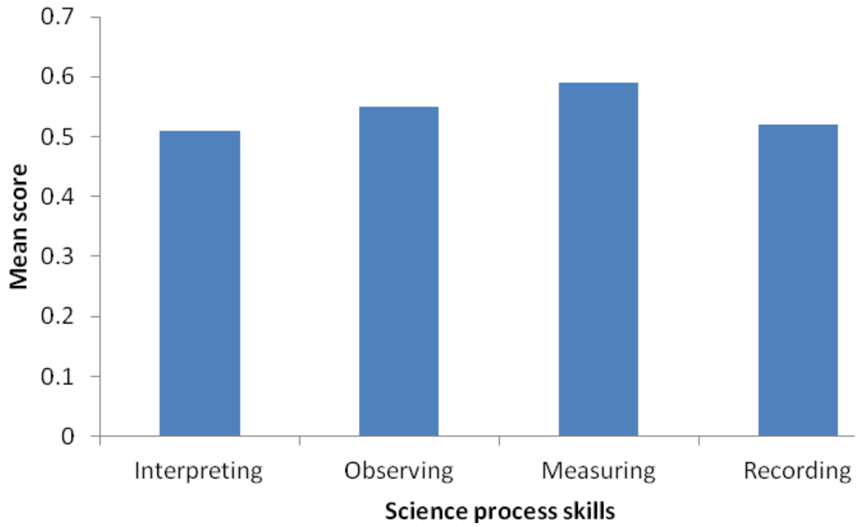

Figure 3: Ranking of students' achievement on CAT in Experimental Groups 1 and 2 combined on Science Process Skills

Table 25 shows Pearson correlation (r) between interpreting, observing, measuring, recording science process skills and overall chemistry achievement mean score on CAT for Experimental Groups 1 and 2 Combined . The matrix gave a correlation coefficient r, which represents the degree of association of two variables and chemistry academic achievement at a time.

Table 25:

Pearson Correlation (r) of Students' Mean Scores on the selected Science Process Skills and Academic Chemistry Achievement on CAT for Experimental Groups 1 and 2 Combined (N = 90)

Control Variables		Interpreting	Observing	Measuring	recording	Chemistry Achievement
Interpreting	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	90				
Observing	Pearson Correlation	.47**	1			
	Sig. (2-tailed)	.000				
	N	90	90			
Measuring	Pearson Correlation	.29**	.32**	1		
	Sig. (2-tailed)	.008	.002			
	N	90	90	90		
Recording	Pearson Correlation	.69**	.41**	.32**	1	
	Sig. (2-tailed)	.000	.000	.002		
	N	90	90	90	90	
Chemistry Achievement	Pearson Correlation	.56**	.46**	.23*	.48**	1
	Sig. (2-tailed)	.000	.000	.030	.000	
	N	90	90	90	90	90

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The results in Table 25 indicate strong, positive correlation between the four selected science process skills and the overall chemistry achievement. In addition, the specific abilities of students on the four science process skills were significantly correlated with each other. The correlation between the individual science process skills and overall chemistry achievement was strong, positive and significant at $p < 0.01$ level (see Table 25). The relationship indicated that if the students' score on each particular science process skill is high then the score on chemistry achievement was also high. In an attempt to establish the extent to which the selected science process skills contributed to the students' achievement in chemistry, multiple regression analysis was carried out on the experimental groups mean score as the dependent variable against the mean scores of each of the four science process skills as the independent variables. The results are summarized in Tables 26, 27 and 28 of the multiple regression analysis for Experimental Groups 1 and 2 combined.

Table 26 shows the R and R- Square values in multiple regression analysis on science process skills and students' achievement in chemistry for the experimental group.

Table 26:

R-Square values in Multiple Regression Analysis on Selected Science Process Skills and Academic Achievement in Chemistry on CAT for Experimental Groups 1 and 2 Combined

Model	R	R- Square	Adjusted R- Square	Std. Error of the Estimate
1	.61[a]	.38	.35	.11

a. Predictors: (Constant), recording, measuring, observation, interpretation

The combined effect of all the four variables resulted in R- Square value of .38, which implied that the science process skills accounted for 38% of the total variation in achievement in chemistry. This leaves 62% unexplained.

Table 27 shows the analysis of variance (ANOVA) of the mean scores on CAT of the four science process skills for Experimental Groups 1 and 2 combined.

Table 27:

Analysis of Variance (ANOVA[b]) of the mean scores of the four selected science process skills for Experimental Groups 1 and 2 Combined

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.67	4	.17	12.74	.000[a]
	Residual	1.11	85	.01		
	Total	1.78	89			

a. Predictors: (Constant), recording, measuring, observation, interpretation

b. Dependent Variable: Achievement in Chemistry

The F-test result showed statistically significant value, F (4, 85) = 12.74 , p<0.05, which means that the b coefficients of all the independent variables (selected four science process skills) were not at zero or rather they were significantly different from zero. This therefore means that there was sufficient evidence to conclude that the selected science process skills were predictive of the academic achievement in chemistry.

Table 28 shows the multiple regression coefficient (beta) values of the individual science process skills and academic achievement in chemistry for Experimental Groups 1 and 2 Combined.

Table 28:
Multiple Regression Coefficients[a]

Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	.28	.06		4.95	.000
	Interpreting	.24	.08	.36	2.88	.005
	Observing	.17	.07	.24	2.41	.018
	Measuring	.01	.09	.01	.11	.914
	Recording	.08	.08	.13	1.06	.294

a. Dependent Variable: Academic Achievement in Chemistry

The t-test showed that the b coefficients of the selected science process skills (interpretation and observation) were significantly different from zero at p<0.05, while recording and measuring skills were not significant, p>0.05. This means that interpreting and observing variables uniquely contribute to the regression equation, thereby making a significant contribution to the prediction, but measuring and recording do not. This can be interpreted to mean that the B's indicate that for every one unit increase in independent variable, the dependent variable will increase by that amount.

In terms of the relative contribution of the individual variables to the students' achievement in chemistry, Table 28 shows that interpreting skill had the highest (beta) contribution or effect (.36), followed closely by observing skill (.24) while the other two skills registered low values, with recording and measuring skills registering beta values of .13, and .01 values respectively. The individual variables made the following contributions and can be used as predictors of academic achievement in chemistry, interpreting, t (90) = 2.88, p <0.05, observing, t (90) = 2.41, p <0.05, recording, t (90) = 1.06, p >0.05 and measuring, t (90) = .11, p >0.05. Therefore the order of contribution was interpreting > observing > recording > measuring. It is important to note that the interpreting skill made the most significant contribution and measuring skill was the least contributor to academic chemistry achievement.

4.7.1 Discussion

The findings of this study revealed two things, the correlation and contribution of the selected science process skills to the overall chemistry achievement. The selected science process skills showed a strong and positive correlation amongst themselves and also with overall chemistry achievement. The contribution of science process skills to the chemistry achievement is shown by the following regression equation, which was used to predict the students' achievement in chemistry.

$Y = a + b1X1 + b2X2 + b3X3 + b4X4$

Where Y = chemistry achievement,

X1 = mean of interpreting process skill

X2 = mean of observing process skill

X3 = mean of measuring process skill

X4 = mean of recording process skill

Achievement (Y) = 0.28 + 0.24X1 +0.17X2 +0.01X3 +0.08X4

The coefficients (b1, b2, b3, b4) of the means of the selected science process skills shown in the mathematical equation above can be used to predict the contribution of each science process skill to the students' achievement in chemistry. However, if the beta (standardized) values are used then the multiple regression equation would read as follows:

Achievement (Y) = 0.28 + 0.36X1 + 0.24X2 + 0.01X3 + 0.13X4

The value of R- square obtained indicated that the four skills had an accurate prediction of the students' achievement in Chemistry. This means that the four science skills (interpreting, recording, observing, and measuring) were able to explain 38% of the total achievement in chemistry while the remaining 62% could be explained by other variables which were not investigated. It is important to note that the 38% of achievement in chemistry explained by the four selected science process skills represents the sample while the adjusted R-square value explains 35% of achievement of the population of the study. The four science process skills investigated in this study contributed majorly to the students' achievement in chemistry and this is a reflection of a strong positive relationship between the four selected science process skills and students' academic chemistry achievement. The information on the relative contribution of the predictor variables indicated that interpreting skill contributed most to the achievement in chemistry followed by observing skill, recording skill and least by measuring skill. The order of contribution to achievement in chemistry as estimated by the proportion of each science process skill was as follows: interpreting skill > observing > recording > measuring. It is interesting to note that interpreting skill contributed majorly in the prediction of the students' achievement in chemistry yet it is an integrated and cognitive skill as compared to the other science process skills, which are mainly basic and manipulative skills in chemistry. However, the major challenge experienced by the students during the exercise was in regard to recording skill where students had difficulty in presenting experimental tables and also in the writing and balancing of chemical equations, which to some extent is cognitive in nature. The data presented in Table 28 show that for every unit increase in X1, Y increases 0.24 unit, for every unit increase in X2, Y increases 0.17 unit, for every increase of X3, Y increases 0.01 unit and for every unit increase of X4, Y increases 0.08 unit. In addition, since the t-values of interpreting and observing science process skills were significant at $p<0.05$, it is an indication that they were predictive of achievement in chemistry.

4.8 Effect of Science Process Skills Teaching Approach on Secondary School Students' Self-Concept in Chemistry.

The SSCS mean scores were analyzed using t-test, ANOVA and ANCOVA to determine the effect of SPSTA on students' self-concept in chemistry. This was to test Ho6, which stated that there is no statistically significant difference in self-concept of students who are taught Chemistry through SPSTA and that of those who are not exposed to it.

Table 29 shows the t-test of the pre-test mean scores on students' self-concept scale (SSCS). The mean scores were used as measures of chemistry self-concept.

Table 29:
Independent Samples t-test of the Pre-test Scores on SSCS

Variable	Groups	N	Mean	Std. Deviation	t	df	Sig. (2-tailed)
SSCS	Experimental Group 1	50	3.74	.53	4.19	75	.000
	Control Group 1	27	3.19	.60			

tcal = 4.19; tcrit = 2.000; df =75; $p<0.05$

It should be noted that the cause of the variation in terms of the number of respondents in Control Group 1 (Tables 8 & 29) was as a result of some students not filling their registration numbers on the SSCS test papers and therefore their marks were not included in the analysis. The mean score for students' self-concept on each group was calculated out of a possible 5 points based on likert scale. The pre-test mean score of the Experimental Group 1 was higher than that of the Control Group 1. There is statistically significant difference in students' chemistry self-concept between Experimental Group 1 and Control Group 1 at the pre-test stage, t (75) = 4.19, p<0.05; thus suggesting that the students in Experimental Group 1 had better self-concept in chemistry than students in Control Group 1.The results showed that the two groups were non-equivalent at the starting point hence; justifying the use of the Solomon Four Control Group Design and ANCOVA in this study.

Table 30 shows (SSCS) post-test mean scores of the students in the four groups. This was to determine the effect of treatment on both the experimental and control groups.

Table 30:
SSCS Post-test Mean Scores Obtained by the Students in the Four Groups

	N	Mean	Std. Deviation	Std. Error
Experimental Group 1	50	3.76	.75	.11
Experimental Group 2	40	3.62	.81	.13
Control Group 1	30	2.96	.73	.14
Control Group 2	33	3.19	.59	.09
Total	153	3.45	.79	.06

The mean scores for Experimental Groups 1 and 2, which received treatment, were higher than the mean scores of the control groups, suggesting that SPSTA had a positive effect on students' chemistry self-concept. Though Experimental Group 2 was not pre-tested, the students in this group obtained more or less the same mean score as compared to the students in Experimental Group 1. This would suggest that the pre-test exercise did not have any effect on the students' chemistry self-concept thereby reinforcing the point that SPSTA contributed to the enhanced chemistry self-concept evident in the students in the experimental groups.

Table 31 shows Analysis of Variance (ANOVA) of the post-test mean scores on the students' self-concept scale.

Table 31:
Analysis of Variance (ANOVA) of the Post-test Scores on the SSCS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	14.79	3	4.93	9.25	.000
Within Groups	79.38	149	.53		
Total	94.17	152			

Fcal = 9.25; Fcrit = 2.67; $F(3,149) = 9.25$; $p<0.05$

Table 31 shows that the difference between and within groups is statistically significant, $F(3,149) = 9.25$, $p<0.05$. In order to establish the groups that showed significant difference between the means, post-hoc comparisons test was carried out.

Table 32 shows post-hoc comparisons of the post-test of SSCS mean scores for the four groups.
Table 32: Post Hoc Comparisons of the Post-test of SSCS Mean Scores for the Four Groups.
Scheffe

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.
Experimental Group 1	Experimental Group 2	.13	.15	.860
	Control Group 1	.80*	.17	.000
	Control Group 2	.56*	.16	.008
Experimental Group 2	Experimental Group 1	-.13	.15	.860
	Control Group 1	.67*	.18	.005
	Control Group 2	.43	.17	.051
Control Group 1	Experimental Group 1	-.80*	.17	.000
	Experimental Group 2	-.67*	.18	.005
	Control Group 2	-.24	.18	.644
Control Group 2	Experimental Group 1	-.56*	.16	.008
	Experimental Group 2	-.43	.17	.051
	Control Group 1	.24	.18	.644

*, The mean difference is significant at the 0.05 level

There is statistically significant difference in the students' chemistry self-concept between Experimental Group 1 and Control Groups 1 and 2, and between Experimental Group 2 and Control Group 1. There is no statistically significant difference between Experimental Group 1 and Experimental Group 2; and between Control Group 1 and Control Group 2. The students in both experimental groups did not display any significant difference in chemistry self-concept probably because they were exposed to SPSTA. There appears to be no significant difference between Experimental Group 2 and Control Group 2, though this was at the borderline ($p = 0.05$). Therefore, the result may not be conclusive in regard to the difference observed be the two groups. However, from the other differences observed between Experimental Group 1 and Control Groups 1 and 2 and Experimental Group 2 and Control Group 1, it may be reasonable to suggest that exposure of students to SPSTA enhanced the chemistry self-concept of students in the experimental groups as compared to those in the control groups.

Table 33 shows the adjusted SSCS post-test mean scores (ANCOVA).

Table 33: Adjusted SSCS Post-test Mean Scores in the ANCOVA

Groups	Mean	Std. Error
Experimental Group 1	3.59[a]	.11
Experimental group 2	3.75[a]	.11
Control group 1	3.21[a]	.16
Control group 2	3.32[a]	.13

a. Covariates appearing in the model are evaluated at the following values: KCPE covariate = 294.91.

The findings showed that the students' exhibited a positive self-concept in chemistry within a range of 3.21 – 3.75 out of the possible mean score of 5.000.

The adjusted mean scores (ANCOVA) for students in the experimental groups were higher than those of the control groups. This may be construed to mean that the experimental groups that were exposed to SPSTA had better chemistry self-concept than the control groups, which were not treated. Since Experimental Group 2 and Control Group 2 were not pre-tested, the possible explanation for greater chemistry self-concept exhibited by the students in Experimental Group 2 was due to exposure to SPSTA.

Table 34 shows the analysis of covariance of the post-test mean scores using KCPE as covariate.
Table 34:
Analysis of Covariance (ANCOVA) of the Post-test Scores on the SSCS

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	17.70[a]	4	4.43	9.41	.000
KCPE	7.11	1	7.11	15.12	.000
Groups	5.18	3	1.73	3.67	.014
Error	62.57	133	.47		
Total	1789.35	138			
Corrected Total	80.27	137			

a. R Squared = .221 (Adjusted R Squared = .197)

Fcal = 3.67; F (3,133) =3.67; $p<0.05$

The findings of ANCOVA test showed significant difference between the groups, F (3, 133) = 3.67, $p<0.05$. The pairwise comparison was carried out to determine the groups that showed significant difference (see Table 35).

Table 35 shows the adjusted post-test mean scores pairwise comparisons.

Table 35: Adjusted SSCS Post-test Mean Scores in the ANCOVA—Pairwise Comparisons

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.[a]
Experimental Group 1	Experimental Group 2	-.15	.16	.338
	Control Group 1	.38	.19	.051
	Control Group 2	.27	.17	.109
Experimental Group 2	Experimental Group 1	.15	.16	.338
	Control Group 1	.54*	.19	.005
	Control Group 2	.43*	.17	.013
Control Group 1	Experimental Group 1	-.38	.19	.051
	Experimental Group 2	-.54*	.19	.005
	Control Group 2	-.11	.19	.562
Control Group 2	Experimental Group 1	-.27	.17	.109
	Experimental Group 2	-.43*	.17	.013
	Control Group 1	.11	.19	.562

*, The mean difference is significant at the 0.05 level

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustment).

There is statistically significant difference between the experimental groups and the control groups except for the Experimental Group 1 and Control Group 2 where no significant difference was observed at p<0-05 level. The experimental groups showed no significant difference between them. The same trend was observed with the control groups. Since the adjusted mean scores of students in the experimental groups were much higher than the mean scores of students in the control groups, the chemistry self-concept of students in the experimental groups was much higher than those in the control groups. From the results it may be interpreted that the students in experimental groups were more motivated and got interested in chemistry after the treatment than students in the control groups. This is an indication that science process skills teaching approach enhanced students chemistry self- concept. Therefore Ho6 is rejected.

4.8.1 Discussion

At the pre-test level, the t-test showed statistically significant difference at $p < 0.05$ between the Experimental Group 1 and Control Group 1. The analysis of variance (ANOVA) indicated statistically significant difference at $p<0.05$ between the groups. Thus, suggesting the SPSTA enhanced students' chemistry self-concept. The post-hoc results showed significant difference between the experimental groups and the control groups at $p< 05$, except between Experimental Group 2 and Control Group 2, where $p=0.05$. It would be argued that the post-hoc results showed statistically significant difference between the experimental and the control groups, thus reinforcing the point that SPSTA improved students' chemistry self-concept. The analysis of covariance (ANCOVA) which was intended to adjust the post-test mean scores of the groups due to lack of similarity of the mean scores evident at the pre-test, generated similar mean scores for the experimental groups as shown in Table 33, except for control groups that showed marginal increase. In fact when KCPE was used as covariate, the ANCOVA results indicated statistically significant difference between the experimental and control groups at $p<0.05$ except for Experimental Group 1 and Control Group 2, which showed no significant difference between them. This may have occurred due to sampling error.

The results from this study showed that the science process skills teaching approach enhanced students' chemistry self-concept. However, very little information is available in the literature showing the effect of science process skills teaching approach on the students' chemistry self-concept. The results of a study carried out by WeBnigk and Euler (2011) to determine the effects of hands-on, practical, and cooperative laboratory-based inquiry activities on students' self-concept in physics and chemistry showed that the laboratory-based activities improved the students' self-concept as well as their image in science especially in physics. Barron and Linda (2008) and Johnson and Johnson (1989) reported that cooperative group work benefits students in improving their self-concept. Since science process skills teaching approach utilizes group work as an organization strategy, it would be reasonable to state that the group activities in chemistry, which involve the sharing of apparatus, equipment and ideas, would contribute towards the improvement of students' self-concept.

The research carried out by Caplin (1969), Ginnsburg-Block et al. (2006) with peer-assisted learning in American elementary schools and Aasma-tuz (2010) with female undergraduates in Pakistan on the relationship between academic and nonacademic measures on students' self-concept revealed that self-concept measures were positively correlated to academic outcomes. The proceeding information supports the findings of this study which showed that science process skills teaching approach enhanced students' achievement in chemistry (Ho1) and by extension, the improved academic achievement has direct relationship to the students' self-concept. Oloyede (2010) carried out an investigation on the correlation between mastery learning strategy and self-concept in chemistry and found that the mastery teaching strategy enhanced students' chemistry self-concept than regular teaching methods.

From the on-going discussion, it is apparent that the major characteristics of science process skills teaching approach such as laboratory investigations, cooperative learning are all designed to engage students in hands-on activities. The approach encourages students to become more skilful in using science process skills and thereby creating better understanding of chemistry concepts, which in turn may improve their chemistry self-concept. Furthermore, the results obtained established the role played by science process skills in the students' perceptions on the image of chemistry in the secondary schools. In addition to achievement in chemistry, the success in an experimental activity is an important determinant of one's self-concept in chemistry. It provides students with achievement experiences in chemistry, which may influence students' self-concept. The findings of a study carried out by Awan et al. (2011) justified the importance of this relationship by concluding that a positive self-concept in a subject is an important factor that is likely to determine success. Therefore, the findings of this study suggest that interventions designed to engage students in science process skills teaching approach can influence the development of self-concept in chemistry.

However, many studies have reported the effect of pedagogic strategies on students' self efficacy. Kirk (2011) reported that inquiry-based laboratory activities and collaborating learning methods showed a positive correlation with increased self efficacy. Bandura (2008) findings revealed that cooperative learning strategies, in which students work together and help one another tend to promote more positive self-evaluations of capability and higher academic attainments than do individualistic or competitive ones.

4.9 Effect of Science Process Skills Teaching Approach on Chemistry Self-Concept of Secondary School Boys and Girls.

Table 36 shows the t-test of the pre-test mean scores, standard deviations on SSCS with regard to gender.

Table 36:

Independent Samples t- test of the Pre-test Scores on SSCS Based on Students' Gender in Experimental Group 1

Expt 1	N	Mean	Std Dev	t	df	Sig (2-tailed)
Boys	39	3.80	.54	1.53	48	.132
Girls	11	3.53	.44			

The mean scores of the boys and the girls were comparable at the pre-test stage. In both cases the standard deviations were quite small relative to the mean scores. This was an indication that the means adequately represented the samples' scores. There is no statistically significant difference between the self-concept of boys in chemistry compared to that of girls at the pre-test level, t (48) = 1.53, p>0.05.

Table 37 shows the t-test of the post-test mean scores on SSCS for Experiment Groups 1 and 2 with regard to gender. The two groups were exposed to SPSTA (treatment). It sought to test Ho7, which stated that there is no statistically significant difference in self-concept between secondary school boys and girls who are taught Chemistry through SPSTA.

Table 37:

Independent Samples t-test of the Post-test Scores on SSCS for the Experimental Groups 1 and 2 Combined, based on Gender

Gender	N	Mean	Std. Deviation	t	df	Sig.(2-tailed)
Boys	63	3.76	.76	1.24	88	.218
Girls	27	3.54	.79			

The mean score for the boys was higher than the mean score for the girls in the experimental groups. There is no statistically significant difference between the mean score of boys and girls in chemistry in the experimental groups, t (88) = 1.24, p>0.05. Therefore Ho7 is accepted.

Table 38:

Adjusted Post-test Mean Scores of SSCS based on Gender for Experimental Groups 1 and 2 Combined, using KCPE as covariate

Gender	N	Mean	Std Error
Boys	62	3.75[a]	.097
Girls	25	3.68[a]	.155

a. Covariates appearing in the model are evaluated at the following values: covariate = 303.47.

In the experimental groups, the adjusted post-test mean score for the boys on SSCS is slightly greater than that of the girls.

Table 39 shows the analysis of covariance of the post-test mean scores of boys and girls in Experimental Groups 1 and 2 Combined.

Table 39:

Analysis of Covariance (ANCOVA) of the Post-test SSCS Mean Scores of Boys and Girls in Experimental Groups 1 and 2 Combined.

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.14[a]	2	1.07	1.86	.162
KCPE	1.74	1	1.74	3.03	.086
Gender	.08	1	.08	.14	.705
Error	48.29	84	.58		
Total	1257.56	87			
Corrected Total	50.43	86			

a. R Squared = .042 (Adjusted R Squared = .020)

The findings of ANCOVA showed that there is no statistically significant difference between the mean scores of the boys and that of the girls who were exposed to SPSTA, F (1, 84) = 0.14, p>0.05. This led to the retention of Ho7.

4.9.1 Discussion

The results in Table 37 indicated that there was no significant difference in chemistry self-concept between the boys and girls in the experimental groups. This was confirmed by the results of ANCOVA (see Table 39), which was applied to eliminate pre-existing differences in the groups at the initial stages. From the findings, it is possible to suggest that the treatment package (SPSTA) did not make a difference between the boys and girls self-concept in chemistry. However, research studies on sex differences in academic self-concept show conflicting patterns of findings, with some studies showing that boys have higher self-concepts in mathematics and science than the girls (Seigle & Reis, 1998; Marsh, 1989; Olowu, 1985; Ackerman et al., 2001; Watt, 2006; Sullivan, 2009). Some studies show that girls have greater self-concepts than boys (Schroeder, 1973), while other studies show that there is no significant difference between boys and girls on chemistry self-concept (Aal-Hussain, 1991; Yusuf, 2005; Shaw et al., 2010). Though it has been observed in this study that science process skills teaching approach has significant effect on the students' self-concept in chemistry (see Ho6), but in line with the findings of this study, it can be argued that science process skills teaching approach (SPSTA) has no significant effect on students' chemistry self-concepts in regard to gender.

4.10 Effect of Science Process Skills Teaching Approach on the Chemistry Self-Concept of Girls in Girls' only Groups and Mixed sex Groups.

The SSCS post-test mean scores obtained by the girls were analyzed with a view to test hypothesis Ho8, which stated that there is no statistically significant difference in chemistry self-concept between the girls who were taught chemistry through SPSTA in girls' only groups and those in mixed groups.

Table 40 shows the t-test of the post-test mean scores on SSCS based on group composition. The students in the experimental groups were organized into girls only and mixed sex groups. Both groups were subjected to treatment.

Table 40:

Independent Samples t-test of the Post-test Mean Scores on SSCS for Experimental Groups 1 and 2 Combined, Based on Group Composition

Group Composition	N	Mean	Std. Deviation	t	df	Sig.(2-tailed)
Girls only group	12	3.49	.95	-.29	25	.777
Girls in mixed group	15	3.58	.69			

The mean score of girls in mixed sex group was slightly higher than the mean score of girls in girls' only group. However, the difference was not statistically significant, t (25) = -.29, p>0,05, suggesting that the science process skills teaching approach did not affect the girls' self-concept in chemistry whether they did chemistry experiments in girls' only groups or in mixed sex groups, therefore Ho8 is accepted. Though the groups were rather small, they were indicative of what could be expected with large samples.

4.10.1 Discussion

The findings of this study is supported by a research study carried out with A-level students in chemistry in the UK, which found no significant difference in chemistry self-concept between boys and girls (Shaw et al., 2010). However, Leonard (2007) in a study carried out in the UK reported that girls in girls' only schools and boys in boys' only schools were more confident in their abilities in science and were more likely to pass in the subject than girls and boys in mixed schools. But the outcome of another research study carried out by Sullivan (2009) on the impact of gender on academic self-concept for a cohort of 16 year olds born in 1958 in the UK showed that academic self-concept was highly gendered, that is, boys had higher self-concept than girls in science, though single sex schooling reduced the gender gap in self-concept in science. This study showed no significant difference in chemistry self-concept between the girls in girls' only groups and girls in mixed sex groups, therefore, it can be suggested that the presence of boys in the groups did not affect the girls' chemistry self-concept. In other words the chemistry self-concept of girls is not dependent on gender composition of the groups when they are exposed to science process skills instructional strategy.

4.11 Effect of Science Process Skills Teaching Approach on Boys' Chemistry Self-Concept in Boys' only Groups and Mixed Sex Groups.

This study was set to examine the effect of SPSTA on chemistry self-concept of the boys in boys 'only groups and the boys in mixed groups during chemistry practical lessons. The students were organized into boys' only groups and boys mixed with girls' groups and taken through science process skills teaching approach. The purpose was to establish whether there is statistically significant difference in chemistry self-concept between the boys when they work in boys' only groups or in mixed sex groups during chemistry experiments (Ho9).

Table 41 shows the t- test of the post-test mean scores on SSCS based on group composition. The groups consisted of boys only and boys mixed with girls.

Table 41:

Independent Samples t-test of the Post-test Mean Scores on SSCS Based on Group Composition for Experimental 1 and 2 Groups Combined.

Group Composition	N	Mean	Std Deviation	t	df	Sig.(2-tailed
Boys only	33	3.99	.65	2.60	61	.012
Boys in mixed groups	30	3.51	.81			

The general observation of the results obtained showed that the mean score for boys from boys' only groups was higher than those for boys from mixed groups. The dispersion of the scores from the mean in the boys' only group was smaller compared to those of the boys in mixed sex groups. There is statistically significant difference in the mean scores between the boys in boys' only groups and the boys in mixed groups, $t(61) = 2.60$, $p<0.05$; thus suggesting that the treatment promoted the development of boys' self-concept in chemistry when they did experiments in boys' only groups than when they operated in mixed groups. This led to the rejection of hypothesis (Ho9), which stated that there is no statistically significant difference in chemistry self-concept between the boys exposed to SPSTA in boys' only groups and boys in mixed groups during chemistry lessons.

Table 42 shows the adjusted post-test mean scores on SSCS based on group composition for the experimental groups, which included boys from boys' only groups and boys from mixed groups.

Table 42:

Adjusted Post-test Mean Scores of SSCS based on Group Composition for Experimental Groups 1 and 2 Combined, using KCPE as covariate

Group Compositon	N	Mean	Std. Error
Boys only	33	3.98[a]	.13
Boys in mixed group	29	3.53[a]	.14

a. Covariates appearing in the model are evaluated at the following values: covariate = 308.9355.

Table 43 shows analysis of covariance (ANCOVA) of the post-test SSCS mean scores for boys in boys' only and mixed groups.

Table 43:

Analysis of Covariance (ANCOVA) of the Post-test SSCS Mean Scores for Boys in Boys' only Group and Boys in Mixed Group in Experimental Groups 1 and 2 Combined.

Source	Sum of Squares	df	Mean Square	F	Sig
KCPE	.71	1	.71	1.32	.256
Group Composition	3.52	1	3.52	5.85	.019
Error	31.83	59	.54		

The ANCOVA results confirmed that the significant difference observed in chemistry self-concept between the boys in boys' only groups and boys in mixed groups, $F(1, 59) = 5.85$, $p<0.05$, was not due to any other factors apart from the treatment.

4.11.1 Discussion

The findings of this study showed that there is significant difference in chemistry self-concept between boys who did chemistry practical lessons in boys' only groups and boys who were in mixed groups. The outcome of this study, which yielded significant difference in favour of boys in boys' only groups to boys in mixed groups, is supported by other studies that found that boys in single sex schooling had higher academic self-concept. For example, Haussler and Hoffmann

(2002) designed an intervention to enhance self-concept in physics for German girls in mixed schools. The intervention used new materials thought to be interesting across gender and manipulated the composition of the classes. The findings showed that although the overall self-concept in physics declined for all students, the decline was steeper for both boys and girls in mixed classes and those in the same- sex classes experienced the lowest decline in self-concept.

Another study carried out with secondary school students in Australia showed that boys in single sex classes within the mixed school set up enjoyed the opportunity to work in single sex groupings and felt they were less distracted, confident and actively participated in the lessons by answering questions (Sukhnandan et al., 2000). In this study, mixed schools appeared to offer a better environment for boys working in boys only groups for developing chemistry self-concept than boys in mixed groups as exemplified by the higher mean score obtained by boys in boys' only groups in Table 42. This can further be explained by the subject stereotypes arising from the socialization of boys in single sex groups and boys in mixed sex groups. In addition, boys who work with girls in the same groups tend to experience more behavioral and discipline problems than their counterparts in single sex groupings.

The relatively low chemistry self-concept shown by the boys in mixed groups may be explained in the light of how the boys related to the girls when they worked together in a given task. For instance, in terms of class organization, boys in mixed groups may feel intimidated in the presence of girls when they make mistakes or give incorrect answers to questions set in class. This kind of fear may make them timid and could lead to withdrawal from class activities and therefore, inhibit their participation in the group tasks. In another related study involving university engineering students where the lecturers provided an open interactive learning environment, the findings showed that both men and women experienced greater self-concept in an environment where they felt safe to ask questions and interact with each other as opposed to situations where they felt intimidated to ask questions (Vogt, 2008). These results suggest that interventions designed to engage students in quality instruction and group composition can influence the development of academic self-concept. Therefore, the good performance of boys in boys' only groups over the boys in mixed groups in chemistry achievement test (see Table 23) may have positively influenced their chemistry self-concept.

4.12 Relationship between the academic self-concept sub-scales in the attainment of students' self-concept in chemistry.

In this study, the students' chemistry self-concept was measured using academic self-concept sub-scales based on the likert scale. The items in SSCS were grouped to reflect the six chemistry self-concept sub-scales. The sub-scales (dimensions) of chemistry self-concept investigated in this study were; Cognitive ability, Psychomotor ability, Ability to use Mathematical applications, Overall academic ability, Enjoyment in chemistry learning and Creativity. The students' mean scores on the chemistry self-concept sub-scales were correlated to the students' mean scores in chemistry self-concept using Pearson's (r), see hypothesis (Ho10), p. 13.

Table 44 shows the students' post-test mean scores on the six sub-scales of the Self-concept in chemistry (SSCS) at the post-test level, scored on a (1-5) scale, for Experimental Groups 1 and 2 Combined.

Table 44:

Post test Mean Scores of Students on the Self-Concept Sub-scales (SSCS) for Experimental Groups 1 and 2 Combined

	N	Mean	Std. Deviation
Cognitive ability	90	3.69	.84
Psychomotor ability	89	3.79	1.02
Mathematical ability	90	3.74	.96
Overall academic ability	90	3.33	1.05
Enjoyment in learning	90	3.99	.77
Creativity	88	3.67	.82

The students in the experimental groups scored better on items that were related to enjoyment aspects of learning chemistry, followed by achievement on psychomotor ability. The ability to use mathematical applications was ranked third, followed by cognitive and creativity abilities, and lastly the students scored poorly on items which were related to overall academic ability in chemistry. The low score obtained in overall academic ability could be explained in terms of the general academic ability of students enrolled in the district schools, which admit students with average grades at KCPE level. The outcome of this study indicated that the students who enrolled in district schools enjoyed work with practical orientation in chemistry and it did not make a difference whether the students were of high or low academic ability. This is possibly the reason why the students from the experimental groups scored better points in the areas that were related to enjoyment in the learning of chemistry and the psychomotor ability sub-scales of chemistry self-concept

.

Figure 4 shows the ranking of self-concept subscales in Chemistry as performed by the students.

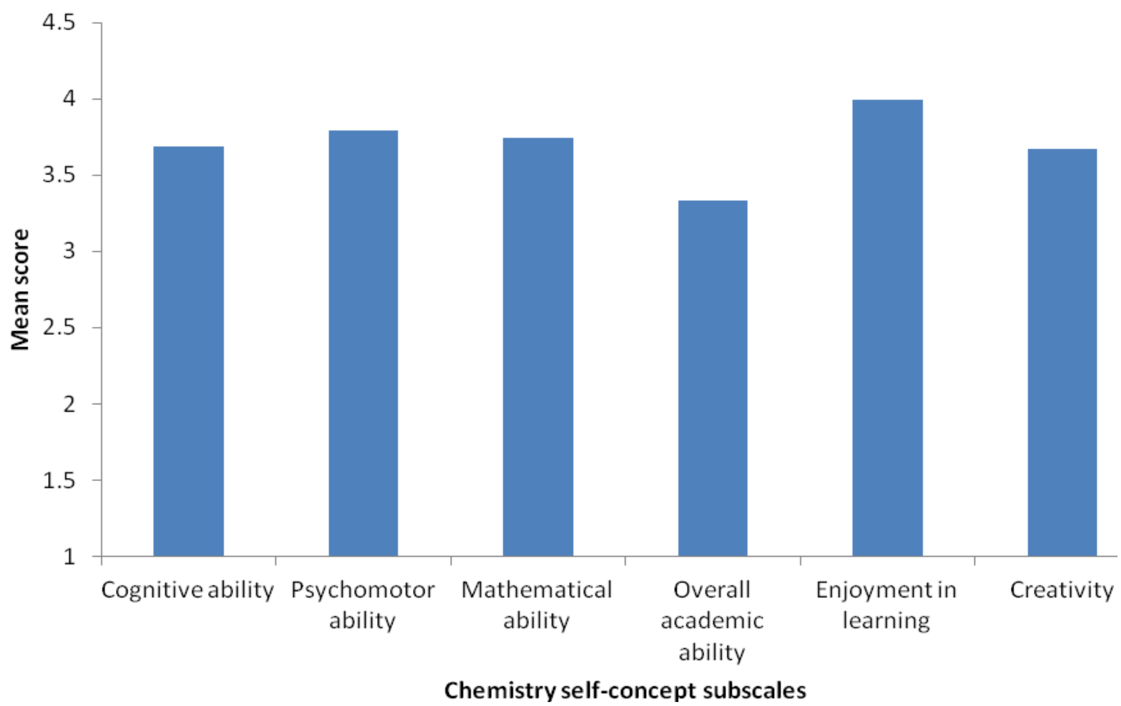

Figure 4: Ranking of students' chemistry self-concept on SSCS in Experimental Groups 1 and 2 combined on the Self-Concept Sub-scales

Table 45 shows the correlation matrix of the six self-concept sub-scales of chemistry self-concept of students in Experimental Groups 1 and 2 combined. According to the literature, the cognitive ability subscale had seven items, which were items 1, 2, 3, 4, 5, 6 and 7. The psychomotor ability had five items (8, 9, 10, 11, and 12). Ability to use mathematics applications had seven items (13, 14, 15, 16, 17, 18, and 19). Overall academic ability in chemistry had seven items (20, 21, 22, 23, 24, 25, and 26). Enjoyment in learning chemistry had seven items (27, 28, 29, 30, 31, 32, and 33). Creativity had seven items (34, 35, 36, 37, 38, 39, and 40).

Table 45*:*
Correlation matrix of Post-test Mean Scores of Students' on Chemistry Self-Concept Sub-scales and Chemistry Self-Concept for Experimental Groups 1 and 2 Combined

Control ariables		Cognitive ability	Psychomotor ability	Mathematical ability	Overall Chemistry ability	Enjoyment in Chemistry	Creati vity	Mean score Chemistry Self-Concept
Cognitive ability	Pearson Correlation	1						
	Sig. (2-tailed)							
	N	90						
Psychomotor ability	Pearson Correlation	.61**	1					
	Sig. (2-tailed)	.000						
	N	89	89					
Mathematical ability	Pearson Correlation	.79**	.55**	1				
	Sig. (2-tailed)	.000	.000					
	N	90	89	90				
Overall Chemistry ability	Pearson Correlation	.82**	.58**	.74**	1			
	Sig. (2-tailed)	.000	.000	.000				
	N	90	89	90	90			
Enjoyment in Chemistry	Pearson Correlation	.69**	.64**	.62**	.59**	1		
	Sig. (2-tailed)	.000	.000	.000	.000			
	N	90	89	90	90	90		
Creativity	Pearson Correlation	.76**	.67**	.70**	.75**	.73**	1	
	Sig. (2-tailed)	.000	.000	.000	.000	.000		
	N	88	87	88	88	88	88	
Mean score Chemistry Self-Concept	Pearson Correlation	.91**	.77**	.87**	.89**	.81**	.89**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	
	N	90	89	90	90	90	88	90

**. Correlation is significant at the 0.01 level (2-tailed).

The results obtained from the two experimental groups showed significant positive correlation among the chemistry self-concept sub-scales at $p < 0.01$ level (see Table 45). Similarly the students' chemistry self-concept mean scores were positive and significant at $p<0.01$ with the subscales, that is, cognitive ability ($r = .91$), psychomotor ability ($r = .77$), ability to use mathematics applications ($r = .87$), overall academic ability ($r = .89$), enjoyment of learning chemistry ($r = .81$) and creativity ($r = .89$).

4.12.1 Discussion

The findings of this study showed that the identified chemistry self-concept sub-scales had high correlation with each other in the realization of students' self- concept in chemistry. The Pearson Correlation Coefficients were used to test Ho10, which was to determine the relationship between the chemistry self-concept sub-scales and chemistry self-concept. The strong positive correlation among the chemistry self-concept sub-scales and also with the chemistry self-concept evident in this study may be interpreted to mean that a student who is good at psychomotor activities will develop cognitive ability which is likely to make him/her more creative and therefore able to use mathematical applications. The same student is likely to enjoy learning chemistry and therefore attain overall academic ability in chemistry.

Silvernail (1987) reported two theories of thought in regard to the reciprocal nature of the relationship between self-concept and achievement. One theory believes that identifying teaching strategies to improve students' academic achievement will enhance their self-concept. The other theory argues that changes in self-concept cause changes in achievement and thus improving students' self-concept. Some studies have supported the former theory, for example, Kifer (1973) as cited in Silvernail (1987) reported that self-concept of ability depended on students' perceptions of their achievement. Anissa (2011) stated that from the reciprocal nature of the relationship between self-concept and achievement, it is reasonable to suggest that improving students' self-concept will in most cases enhance their academic achievement. In the same way history of success will positively influence students' perceptions of their abilities, as they are more likely to experience more success in the future, which will undoubtedly boost their academic self-concept. Students' academic abilities can be improved through a variety of teaching methods. Practical based learning where students engage in activities such as observing; measuring and assembling apparatus has been recognized as the most appropriate in having a great influence on students' achievement and attitudes (Dunn et al., 2009).

CHAPTER FIVE

SUMMARY, CONCLUSION, IMPLICATIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter consists of four sections. Section one summarizes the findings of the study based on the hypotheses. Section two outlines the conclusions based on the objectives and section three gives the implications of the findings of the study to the process of education in the secondary school level in Kenya. In section four, recommendations are offered and areas for further research are identified.

5.2 Summary

The inadequacies of the traditional methods of teaching chemistry led to the focusing of attention on other alternative strategies for communicating chemistry concepts more meaningfully to the learners. The findings of this study revealed that:

i) There is a significant difference in Chemistry achievement in favour of students who are taught through science process skills teaching approach to those who follow regular teaching methods.

ii) There is a significant difference in Chemistry achievement in favour of boys to girls when taught through science process skills teaching approach.

iii) There is no significant difference in the achievement in chemistry between girls exposed to science process skills teaching approach in girls' only groups and girls in mixed sex groups.

iv) There is no significant difference in the achievement in chemistry between boys in boys' only groups and boys' in mixed sex groups when exposed to science process skills teaching approach.

v) There is a significant correlation between each of the selected science process skills and students' achievement in Chemistry and the order of contribution of the science process skills toward students' achievement in chemistry is as follows: interpretation > observation > recording > measuring.

vi) There is a significant difference in the chemistry self-concept in favour of students who are taught Chemistry through science process skills teaching approach to those who follow regular teaching methods.

vii) There is no significant difference in chemistry self-concept between boys and girls taught Chemistry through science process skills teaching approach.

viii) There is no significant difference in chemistry self-concept between girls exposed to science process skills teaching approach in girls' only groups and in mixed sex groups.

ix) There is a significant difference in chemistry self-concept in favour of boys exposed to science process skills teaching approach in boys ' only groups to boys' in mixed sex groups.

x) There is a significant correlation among the chemistry self-concept sub-scales and each individual sub-scale correlates significantly with students' chemistry self-concept.

5.3 Conclusions

It has been suspected that the major cause of poor performance in chemistry at Kenya Certificate of Secondary Examination is attributed to among others, the use of inappropriate instructional strategies employed by the chemistry teachers. Based on the findings of this study the following conclusions were made.

1. Science process skills teaching approach facilitates students' achievement in chemistry more than regular teaching approaches.

2. Gender affects the students' achievement in chemistry when they are taught through science process skills teaching approach, with boys attaining significantly higher mean scores in chemistry than the girls.

3. Group composition (girls in girls only and girls in mixed sex) does not affect their achievement in chemistry when they are taught through science process skills approach.

4. Mixed sex and boys' only groups composition during chemistry practical lessons do not affect the boys' achievement when they are taught using science process skills teaching approach.

5. There is a strong, positive correlation between the students' abilities in each of the selected science process skills and the overall students' achievement in chemistry. The combined effect of the selected science process skills accounted for 38% variation in achievement in chemistry. The order of contribution of each of the science process skills to achievement in chemistry was as follows: interpreting > observing > recording > measuring.

6. The science process skills teaching approach enhanced students' self-concept in chemistry compared to those who followed regular teaching methods.

7. Gender does not affect the students' chemistry self-concept when they are taught through science process skills teaching approach.

8. The composition of groups into girls' only and mixed sex during chemistry practical lessons when they are taught using science process skills teaching approach does not make a difference in the chemistry self-concept of girls.

9. When science process skills teaching approach is used, the grouping of boys in mixed and boys' only during chemistry practical lessons affect the boys' chemistry self-concept with boys in boys' only groups attaining better self-concept in chemistry than boys in mixed groups.

10. The chemistry self-concept sub-scales are positively correlated among themselves and each individual sub-scale is positively correlated to the students' self-concept in chemistry.

5.4 Implications of the Study.

The challenge encountered by the majority of students enrolled in district schools in Kenya is their poor performance in KCSE chemistry examination. However, this study has shown that science process skills teaching approach enhances students achievement at Form Three level compared to regular teaching method. This therefore means that:

1. If science process skills instructional strategy is implemented by the chemistry teachers in the secondary school education then there is likelihood of improvement in the performance of chemistry at KCSE.

2. Students' improvement in performance in chemistry may make the subject popular at the secondary school level and this would attract many candidates to opt for science subjects thereby making science oriented courses accessible at professional level and therefore paving the way for advanced technology and industrialization.

3. Since chemistry occupies a middle position between biology and physics in the secondary school curriculum, the difference in performance of boys and girls in chemistry evident in this study in favour of boys may disadvantage female students from pursuing courses at the tertiary level of education with bias to the physical and biological orientation and reinforce the view held by many educators that such courses as Engineering, Information Communication and Technology (ICT), Agriculture and Medicine are exclusively boys preserve.

4. The science process skills teaching approach need to be implemented in a manner that would bridge the gender gap in chemistry achievement by providing equal opportunities for both boys and girls to interact with the teachers, amongst themselves and the resources.

5. It should be recognized that grouping of students during chemistry practical lessons provides important socializing contexts that allow informal interactions in the groups, which influence students' achievement in the subject. But from the results of this study the conclusion one may arrive at is that science process skills teaching approach does not make a difference in the achievement of secondary school students in chemistry whether they perform class activities in single sex or mixed sex groups.

6. Groupings of students are effective learning environments and that boys and girls can fit in any group and still do well in chemistry. It may also imply that patterns of students grouping in the classroom set up may not advantage girls or boys on their interactions and performance in chemistry.

7. Boys and girls may not require separate orientation during class activities in order to perform better in Chemistry. The issue that needs to be considered is to demystify the perception of teachers, educational administrators and religious communities that girls and boys perform better academically when they work on their own groups.

8. Chemistry teachers need to embrace science process skills teaching approach in the instructional sessions in an effort to enhance the students' self-concept in the subject. This will have a bearing on the students' interests and motivation in the subject and eventually improve the image and performance in chemistry.

9. If secondary school chemistry teachers adopt science process skills teaching approach during classroom sessions, then both boys and girls will be encouraged to participate in practical activities in chemistry and the approach could lead to improved psychomotor abilities in chemistry which pose great challenge to boys in general and girls in particular for boosting their achievement in science.

10. When students engage in experiments during chemistry lessons, they sharpen their process skills and acquire scientific skills which impact on the overall achievement in chemistry.

11. The policy for science education in secondary schools should reinforce the need to establish and equip science laboratories in all secondary schools to encourage students' involvement in practical related activities.

12. Since the achievement in chemistry enhances the development of students' self-concept, it would therefore be necessary for chemistry teachers to incorporate achievement opportunities in class activities.

13. The interpreting skill contributed much more to the students' achievement in chemistry compared to the basic skills such as recording, observing and measuring; there is need for steps to be taken to expose students to basic skills necessary for any major tasks.

5.5 Recommendations

This study has presented and discussed the results of a research carried out in Nyando District, Kisumu County with the objective of finding out the effect of science process skills teaching approach, gender and group composition on secondary school students' achievement and self-concept in Chemistry. It has also provided data on the effectiveness and contribution of science process skills teaching approach in enhancing academic achievement. Therefore the following were recommended:

1. Chemistry teachers should use science process skills teaching strategy in the teaching of chemistry, particularly at the secondary school level because it can address the poor performance in the subject.

2. The Ministry of Education through KIE, QASO institutions and other professional bodies like Head teachers Association, Science Teachers Association, SMASSE should organize workshops, seminars for retraining chemistry teachers on the appropriate utilization of science process skills teaching approach.

3. The institutions offering Teacher Education programmes should train their products to utilize science process skills teaching approach and structure their learning environments that can increase interaction among the learners and enable active participation in the learning process.

4.The chemistry teachers to enhance active participation of secondary school students by organizing frequent practical sessions, provide adequate laboratory facilities and materials for doing experiments and create opportunity for students to share ideas as these activities will engage them effectively in the lesson.

5. The chemistry teachers to structure lessons to provide hands-on activities, with a hope to stimulate students' understanding of science as a process of discovering and acquiring scientific knowledge.

6. The educational policy makers and practitioners to advise the school communities to embark on the development of mixed day schools, which are cost effective and can, accommodate the majority of the students from the locality.

5.6 Areas for Further research

1. Researchers may use the findings of this study to guide them conduct further research on other science process skills particularly those which relate to integrated skills, for example, experimenting, hypothesizing, determining variables in order to gain more knowledge on the effect of science process skills teaching approach on students' achievement in chemistry.

2. Further work may also be preferred on more demanding scientific process skills such as planning and designing of experiments, as they may have an impact on students' creativity in science.

3. Studies may also be carried out to find the development of self-concept in boys and girls since the findings of this work do not provide evidence on whether self-concept develops differently in boys and girls in Chemistry subject. In other words, are boys and girls influenced differently by the nature and /or prior knowledge of the subject matter?

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APPENDICES

APPENDIX A

THE STUDENT'S MANUAL (TREATMENT)

CHEMISTRY PRACTICAL EXERCISE.

LESSON ONE **GROUP-----------------------**

Experiment 1(a): Acid-Base Titration Reaction.

Prepare a 0.1M solution of Sodium Carbonate using the procedure below.

Procedure

1. Gently heat about 15g of anhydrous Na_2CO_3 in a crystallization dish to a constant mass.

a) What do you observe?

----

2. Weigh approximately 10.6g of Na_2CO_3 in a beaker.
3. Add warm water and stir with a glass rod to dissolve the solid.
4. Filter the contents of the beaker into 1 litre volumetric flask, rinse the beaker and filter paper with distilled water and put this water into the volumetric flask as well.
5. Add distilled water to the solution in the flask until it reaches the mark.

Questions

(a) Why do we heat Sodium Carbonate?

(b) Is there any risk of Sodium Carbonate undergoing decomposition on heating?

(c) Why is warm water used to dissolve the solid?

LESSON TWO **GROUP------------------------**

Experiment 1(b): Titration of the Sodium Carbonate with Hydrochloric acid.

Procedure Using a pipette, place $25cm^3$ of 0.1M Na_2CO_3 solution prepared earlier into a conical flask.

Support a burette with a retort stand and fill it with 0.1M HCl upto the zero mark.

Add two drops of methyl orange into the flask containing Sodium Carbonate solution.

Titrate the Sodium Carbonate solution with HCl until the colour of the indicator changes. Read the volume of the acid used and record (1^{st} reading). Repeat titration two more times in separate conical flasks. This time add acid, one drop at a time towards the end, until the indicator colour changes. Read the burette accurately.

Record the readings obtained in the Table below.

Titration	1	2	3
Final reading (cm^3)			
Initial reading (cm^3)			
Volume of HCl (aq) used cm^3)			

Calculate the average volume of HCl used in the space below.

What is the colour of methyl orange?

(i) In Na_2CO_3 (aq)?--

(ii) At the end point? --

(iii) In HCl (aq) --

Write a balanced chemical equation for the reaction.

Calculate the number of moles of Sodium Carbonate used.

Calculate the concentration of Sodium Carbonate.

Calculate the number of moles of Hydrochloric acid used.

Calculate the concentration of hydrochloric acid.

R.A.M. (Na = 23, O = 16, C = 12, H = 1, Cl = 35.5)

LESSON THREE **GROUP---------------------**

Experiment 2: To Carry out Qualitative Tests on some Chemical Substances

(I) You are provided with a solid Q. Carry out the tests below. Write your observations and inferences in the spaces provided.

(a) Observe solid H carefully and record its nature.

Solid H	Appearance

(b) i) Place a little of solid H in a dry test-tube and heat strongly.

Test the products using Cobalt Chloride paper	Observation	Inference

ii)

Test the gas emitted using moist red and blue litmus paper.	Observation	Inference

(c) Dissolve the remainder of the solid H in about $20cm^3$ of distilled water in a boiling tube, and take the temperature of the mixture.

(i) Temperature ---

(d) Into 5 separate test tubes, put 2 cm^3 portions of the solution and use it for test (ii) to (vi) below.

(ii) To the first portion, add 2 or 3 drops of lead nitrate solution.

Observations	Inference

(iii) To the second portion, add 2 or 3 drops of Barium Chloride solution.

Observations	Inference

(iv) To the mixture in (iii) above, add 5 drops of dilute hydrochloric acid.

Observations	Inference

(v) To the third portion add 1M sodium hydroxide solution drop wise until in excess

Observations	Inference

(vi) To the fourth portion, add dilute ammonia solution dropwise until in excess.

Observations	Inference

(vi) What is the formula of the substance formed in the reaction (vi) above?

LESSON FOUR **GROUP-----------------------**

(II) You are provided with a solid G. Carry out the following tests.
Write your observations and inferences in the spaces provided.

(a) Observe solid G carefully and record its appearance.

Solid G	Appearance

(b) Place about 1gm of Solid G in a dry test-tube and heat gently, test the gas emitted with

(i) A glowing splint

ii) Moist red and blue litmus paper and record your observations in the space below.

(c) Dissolve about 1gm of Solid G in about 20 cm^3 of distilled water in a test-tube.

Add a few drops of aqueous ammonia to the solution.

Observation

Add excess of aqueous ammonia

Observation

Inference/Conclusion

APPENDIX B

CHEMISTRY ACHIEVEMENT TEST

Name---

Admission No. --------------------- Class---------- Sex------------ School----------------

INSTRUCTIONS

Answer ALL Questions.

Q1a. The table below gives some properties of substances I, II, III and IV. Study it and answer the questions that follow.

Substance	Electrical Conductivity		M.pt	B.pt
	Solid	Molten	°C	°C
I	Does not conduct	Conducts	801	1420
II	Conducts	Conducts	650	1107
III	Does not conduct	Does not conduct	1700	2200
IV	Does not conduct	Does not conduct	113	440

What type of bonding exists in substances I and II?

(i)

What type of bonding exists in substances I and II?

I……………………………………………………….(1 mark)

II…………………………………………………… (1 mark)

(ii) a Which substance is likely to be Sulphur? (1 mark)

…………………………………………………………………………

b Explain. (1 mark)

………………………………………………………………………….

……………………………………………………………………….

b) Four metals, A, B, C and D were separately added to cold water, hot water and steam. The table below is a summary of the observations made and the formulae of the hydroxides formed.

Metal	Cold water	Hot water	Steam	Formulae of Hydroxide
A	Reacts slowly	Reacts fast	Reacts very fast	$A(OH)_2$
B	No reaction	No reaction	No reaction	
C	Fast	Reacts very fast	Reacts explosively	COH
D	No reaction	Reacts slowly	Reacts fast	$D(OH)_2$

(i) Which two elements are likely to be in the same group of the periodic table?

……………………………………………………………………………………..

(1 mark)

(ii) Arrange the metals in the order of their reactivity starting with the most reactive.

(1 mark)

c) The table below shows liquids that are miscible and those that are immiscible.

Liquid	L3	L4
L1	Miscible	Miscible
L2	Miscible	Immiscible

Use the information given to answer the questions that follow:

(i) Name the method that can be used to separate L1 and L3 from a mixture of the two. (1 mark)

(ii) Describe how a mixture of L2 and L4 can be separated. (1 mark)

2a). Fill in the blanks in the questions that follow with one of the alternatives given.

(i) A burette reading can be wrong due to an error caused by ----------- (parallax, meniscus)

(1 mark)

(ii) The colour of methyl orange in acid is ------------- (yellow, red)

(1 mark)

(iii) The colour of phenolphthalein in acid is -----------(reds, colourless)

(1 mark)

(iv) A chemical ---------- represents the reactants and products in a chemical reaction. (formula, equation) (1mark)

(v) The ------------- is the point at which the indicator just changes colour and is determined using an appropriate internal indicator.
(reaction point, end point) (1 mark)

(vi) 0.4g of NaOH is dissolved in water to make $250cm^3$ solution. Calculate the molarity of the solution.
(Na = 23, O = 16, H = 1) (1 mark)

Use the space below for calculation.

(b) Indicate whether the following statements are TRUE or FALSE.

(i) During acid-base titration, a base should not be put in the burette.

True ( ) False ( ) (1 mark)

(ii) Pipette filler is highly recommended when a poisonous or dangerous liquid is being pipetted.

True ( ) False ( ) (1 mark)

(iii) The following figures, 16.20, 21.65 and 22.81 are all correct burette readings obtained during the same titration.

True ( ) False ( ) (1 mark)

(iv) Molarity of a solution is given using the units' mol dm^3.

True ( ) False ( ) (1 mark)

(v) Concentration is the amount of a substance in $1dm^3$ of solution.

True ( ) False ( ) (1 mark)

(vi) A molar solution is prepared by dissolving 1 mole of a substance in $1dm^{-3}$ of distilled water.

True ( ) False ( ) (1 mark)

(vii) The symbol of molarity is mole.

True ( ) False ( ) (1 mark)

(viii) The unit of measurement for relative molecular mass of a substance is gramme.

True ( ) False ( ) (1 mark)

Q3. Answer the questions below in the spaces provided after each question.

(a) You are provided with sample readings (results) of a titration between Sodium Carbonate solution and Hydrochloric acid using methyl orange indicator.

The following are the readings taken after each trial (Titration).

	Initial reading	Final reading
1st trial	22.05 cm^3	41.30 cm^3
2nd trial	1.80 cm^3	21.10 cm^3
3rd trial	21.10 cm^3	40.40 cm^3

Questions

(i) Develop a table in the space provided below, showing how you can present the results (reading) above in the best organized and acceptable method. (1 mark)

(ii) In the table developed in (i) above, include the volume of HCl (aq) in each trial. (1 mark)

(iii) From the volumes of HCl (aq) shown in the table developed in (i) above, give two consistent titres. (1 mark)

(iv) State the reason why the two titres given in 2 (a) iii above are consistent. (1 mark)

(v) Calculate the average volume of HCl used. (1 mark)

(vi) State why a burette is used to measure concentrated hydrochloric acid rather than a pipette. (1 mark)

(b) In question 3(a), 25cm^3 of Sodium Carbonate solution was titrated with 0.1M Hydrochloric acid.

(i) Calculate the number of moles of Hydrochloric acid used. (1 mark)

(ii) Calculate the number of moles of Sodium Carbonate used (1 mark)

(iii) Calculate the concentration of Sodium Carbonate. (1mark)

Na = 23, O = 16, C = 12.

iv) Write a balanced chemical equation for the reaction. (1mark)

----

v) Write the ionic equation for the chemical reaction. (1mark)

Q4. The following observations were made when unknown substance (Q) was tested as shown below. Write your inferences/conclusions in the spaces provided.

(a)

Test	Observation	Inference
Heat a little of solid Q strongly in a dry test-tube and test the product using Cobalt Chloride.	A white powder is formed. The substance produced turned blue cobalt chloride paper pink.	

(1 mark)

(b) A little of the solid Q was dissolved in about 20cm^3 of distilled water in a boiling tube. 2 cm^3 portions of the solution was placed into 5 separate test tubes and used for the tests (i) to (v) below.

	Test	Observation	Inference
(i)	Add 2 or 3 drops of lead nitrate solution to test tube 1	White ppt formed	
(ii)	Add 2 or 3 drops of Barium Chloride solution to test tube 2	White ppt is formed	
(iii)	Add 5 drops of dilute hydrochloric acid to test tube 3	White ppt persists	
(iv)	Add Sodium hydroxide solution drop wise until in excess to test-tube 4	Pale blue ppt is formed, which is insoluble in excess-solution	
(v)	Add dilute Ammonia solution drop wise until in excess to test-tube 5	Pale blue ppt occurs, which dissolves in excess solution to give deep blue solution	

(1 mark each)

Q5. Excess marble chips (Calcium carbonate) was put in a beaker containing $100cm^3$ of dilute hydrochloric acid. The beaker was then placed on a balance and the total loss in mass recorded after every two minutes, was shown in the table below.

Time (min)	0	2	4	6	8	10
Total loss in mass (g)	0	1.8	2.45	2.95	3.2	3.3

a) Why was there a loss in mass? (1 mark)

b) Calculate the average rate of loss in mass between

i) 0 and 2 minutes. (1 mark)

ii) 6 and 8 minutes (1 mark)

iii) Explain the difference in the average rates of reaction in (b) (i) and (ii). (1 mark)

iv) Write the equation for the reaction, which takes place in the beaker (1 mark)

Q6. When a few drops of aqueous ammonia were added to Copper (II) nitrate solution, a light blue precipitate was formed. On addition of more aqueous ammonia, a deep blue solution was formed.

a) Identify the substance responsible for the

i) Light blue precipitate (1 mark)

…………………………………………………………………………

ii) Deep blue solution (1 mark)

……………………………………………………………………………….

(b) The table below shows the tests carried out on a sample of solution and the results obtained.

	Tests	Results
I	Addition of Sodium hydroxide solution drop wise until in excess.	White ppt which dissolves in excess
II	Addition of excess aqueous ammonia	Colourless solution obtained
III	Addition of dilute hydrochloric acid and barium chloride	White ppt.

(i) Identify the cation present in the solution (1 mark)

(ii) Identify the anion present in the solution. (1 mark)

……………………………………………………………………………..

(iii) Write ionic equations for the reaction in I. (1 mark)

…………………………………………………………………………………….

(iv) Write the formula of the complex ion formed in II. (1 mark)

…………………………………………………………………………………….

(iv) Identify the white ppt in III. (1 mark)

…………………………………………………………………………….

(c) When a few drops of water are added to anhydrous Copper (II) Sulphate, it turns blue with rise in temperature.

(i) Identify the type of chemical reaction that takes place in the above. (1 mark)

……………………………………………………………………………………

(ii) What change would occur to the blue Copper (II) crystals if the water was removed? (1 mark)

……………………………………………………………………………………..

(iii) Identify by inserting a tick in the box, the type of change that Copper (II) Sulphate undergoes through c(ii) above. (1 mark)

☐ Physical change ☐ chemical change

Q7a. You are provided with Copper (II) nitrate and you are asked to heat a small amount in a test-tube. Write the expected observations as guided by the following questions.

(i) What would be the colour of the gas evolved? (1 mark)

…………………………………………………………………….

(ii) Identify the gas (1 mark)

……………………………………………………………………

b) i. What would you observe when you lower a glowing wooden splint in the test-tube? (1 mark)

……………………………………………………………………………..

ii. What conclusion would you make from this observation?

(1 mark)

………………………………………………………………………

iii. a) What would be the colour of the solid left in the test-tube? (1 mark)

……………………………………………………………………………….

b) Identify the solid………… (1 mark)

c) When water is added to Sodium hydroxide pellets, it dissolves with increase in temperature.

Identify the chemical reaction that takes place in the above.

(1 mark)

……………………………………………………………………………….

APPENDIX C

STUDENTS SELF-CONCEPT SCALE (SSCS)

'THE WAY I FEEL ABOUT MYSELF IN CHEMISTRY'

Name---

Admission No. ---------------------------------- Sex--------------

Class--------------------- School--------------------------------

Instructions

Find below some statements that tell how students feel about learning Chemistry. Read each statement carefully and decide whether or not it describes the way you feel about Chemistry. Select one of the five responses next to each statement that shows exactly the extent to which you agree with the statement. If you strongly agree, choose the letters 'SA'. If you agree, choose the letter 'A'. If you are undecided or uncertain, choose the letter 'U'. If you disagree, choose the letter 'D'. If you strongly disagree, choose the letters 'SD'. Kindly respond to every statement. Choose only one response for each statement.

Strongly Agree (SA)	Agree (A)	Undecided (U)	Disagree (D)	Strongly Disagree SD)

Tick the response that you have chosen

1.I am quite good at dealing with chemistry ideas SA ( ) A ( ) U ( ) D ( ) SD ( )

2. Chemistry ideas are difficult for me to understand SA ( ) A ( ) U ( ) D ( ) SD ( )

3.I am always good at writing chemistry equations SA ( ) A ( ) U ( ) D ( ) SD( )

4. I always have difficulty balancing chemistry equations SA ( ) A ( ) U ( ) D ( ) SD( )

5. I have had problems in discussions requiring chemistry

knowledge SA ( ) A ( ) U ( ) D ( ) SD ( )

6. I participate actively in discussions on chemistry topics SA( ) A ( ) U ( ) D ( ) SD ( )

7. I often answer Chemistry questions in class SA ( ) A ( ) U ( ) D ( ) SD ( )

8. I am quite good at doing Chemistry experiments SA ( ) A ( ) U ( ) D ( ) SD ( )

9. I have trouble doing Chemistry experiments SA ( ) A ( ) U ( ) D ( ) SD ( )

10. I am always nervous when doing Chemistry experiments SA ( ) A ( ) U ( ) D ( ) SD ( )

11. I often feel confused recording observations during Chemistry experiments SA ( ) A ( ) U ( ) D ( ) SD ( )

12. I do badly in Chemistry experiments SA ( ) A ( ) U ( ) D ( ) SD ( )

13. I am always good at solving mathematical questions in Chemistry SA ( ) A ( ) U ( ) D ( ) SD ( )

14. I have problems with mathematical calculations in Chemistry SA ( ) A ( ) U ( ) D ( ) SD ( )

15. I have difficulty determining the empirical formula of a compound given the percentage composition of the elements SA ( ) A ( ) U ( ) D ( ) SD ( )

16. I find it easy to calculate the molecular masses of given chemical compounds SA ( ) A ( ) U ( ) D ( ) SD ( )

17. I have problems calculating molarity of chemical solutions SA ( ) A ( ) U ( ) D ( ) SD ( )

18. I am always good at calculating the number of moles of a substance in a given solution SA ( ) A ( ) U ( ) D ( ) SD ( )

19. I have problems calculating the concentration in a given solution SA ( ) A ( ) U ( ) D ( ) SD ( )

20. Chemistry is one of my best subjects SA ( ) A ( ) U ( ) D ( ) SD ( )

21. I have always learnt Chemistry concepts faster and with ease SA ( ) A ( ) U ( ) D ( ) SD ( )

22. I am always top of my Chemistry class SA ( ) A ( ) U ( ) D ( ) SD ( )

23. I get good marks in Chemistry SA ( ) A ( ) U ( ) D ( ) SD ( )

24. I am very keen in doing Chemistry experiments SA ( ) A ( ) U ( ) D ( ) SD ( )

25. I have difficulty learning Chemistry SA ( ) A ( ) U ( ) D ( ) SD ( )

26. I score low marks in Chemistry SA ( ) A ( ) U ( ) D ( ) SD ( )

27. I would hesitate to enroll in courses that involve Chemistry SA ( ) A ( ) U ( ) D ( ) SD ( )

28. I find Chemistry concepts interesting and challenging SA ( ) A ( ) U ( ) D ( ) SD ( )

29. Practical activities in Chemistry are non exciting and boring SA ( ) A ( ) U ( ) D ( ) SD ( )

30. I feel happy when we are going for Chemistry experiments SA ( ) A ( ) U ( ) D ( ) SD ( )

31. I get worried when there is a Chemistry test SA ( ) A ( ) U ( ) D ( ) SD ( )

32. I do not want to continue with learning Chemistry SA ( ) A ( ) U ( ) D ( ) SD ( )

33. I have a lot of self-confidence when it comes to Chemistry SA ( ) A ( ) U ( ) D ( ) SD ( )

34. I always communicate Chemistry ideas clearly in my class SA ( ) A ( ) U ( ) D ( ) SD ( )

35. I am always ready to accept other students' ideas in Chemistry SA ( ) A ( ) U ( ) D ( ) SD ( )

36. I am always able to explain Chemistry concepts clearly SA ( ) A ( ) U ( ) D ( ) SD ( )

37. I share my ideas with other students during Chemistry lessons SA ( ) A ( ) U ( ) D ( ) SD ( )

38. I have always thought about new ideas in Chemistry SA ( ) A ( ) U ( ) D ( ) SD ( )

39. My thoughts and ideas in Chemistry are not original SA ( ) A ( ) U ( ) D ( ) SD ( )

40. I have interest in making new discoveries in Chemistry SA ( ) A ( ) U ( ) D ( ) SD ( )

Key:

Cognitive ability	1, 2, 3, 4, 5, 6, 7.
Psychomotor ability	8, 9, 10, 11, 12.
Ability to use mathematics applications	13,14,15,16,17, 18, 19.
Overall academic ability in Chemistry.	20, 21, 22, 23, 24, 25, 26
Enjoyment in learning Chemistry	27, 28, 29, 30, 31, 32, 33.
Creativity	34, 35, 36, 37, 38, 39, 40.

APPENDIX D

RESEARCH AUTHORISATION LETTER

APPENDIX E

RESEARCH PERMIT