EFFECTS OF CONSTRUCTIVIST TEACHING APPROACH ON STUDENTS' ACHIEVEMENT AND ATTITUDE TOWARDS SECONDARY SCHOOL CHEMISTRY IN BARINGO NORTH DISTRICT, KENYA

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DECLARATION AND RECOMMENDATION

Declaration

This is my original work and has not been presented for an award of a Certificate, Diploma or Degree in part or as a whole in this or any other University.

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Recommendation

This work has been submitted for examination with our approval as University supervisors.

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DEDICATION

This thesis is dedicated to my dear wife Emily, my daughters Betty, Caroline, Gladys and sons Kelvin and Caleb. They became patient and steadily encouraged me throughout the years of study. This also extends to my sister Benedine, brother Reuben and my parents.

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ABSTRACT

Chemistry teaching and learning is important in any society because it is one of the key subject in the socio-economic development of the society. It is offered in the secondary school curriculum and examined at Kenya Certificate of Secondary Education (KCSE) Examinations. It helps learners to acquire knowledge of facts, principles and events of nature, enabling them to live intelligent and efficient lives in the modern society. Despite its usefulness, the students' performance in Chemistry in National Examinations has been poor thus affecting their enrollment in chemistry related courses in colleges and universities. The teaching approach used by a teacher may affect the students' performance in the subject. The constructivist teaching approach may help improve students' performance in Chemistry, but its usefulness is not known. Therefore this study sort to investigate the effect of the constructivist teaching-learning approach on students' achievement and attitude in the learning of Chemistry. Quasi-experimental research which involved Solomon-Four Non-Equivalent Control Group Design was employed. The population of the study was Form Two learners in Baringo North District. The sample size was 160 Form Two students out of a total population of 1260 from four District co-educational public boarding schools purposively sampled. The four schools were randomly assigned to treatment and control groups. The instruments used in the study were Chemistry Achievement Test (CAT) and Students' Attitude Scales (SAS). Pilot test was done in a school within the Baringo North District but a different division from the schools under study to ascertain the instruments' validity and reliability. To maintain validity, three experts from the Department of Curriculum Instruction and Education Management validated the instruments. The Cronbach's coefficient alpha method was used to estimate the reliability coefficient of SAS and the reliability coefficient of the CAT was calculated using Kuder-Richardson formula 21(KR-21).The reliabilities of SAS and CAT were found to be 0.7591 and 0.7823 respectively which were above the threshold value of 0.7 recommended for the research. The students took a pre-test then a post-test after the treatment followed by post group discussions. The collected data were analyzed using descriptive and inferential statistics. Quantitative data were subjected to t-test, ANOVA and ANCOVA at coefficient alpha (α) equal to 0.05 level of significance with the help SPSS computer package. Results of the study showed that the constructivist teaching–learning approach is highly effective on enhancing students' chemistry achievement but no significant difference was found in their attitudes towards chemistry. The results of this study may be beneficial to curriculum developers, teacher trainers and chemistry teachers in improving the teaching- learning process in Chemistry.

TABLE OF CONTENT

Page

APPENDICES:

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

CAT	**-**	Chemistry Achievement Test.
CDF	**-**	Constituency Development Fund
CTA	**-**	Constructivist Teaching Approach.
K.C.S.E	-	Kenya Certificate of Secondary Education
K.I.E	-	Kenya Institute of Education
KR-21	-	Kuder Richardson (21) formula for estimating the reliability of a test.
KNEC	-	Kenya National Examinations Council
SAS	-	Students' Attitude Scales
SMASSE	-	Strengthening of Mathematics and Science in Secondary Education
SPSS	-	Statistical Package for Social Sciences
8.4.4	**-**	A Kenyan Education system involving eight years of primary, four years of secondary and four years of university education. This is the current education system in Kenya.

CHAPTER ONE
INTRODUCTION

1.1 Background Information

In the recent years, scientific and technological knowledge have grown very rapidly. It is now estimated that this knowledge is doubling every ten years. The changes that science and technology have brought to the environment have been so great that many people view the world as a marvel of man's mastery over the environment. This justifies why students should go through the chemistry curriculum to help them to develop the attitudes, skills and confidence to deal with the present world. A research by the Department of Education and Science (DES) in the United Kingdom showed a gloomy picture about the few number of children choosing science beyond the age of 14, many opting to go out of science (DES, 1979). One outcome of the study was the need to address the types of approaches to be used to teach science to broaden its appeal. The teaching approach that a teacher adopts is one factor that may affect students' achievement (Mills, 1991). One of the disturbing trends in Africa is low academic achievement in science and mathematics. This concern was the agenda of a recent meeting of African ministers of Education in Johannesburg South Africa. The meeting warned that unless science education was improved, the continent's economies would fail to meet the Millennium Development Goals (Kigotho, 2007). The delegates further noted that while low achievement in science in Africa is historical, students' limited interest in studying science is rooted on how the subject is taught.

In the Kenyan case, when the secondary chemistry curriculum was formulated and developed at K.I.E, in 1963, the emphasized approaches became teacher and book centered. The teacher and textbook acted as the absolute authority on the knowledge of chemistry. Since then the chemistry syllabus has undergone several changes aimed at finding the best approach for teaching and learning the subject. The search for a better teaching method has been going on for years (Okere, 1986). Research in teaching behaviour indicates that there are teaching methods that influence students' achievements more positively than others (Wenglinsky, 2000). Wenglinsky further argues that there is a correlation between high academic achievement of the students and the classroom practices of the teacher.

The Kenyan goal of achieving an industrialized status by the year 2020 and vision 2030 depends on how the youth are equipped with scientific skills. Chemistry therefore will play a very important role in the national development if it is properly taught. The main objectives of teaching chemistry in secondary schools in Kenya include; the development of interest and appreciation, development of favorable habits, acquisition of knowledge and information, development of scientific attitudes and training in the scientific method among others (K.I.E, 1992). The mode of testing chemistry in national examinations usually involves a set of three papers; two theory papers and one practical paper.

The MacKay Report (1984) which led to the introduction of 8.4.4. system of education emphasized on the chemistry content and methods which would be directly applicable to the pupils' immediate environment. As a result more attention was paid to students' project. The persistent low performance in the subject however may suggest that appropriate and effective approaches of teaching chemistry have not been realized. For instance the Ministry of Education Science and Technology cites problems in secondary school education as poor performance in core subjects as mathematics and sciences due to lack of text books, teachers' shortage and poor teaching methodology (MOEST, 2005). The 8.4.4. Syllabus for instance is overloaded and exam oriented. The students end up finishing the fourth year without developing all the scientific skills. Traditional instructional practices that centre on teacher dominated pedagogy predominate in most schools. Changeiywo (2000) observes that learning activities in most secondary school classrooms centre around text books and past examination papers. These two serve as major determinant of what is taught in schools.

The dismal performance on the subject in National Examinations (Table 1) may be attributed to poor methods of teaching and learning. In a study on the effect of Integrated Programme Instruction (IPI) in teaching mathematics, Eshwani (1975 & 1974) pointed out that gender differences in achievement and retention can be attributed to teacher's inability to use relevant instructional methods. Many in-service workshops have been organized for science and mathematics teachers in this country to find out a solution to this problem. A notable example of these workshops is the Strengthening of Mathematics and Sciences in Secondary School Education (SMASSE) organized by the Japanese government in collaboration with the Kenyan government. In a study to investigate how students learn mathematics, Oloyede (1996) concluded that the way the teacher handles the instructional process affects students' values, interest and behaviour towards the learning of mathematics. Moreover, Huber (1990) proposed that quantitative and qualitative research studies should be carried out to investigate students' preferences for teaching methods. It is of great concern to note that the student's enrolment in Chemistry Nationally for eight consecutive years has been rising while the performance has never reached 7.0 on a 1-12 scale and improvement has not been consistent, Table 1.

Table 1

Candidates National Overall Performance in Chemistry from the year 2000- 2008

Year	Number of Candidates	Max Score	Mean Score	Mean Score (%)	Standard Deviation
2000	115,968	190	5.03	41.84	21.38
2001	181,238	190	3.63	30.27	18.00
2002	187,261	190	4.11	34.27	21.29
2003	198,016	190	4.49	37.42	22.86
2004	214,520	190	4.75	39.62	20.00
2005	253,508	200	4.57	38.05	23.00
2006	236,831	200	5.98	49.82	32.00
2007	267,719	200	6.09	50.76	31.00
2008	296,937	200	5.46	45.48	31.78

Source: Kenya National Examinations Council (KNEC, 2009).

From 2000 to 2006, consecutively the candidates who scored between grades D+ and E in Baringo District have been oscillating between 57% and 67% (SMASSE Report, 2007). In addition the mean score in the subject has never gone beyond 5.5 despite increased enrolment in the subject, Table 2.

Table 2

Candidates overall performance in Chemistry from the year 2000 - 2007 in Baringo District.

Year	No of Candidates	Max Score	Mean Score	Mean score (%)
2000	1742	190	4.13	34.42
2001	1965	190	3.80	31.67
2002	1777	190	4.42	36.83
2003	1904	190	3.98	33.17
2004	1974	190	4.81	40.08
2005	2326	200	4.71	39.25
2006	2253	200	4.48	37.33
2007	2341	200	4 .31	35.92

Source: SMASSE Report (2008)

Similarly North Baringo District with 25 secondary schools had performance indices of 3.37, 3.89 and 3.61 in the years 2008, 2009 and 2010 respectively which are considered to be very low. The mean score of the district is below the national score hence a reason to try this method to improve students' performance in Chemistry.

1.2 Statement of the Problem

Each society is constantly aspiring to develop itself technologically by utilizing the available resources. Chemistry knowledge has a direct impact on an individual's life at all levels. Chemistry knowledge can be used to accelerate industrial development and also to promote positive environmental and health practices. Despite its contribution, the students' performance of chemistry in National Examinations in Kenya has been deteriorating. This means, few students are able to pursue Chemistry and Chemistry related courses at colleges and universities hence the country may not achieve the 2020 industrial expectation and vision 2030. The teaching approach used by a teacher may affect the students' performance in the subject. The constructivist teaching approach may help improve students' performance in Chemistry, but its usefulness is not known. Therefore, this study sort to investigate the effects of constructivist teaching approach on students' achievement and attitude in the learning of Chemistry.

1.3 The Purpose of the Study

The purpose of the study was to investigate the effects of the constructivist teaching approach on the students' achievement and attitude in the learning of Chemistry among Form 2 learners in sampled secondary schools in Baringo North District, Kenya. The District was chosen because it has been recording low achievements in chemistry at the Kenya Certificate of Secondary Education (KCSE) Examinations. The teaching methods and students' attitudes were thought to be the factors contributing to this low achievement.

1.4 Objectives of the Study

This study was guided by the following objectives:

(i) To determine whether there is any significant difference in students' achievement in Chemistry when taught by the constructivist approach and when taught by the conventional teaching methods.

(ii) To determine whether there is any significant difference in students' attitudes towards chemistry when taught by the constructivist teaching approach and when taught by the conventional teaching.

1.5 Hypotheses of the Study

The following null hypotheses were statistically tested.

Ho1: There is no statistically significant difference in students' Chemistry achievement between those exposed to constructivist teaching approach and those not exposed to it.

Ho2: There is no statistically significant difference in students' attitude towards the learning of Chemistry between those taught through constructivist teaching approach and those not exposed to it.

1.6 Significance of the Study

The study investigated students' achievement on "Structure and Bonding topic" in chemistry. This topic is important in the learning of chemistry because students have difficulties in understanding most of the concepts in chemistry and hold misconceptions which prevent meaningful learning (Staver & Lumpe, 1995). In chemistry, chemical bonding is one of the basic topics; the substances in nature and the changes they undergo can be explained by chemical bonding. Understanding chemical bonding concepts is important in chemistry in order to comprehend the nature of the chemical reactions and some physical properties such as boiling point and melting point. Chemical bonding is an abstract concept that cannot be applied to everyday life directly and many students face many difficulties in comprehending the concept. They cannot relate microscopic world to macroscopic changes (Coll & Treagust, 2003; Harrison & Treagust 2000, Nicoll, 2001). Kempa and Dude (1974) reported that pupils' interest in science is associated with the achievement in science. Adesokan (2000) and Onwu (1981) asserted that despite of the recognition given to chemistry among the science subjects, it is evident that students still show negative attitude towards the subject thereby leading to poor performance and low enrolment. Attitude is an important component in science education and proper attitude in chemistry is very necessary to enhance students' participation, achievement and success in chemistry and related careers.

The findings of this study may assist teachers to evaluate their teaching methods in relation to students' understanding and attitudes in chemistry so as to improve their performance in the subject. This will enable students to pursue chemistry and science related causes in universities and colleges enabling the country to industrialize and achieve vision 2030. The findings may also be used by curriculum developers to make appropriate amendments on the selection of content, objectives and evaluation approaches. Finally it is hoped that the findings may stimulate further research on the appropriate methodologies in the teaching-learning of chemistry.

1.7 Scope of the Study

The study was conducted in four public district co-educational secondary schools taking the 8-4-4 syllabus. The study involved Form Two learners since the topic of study is introduced at this level as outlined in the K.I.E syllabus 2005. The study took three weeks and it involved a sample of one hundred and sixty students and four teachers. The findings of the study was generalized to Form Two students in North Baringo District and Kenya in general since majority are district schools.

1.8 Assumptions of the Study

The following were assumed in this study:

(i) The data collected from the students will be a true reflection on their understanding on Structure and Bonding topic and their attitude towards the learning – teaching of chemistry.

(ii) The study will run smoothly without any logistical problems like uncooperative school administrators, teachers and students strikes.

1.9 Limitations of the Study

The findings of the study were only limited to Form Two students in North Baringo District Public Co-educational Secondary Schools, Kenya. Admission of students to district schools is based on a certain cut off points and so provincial schools were not sampled. The teachers involved in the study were trained by going through the module and theory of constructivist to reduce the variations when they are teaching. The findings of the study were generalized to the topic "Structure and Bonding" and also chemistry in general.

1.10 Definition of Terms

Achievement – Ability to perform in the area of recall, comprehension, application and higher order skills (Grondlund, 1981) as a result of instruction. This ability was measured using Chemistry Achievement Test. See Appendix A.

Co-education – A system of education where both boys and girls learn together. In this study, co-education refers to the Kenyan educational system where both boys and girls learn together in each class.

Co-educational secondary school – This refers to a secondary school system in which boys and girls learn together in each class.

Conception – Form an idea, a plan of something in the mind. It also refers to achievement. In this study, it refers to the understanding of the concepts in "structure and bonding" topic.

Constructivist Teaching Approach - This view of learning is based on the believe that knowledge is not a thing given by the teacher at the front of the class to students in their desks. Rather knowledge is constructed by the learners through their active constructions.

Conventional Teaching Approach – Also refers to as regular or conventional method. This refers to an instructional method in which the amount of verbal interaction between the teacher and student is maximum (Mbuthia, 1996).

District Public Secondary Schools – In this study they refer to local secondary schools in the district which are subsidized by the government.

Effect – Change produced by an action or cause; results or outcome. In this study, it refers to either the positive or negative change that occurs to the students' achievement or attitude when taught by either the constructivist teaching approach or the conventional teaching methods.

FORM 2 - Refers to the 2^{nd} level of the Secondary Education base in Kenyan Education System.

Students' Attitude – Refers to students' acquired internal state of feelings influencing their choices towards learning (Wittrock, 1986). In this study, the term will refer to students' disposition towards chemistry as a result of instructional approach adopted by the teacher.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews and summarizes the literature on the need for science education in society, the development of science curriculum in Kenya, and the various chemistry teaching methods. These methods were reviewed in relation to students' conceptions, achievements and attitudes in chemistry. It also reviews on the methods of gathering information on attitudes. Finally, the conceptual framework used in the study is presented.

2.2 Chemistry Education in the Society

Before the beginning of 19th Century, the pursuit of science was either a hobby of the few people or the solidarity of effort of those with scientific talent (Das, 1985; Wachanga, 2002). Since then, science has developed to today where people live in a scientific civilization in which science is no longer confined to a few devoted persons (Newton, 1988). Science is involved in the production, processing and preservation of the food eaten as well as purification and storage of drinking water. Scientific knowledge is also used in health care, transport systems and energy sector. In other words, science affects all aspects of human life hence every member in the society should acquire scientific knowledge. The teaching of science therefore becomes part of the general education of the society (Mohapatra, 1989).

Chemistry is a major science subject which forms part of the Kenyan secondary school curriculum. Its study involves the pursuit of truth, and therefore it inculcates intellectual, honesty, diligence, perseverance and objective observation in the learners. Chemistry learning develops a scientific attitude in the learners which includes critical observation, broad mindedness, non-belief in superstitions and the respect of other peoples opinions. When these qualities are developed in the learners, they help in solving many problems either individual or societal (Das, 1985; Wachanga, 2002). In addition to being part of the general education of individuals, secondary school chemistry prepares students for vocation and forms a basis for specialization at higher educational levels. Chemistry therefore, is a critical subject which should be taught in a way that learners understand and enjoy.

2.3 Development of Chemistry Education in Secondary Schools in Kenya

There are several changes in education curriculum that have been made since independence. One major immediate change was training of local teachers to replace expatriate. Several teacher training colleges were put in place (Wachanga, 2002). However, it was realized that adequate teacher supply does not necessarily mean improved education quality because many teachers out from colleges could not operationalize the training skills acquired to bring out the desired change in students (Johnson, 1997).

The problem that the teachers faced was a carry over of the approaches used before independence which were mainly rigorous drills aimed at instilling the information needed for students to pass examination (Sheffield, 1973). After independence, the Kenyan government found out that the quality of education given to students was not compatible with the country's scientific and technological needs (Government of Kenya, 1964). The Ministry of education took the initiative to reform the science curricula to make it meet the national needs. Due to lack of African models from which to borrow experience, curriculum developed in the developed world was adopted (Kiboss, 1997). Science Curriculum such as the Nuffield Science (NS) influenced the development and implementation of the School Science Project (SSP) in Kenya. The aims of teaching science in secondary school called on the teacher to:

i. Assist the students to know how scientists carry out their inquiries, how they arrive at conclusions and how discoveries are used.
ii. Stimulate students to view science as interplay of theory, exploration and application of scientific discovery.
iii. Create confidence in students by letting them experiment with events in their day to day life.

These aims of education were re-emphasized under the 8.4.4 education system introduced in Kenya in 1985. The main objectives of 8.4.4 were to prepare learners for self reliance, training and further education (K.I.E, 1982). Its Chemistry component in the secondary education cycle emphasized the acquisition of scientific concepts, principles and skills as well as practical investigative approach by learners. In addition to the use of materials available in school laboratories, chemistry teachers were expected to subsidize and improvise them by using locally available materials. Although this was the approach intended for the teaching of chemistry, students have continued to perform poorly in National Examinations because many teachers tend to use expository teaching methods as opposed to teaching by exploration (KNEC, 1994).

2.4 Chemistry Conceptions

The understanding of chemistry concepts is required if students are to do well in chemistry. Trucoe (1983) study in middle schools found many varieties of teaching styles and concluded that the conception of science is strongly influenced by the way it is taught. The secondary school chemistry content is made up largely of concepts which are abstract in nature, and students face many difficulties in conceptualizing them. Basically constructivists believe that learners approach learning tasks with a set of beliefs, motivation and conceptions about knowledge itself. When learners are taught, they construct individual meanings from the material by relating it to their existing conceptions and frameworks of knowledge. Kroll and Black (1993) pointed out that, an important component of constructivism is the recursive nature of learning that new knowledge is acquired by consolidating old knowledge through practice and extending it to new situations.

2.5 Structure and Bonding Topic

The topic “structure and bonding” usually raises many challenges to secondary school chemistry students in Kenya. Usually students perform poorly in this topic and other related topics in National Examinations. The Kenya National Examinations Council has pointed out that the items on “Structure and Bonding” are extremely unpopular to students (KNEC Report, 2005). The reason suggested for this observation is the difficulty of the concepts among Form Two learners. Furthermore, this topic is usually abstract in nature and teachers find difficulties in organizing experiments on the topic. Consequently teachers end up using chalk and talk approaches to teach it. This often leads to poor performance, low motivation and negative attitudes towards the subject. A sound understanding of this topic may enable students to perform well in other core and related topics like organic Chemistry, Chemical reactions, thermochemistry, Effect of electric current on substance and many other areas. Therefore it is important that research is done to find out better approaches of teaching and learning the topic.

2.6 Constructivism as a Learning Theory

Although the main philosophy behind constructivist theory is credited to Jean Piaget (1952), the construction of knowledge through active learning has roots in the lessons of scholars over twenty two hundred years ago. Socrates, Plato and Aristotle repeatedly spoke of the formation of knowledge (Crowther, 1997). History reveals many examples of constructivism. Saint Augustine (300 AD) and John Locke (1800 AD), all emphasized sensory experience as the source of new knowledge (Crowther, 1997). However, Piaget still remains the father of constructivism and provides the foundation for modern constructivist theory. He believed that intelligence consist of two interrelated processes, organization and adaptation. People organize their thoughts so that they make sense, separating the ones that are important from those that are not, as well as connecting multiple ideas together. Simultaneously people adapt their thinking to include new ideas as new experience provides additional information.

According to Piaget, adaptation has two pathways: assimilation and accommodation. In the former, new information is added to the existing cognitive organization. In the latter, the intellectual organization has to change to adjust for new information (Berger, 1978). Dentici (1984) in one study pointed out of the value of cognitive conflict in children where things that happened caused children to doubt their existing ideas and re-fashion them in the light of that new experience.

Constructivism is a familiar word to most members of the science education community (Caine, 2002; Campbell, 1998 & Illman, 1998). Constructivist theorists believe students improve their critical thinking and problem solving skills when they construct new knowledge based on background experiences and multiple resources (Price, 1997). Students construct knowledge independently or as part of a social unit. They think critically when they combine background knowledge, independent research and class presentation to build their existing schema, and expand the foundation of their knowledge (Maypole & Davis, 2001). Constructivism therefore is a theory of knowledge that emphasizes on the active construction of knowledge by learners (Glasersfield, 1989). Constructivists see learning as a process of actively exploring information and constructing meaning by linking it to previous knowledge and experience (Alesandrini, 2002). Good and Brophy (1995) explains the constructivist model of learning as the one that emphasizes the development of knowledge through active discussion process that link new knowledge to prior knowledge. This is as opposed to the transmission model of learning where the teacher acts as the sender of a fixed body of content to passive learners.

According to D'Amico and Schmid (1997), cooperative learning is consistent with the constructivist approach. Meaningful learning occurs when students create ideas from existing information such as facts, concepts and procedures. Ausubel (1968), asserts that the most important single factor influencing learning is what the learner already knows and one should ascertain it and teach accordingly. Constructivism can be contrasted with objectivism which holds that knowledge is an absolute sense, independent of people. D'Amico and Schmid (1997) further noted that in the learning process, the learner builds a personal view of the world by using existing knowledge, interest and goals to select and interpret currently available information. Siegal (1990) argues that when teaching is only concerned with simply leading a learner to a correct answer without enabling the learner to understand the reason why, teachers are creating a non-evidential style of belief, which is tantamount to indoctrination. Information transmission pedagogy stifles intellectual development because it weakens vigor and efficiency of thought (Ndirangu, 1991). Tytler (2002) asserts that if school science knowledge is to be useful to the students, continual links must be made between school experiences and social uses of the science knowledge.

2.7 Constructivist as a Learning Approach

In the constructivist classroom, the teachers' role is to organize situations which will allow the learners to hypothesize, predict, manipulate objects, pose questions, research, investigate and invent meanings. A constructivist classroom is student centered placing more value on student learning rather than the teacher teaching. The teacher watches, listens and asks questions in order to learn about students and how they learn so that students benefit more rather than dispensers of knowledge. In other words, the teacher behaves as a researcher (Calkin, 1986). Correct answers and single interpretations of phenomena are de-emphasized.

2.8 Teaching Science Using Constructivist Approach

Research has shown that many children lack the necessary knowledge and skills in science and technology to function in the modern world (AAAS, 1989; Ogawa, 1998). This comes at a time when there is increasing demand for scientifically literate individuals who can analyze and anticipate novel problems rather than memorize facts. However, what is happening in schools is not promising. Students' performance and interest in science is declining (Markow & Lonning, 1998). Secondary school and college students' knowledge of science is often characterized by lack of coherence and majority of students essentially engage in rote learning (Barakat, 2000, Brandt et al., 2001, Nakhleh, 1992). The problem is twofold. The abstract and highly conceptual nature of science seems to be particularly difficult for students and teaching methods and techniques do not seem to make learning process sufficiently easy for students (Gabel, 1999; Schimid & Telaro, 1990).

These problems are quite serious in chemistry which is widely perceived as a difficult subject because of its specialized language, mathematical and abstract nature and the amount of content to be learnt (Gabel, 1999; Moore, 1989). The prevailing teaching practices do not actively involve students in the learning process and seem to deprive them from taking charge of their learning (Francisco, Nicholl & Trautmann, 1998). Improving educational quality requires, at least placing learners in an active rather than passive roles (Moore, 1989). People learn by being engaged actively and a person is not an empty vessel to be filled with information. Knowledge that empowers and increases the learners' self confidence is that which results from the coming together of individuals actions, feelings and conscious thoughts (Novak, 1998). Rote memorization disempowers learners and promote fear of learning because it is irrelevant to their own experiences. In addition, information learnt by rote in the absence of connections with previously acquired frameworks is largely forgotten (Novak, 1998).

In the constructivist teaching approach, the teacher should allow learners to hypothesize. This is achieved by giving them a wide variety of examples and non examples to illustrate concepts and to correct alternative frameworks. Errors are common but necessary in the process of formulating more sophisticated hypotheses. Students should not be penalized or condemned fort taking risks that lead to errors during the learning process. Instead they should be assisted with patience and tolerance to eliminate what is perceived as error (Weaker, 1996). It is recommended that before undertaking students' error correction the teacher must consider the possible effect it might have in their understanding of the concept under discussion. Therefore, learning is most likely to be effective when students are actively involved in dialogue and construction of meanings that are significant to them (Wells & Mejia, 2006).

2.8.1 Teacher Perspectives on a Constructivist Learning Approach

When a teacher asks a student a question after a lesson, the students can give wrong answers or no answer. This may imply the student has not understood or has been passive at the lesson. The teacher should therefore strive to get the best means to enhance effective learning. When constructing meaning learners not only understand concepts but also learn to use them in other unfamiliar contexts. In a study on teacher perspectives on a constructivist learning design among four experienced teachers representing primary, intermediate, middle arts and high school mathematics, Cagnon (1996) observed that teachers found that learners are more at home when doing something than just observing facts. Teachers appreciate the structure and sequence of the constructivist design of learning, but they also agree that it is time consuming. In their study on changing teaching methods in school mathematics Cubinovâ and Novotnâ found out that constructivist approaches in teaching mathematics were more successful on task which demanded the application of knowledge and understanding to unfamiliar contexts (Andima, 2004). They however did not use pre-test. This means they did not take care of extraneous variables. The present study however will make use of both pre-test and post-tests.

In the constructivist paradigm, the teacher's role is not to lecture or provide structured activities that guide students to mastery of some teacher-imposed goal. Instead teachers act as facilitators who coach learners towards meaningful goals (Alesandrini & Larson, 2002). They combine their understanding of how students learn with expert knowledge of a particular discipline. They encourage students to respond to texts and to one another enabling them to think in increasingly complex ways about multiple possible perspectives (Chrenka, 2001).

Constructivism or constructivist theory puts the students, their interest and previous experiences and knowledge as paramount parts of understanding in designing curriculum (Stofflett, 1998). This has a particular impact when exploring the implications of pedagogy and teacher training. There are two approaches of constructivism applied in educational studies. These are radical constructivism and social constructivism. Radical constructivism places emphasis on the shared cultural meaning- making process of knowledge construction while social constructivism places emphasis on the shared cultural meaning-making process in social interaction of knowledge construction (Richardson, 1997). However to enhance knowledge construction, the two methods should be infused. The teacher facilitates cognitive alteration through designing tasks that create dilemmas to students. On the other hand, teachers should pay attention to the importance of social element of learning and on the power of relationships among the teachers, students and formal knowledge.

There are several tenets of the constructivist learning approach (Brooks & Brooks, 1993,. pp. 232 - 243). However for the purpose of this study, the following features will be focused on:

a. Learning involves the construction of meaning not transmission.
b. Prior knowledge impacts the learning process
c. Learning is a collaborative activity
d. Building useful knowledge is an effortful and purposeful activity
e. Learning is embedded in problem –solving situation
f. Teachers should allow for some students autonomy during the learning process.

The following represents a summary of some of the suggested characteristics of a constructivist teacher (Brooks and Brooks, 1993, pp 232-243).

i) Become one of the many resources that the student may learn from, not the primary source of information.
ii) Engage students in experiences that challenged previous conceptions of their existing knowledge.
iii) Allow student responses to drive lessons and seek elaborations of students' initial responses. Allow students some thinking time after posing questions.

iv) Encourage the spirit of questioning by asking thoughtful, open-ended questions. Encourage thoughtful discussions among students.

v) Use cognitive terminology such as “classify”, “analyze” and “create” when framing tasks.

vi) Encourage and accept student autonomy and initiative. Be willing to let off go classroom control.

vii) Use raw data and primary sources , along with manipulative, interactive physical materials.

viii) Don’t separate knowing from the process of finding out.

ix) Insist on clear expressions from students. When students can communicate their understanding, then they have truly learned.

2.8.2 Criticisms of Constructivist Approach

Many criticisms have been labeled against the constructivist learning approach. Cheng (2001) points out that some of the problems associated with the constructivist approach include chaotic classrooms, cultural constraints and the fact that most teachers are used to traditional approaches. Furthermore, the approach emphasizes prior knowledge as the foundation on which students build knowledge. However, if the students are low achievers or posses limited background knowledge, the process of knowledge construction may be greatly hindered. Another problem is little research done to show the best way to handle the alternative constructs once identified (Head, 1989). These challenges can easily be addressed in constructivist classrooms. For instance prior knowledge can be developed if the students are trained on constructivist approaches at an early age. This will make them critical thinkers and problem solvers while they are still young. Effective classroom management will reduce the fear of classrooms turning chaotic. Teacher training institutions could also introduce the constructivist approaches in their training. The present study addressed some of the above shortcomings.

2.9 Instructional Methods Used in Teaching Chemistry in Kenya

Currently a spot check in most classrooms will reveal that teachers are using traditional teaching methods. Proponents of these methods view knowledge as a fixed entity that the students must come to know. They view learners as recipients of knowledge, transmitted by the teacher who acts as a pipeline through which one’s thoughts and meanings find a way into the students’ minds. However, it should be realized that these view subject students to rote learning. This memorized knowledge is not sufficient in the understanding of concepts and in applying them in unfamiliar contexts. Therefore the present study sort to address above challenges. The conventional teaching methods commonly used by chemistry teachers in Kenya include: Lecture method, Discussion method, Teacher Demonstration, Questioning method, Class experiment, Project work and Field work.

2.9.1 Lecture Method

This is an oral presentation of organized thoughts and ideas by a speaker. The teacher in this case assumes that by the process of speech, thought will be initiated, problems will be identified and learners may be made active. The teacher may manage to cover a wide content in a short time and present information in a logical order among other merits (Okere, 1996). However, this method does not take into consideration the learning taking place. There is usually minimal student understanding of concepts discussed in lectures.

In a study on students attitude towards Biology (Prokop, 2007) noted that in order to improve students attitude towards science and mathematics, teachers must direct their lessons away from their traditional methods to a more student centred approaches.

In a study carried out by Obede (1981) on social studies, it was revealed that lecture methods had a negative effect on students' motivation, attitude, content coverage and achievement on both the students and the teachers. It does not stimulate innovation and scientific attitudes. Lecture method encourages students to cram facts which are easily forgotten. Lecture method is not appropriate and ineffective for achieving the high objectives of social studies programme (Adeyemi, 2003). The focus in lectures is usually on the teacher presenting as much content as possible in an orderly way. However, with the shift from transmission to transactional paradigms in education, much focus ought to be on how much learners are able to learn for themselves and with a minimum role from the instructor. Lecture method has several limitations which include the inability for some students to listen for a long time and poor comprehension. In addition, the material to be covered in a lecture may as well be given out in form of handouts. According to Twoli, (2006) lecture method is not appropriate for most secondary school students because their attention span is short.

2.9.2 Discussion Method

This method involves all students in a discussion (usually of a general nature) often structured and frontally led by the teacher. This method helps learners to feel isolated and less nervous through the knowledge that other learners too have the same worries as themselves which help them develop group reliance (Okere, 1996). Discussion method enables students to express themselves, justify opinions and tolerate different viewpoints. Oyedeji (1996) explained that discussion method works on the principle that knowledge and ideas of several people are more likely to find solutions and answers to specified problems or topics. It is also good for objectives like evaluation of ideas, syntheses of personal views and enables learners to understand difficult concepts that go against common sense. However, discussion method has some limitations. For instance all the learners will not have a chance to contribute if it is not well structured. In addition the high ability students may dominate the discussion at the expense of the low achievers. Moreover, a few learners who are shy may feel intimidated in presenting their views to the whole group, forcing them to use rote learning methods and techniques hence impacting negatively on their motivation and attitudes towards the subject. A lot of planning and structuring is needed to ensure success of discussion method. Discussion can get out of hand if not controlled and the class may turn to a market place and confusion if not properly managed. This was the focus of the present study.

2.9.3 Demonstration Method

This involves the demonstration of a technique or a lesson to learners by an instructor or another learner. This may be attractive to learners in that it is an alternative to long and tedious explanations. It also allows the teacher to do what one can do best at teaching (Okere, 1996). Focus in this method is the teachers' preparedness to accomplish a teaching task and not the learners accomplishing the learning content. The real problem with demonstration is that learners must inevitably view them as models and hence tempted to imitate without fully thinking through the worth of the activity or soundness of the technique. White (1996) also talks about students using science knowledge but notes that there is a risk that students miss the links between the theoretical and the practical education. The students marvel at teacher's expertise and view themselves as backwards.

The aim of laboratory lessons is to support meaningful learning by complementing theories and to stimulate development of analytical and critical capacity (Lazarovitz & Tamir, 1994). Demonstration must be accompanied by a thorough explanation which is essentially a lecture. Other problems associated with teacher demonstrations include, the tendency of students to become passive and the possibility of learners missing out the chance to practice manipulative skills. Information does not become knowledge automatically until learners have been actively involved in its processing (Akinleye, 2010). Active participation in the learning process leads to improvement in achievement and attitudes towards a subject.

2.9.4 Questioning Method

The questioning technique is a useful method in chemistry teaching because it can be used on its own, or as part of another method. It should always accompany the lecture method which could then lead to a class discussion. Questions have various aims, a few of them are: get feedback from the students, understand learners’ present level of understanding and also to promote their interest. The problem with this method is that it requires an expert teacher with good questioning skills (Okunniyi, 1984). Too frequent use of questioning may also lead to time wastage due to the possibility of digression from the main lesson objectives (Twoli, 2006).

2.9.5 Class Experiment

Practicals in chemistry involve either the teacher demonstration discussed above or class experiments where the pupils perform the experiments (or class activities). Class experiments are better than other methods because students develop manipulative skills. Hofstein (2004) posits that teachers need knowledge about enabling students to interact intellectually and physically both in hands-on work and minds-on reflection. Many researchers agree that there is need for more research about assessing group learning and interaction during laboratory work and about students’ perspectives on laboratory work (Nakhleh, Polles & Malina, 2002). Furthermore, Eylon and Linn (1988) & Tasker (1981) asserts that to many students a laboratory work means manipulating of equipment but not manipulating of ideas.

The aim of laboratory work is not to demonstrate what has been learnt in the lectures, but rather to enable the pupils to understand the origin of scientific laws (Okere, 1996). The disadvantage of class experiment is that many topics in chemistry are abstracts in nature hence difficult to plan class experiments. Class experiments are also prone to misuse by inexperienced teachers. For instance it is improper to tell learners to go to the laboratory to verify laws, which have already been stated by the teacher because this will inhibit their curiosity and creativity (Okere, 1996). In addition lack of proper planning of class experiments may lead to unworkable experiments which may demoralize learners. Further more, research show that there is no substantive relationship between practical skills tests and written science examination (Al Busaidi, 1992).

2.9.6 Cooperative Learning Approach

This is a program designed for all students in a regular classroom. Students work in small groups of four to six and receive rewards based on group, rather than individual performance. The goal of this module is to raise the academic performance of individual students, teach students to be cooperative rather than competitive, improve the learning of both high and low achievers and improve race and ethnic relations in the classroom. In competitive classrooms, students engage in a win-lose struggle in an effort to determine who is best (Johnson &

Johnson, 1991). Brown et al (1997) and Mercer (1996) concluded that students have to learn strategies for successful learning and that they have to learn about how to cooperate

Cooperative learning is mainly applied to class experiments and may not work well in chemistry topics which have abstract concepts (Wachanga, 2004). In addition, cooperative learning usually emphasizes academic improvement based on group achievement and rewards (Banks & Thomson, 1995). Perrault (1982 & 1983) found out that cooperative learning resulted in significantly higher achievement in industrial arts students at knowledge and comprehension levels but not on application level compared to other methods. Issues concerning misconceptions and clarifications however, cannot be addressed well. Furthermore, cooperative learning does not seem to significantly lead to an improvement in students' attitude and social interactions in chemistry (Merebah, 1987). The current study sort to address the above challenges.

2.9.7 Discovery Learning Approach

Discovery as a way of learning is as old as mankind. From the earliest times, man has continued to be curious about the environment and has made discoveries that have revolutionized human way of life. Today man is still curious, and seeks through science and explorations to solve the problems encountered daily. We can find traces of discovery in the teaching methods of the Greek philosopher Socrates who taught through questions. Socrates refused to provide answers but posed question that forced learners to seek for answers. Discovery learning can be carried out using formal teaching methods but lacks the spontaneity of the real thing; it flourishes under the informal teaching methods. In discovery learning, the teacher presents specific examples, and the students work with the examples until they discover the interrelationships and thus the subjects' structure.

This approach to learning emphasizes the importance of understanding the structure of a subject being studied, the need for active learning as the basis for true understanding and the value of inductive reasoning in learning (Woolfolk, 1995). On discovery learning theory, Bruner (1961) pointed that learning is not only restricted to finding out something that before was unknown to mankind, but rather includes all forms of obtaining knowledge, for oneself by the use of one's mind (Anderson & Ausubel, 1996). According to Bruner, discovery learning is based on four major principles: Motivation, Structure, Sequence and reinforcement. Critics of discovery learning base their arguments on the minimal role assigned to the teacher in the learning process.

The limitations of Discovery learning approach are several. For instance the consequence of assigning minimum role to the teacher may be abused by inexperienced and lazy teachers who may withdraw completely from teaching and lesson planning. Bruner (1978) warns that too much reliance on discovery learning theory may lead to absence of structure both in the classrooms and in the child's conceptual development. The importance of children deriving concepts from a body of material cannot be minimized. However in the absence of structure students may derive wrong concepts making the entire learning process confusing and disastrous. Furthermore, what will students of little background knowledge discover by themselves? The idea of throwing the learner into amaze in which one must re-arrange a given array of information and integrate into the one's cognitive structure is time consuming. In addition, the success of discovery learning approach is not supported by literature (Ausubel, 1977).

The common questions that students ask themselves concerning discovery learning are:- Why discover yet all the information is found in the currently accepted text books? Of what benefit is discovering what is there? It is to be noted that in discovery approach, errors in students' data make identification of patterns very difficult. Bruner also noted that to teach by discovery, the teacher has to present learners with many examples and non- examples so that the learners eventually discover the basic properties of what is to be learned . The challenge however is in a case where examples and non -examples are not there or limited as in the case of chemical "structure and bonding" topic. Head (1989) points out that by 1970 the limitation of discovery learning was quite clear such that concepts like the chemical bond approach were too difficult, almost unteachable in the school context.

2.9.8 Guided Discovery Approach

This theory of learning was advanced by an American psychologist (Ausubel, 1950) in response to the limitation of Bruner's discovery learning. Ausubel dealt with what is called meaningful verbal learning. According to Ausubel, an object has meaning to a learner only when it can be related to an idea already present in the mind. Thus learning involves relating new ideas to existing ones. Ausubel criticized the discovery approaches advocated by Bruner on the grounds that they were time -consuming and limited research evidence to support the claim that they led to superior learning. Indeed, Ausubel's work contrasted with that of Bruner at a fundamental level: The former sees effective learning as arising from presenting learners with organized information whereas latter sees it as taking place when the learner develops the organizational framework.

Ausubel is a champion of meaningful learning as opposed to rote learning and this idea had a lot of influence on constructivism. Ausubel sees the teacher as playing a central role in a learning situation. Ausubel would rather have discovery learning theory termed guided discovery learning. Consequently, the teacher's responsibility is to convey meaningful learning through actual teaching. Ausubel (1963, 1967) stresses that the material can easily be learned if it is logically arranged. In addition the learner must be ready to receive the ideas presented. The learners should have the desire and intent to relate new knowledge to past experiences. Consequently it was suggested that teachers should provide advance organizers before presenting new materials to the learners. Ausubels' approach is preferred by experienced teachers (Woolfolk, 1996) and may not work with the young and inexperienced teachers because of the planning involved. Without proper planning the entire process of guided discovery may turn to be rote learning (Slavin, 1995 & Woolfolk, 1995). Presenting information in a finished form may inhibit discovery and make learning a passive activity. Guided discovery is a form of inquiry teaching approach. Holdzcom and Lutz (1985) reported that when inquiry models of teaching were implemented, they were very effective in enhancing students' performance, attitudes and skill development.

Summers (Ibid) explains that unless the learners already possess the relevant knowledge to which the new material can be assimilated in a meaningful way, then rote learning will result, independently of whether reception or discovery methods are used. In this case discovery methods can be as disastrous as didactic teaching. Although guided discovery learning has influenced educational practice, it is not effective as its enthusiasts thought due to practical problems like class sizes (Slavin,1995). On the other hand, meaningful learning may not be effective because of learners' differences in maturation and background. While the inclusion of inquiry models of teaching in secondary science classroom is desirable, the reluctance on the part of the science teacher to implement the inquiry in the classroom are due to lack of skills and strategies, lack of equipments and materials and the claim that inquiry is only effective with bright students and not beneficial to students lower ability. Nevertheless, Ausubel (1968) work had a great influence on constructivism approaches.

2.10 Research in Chemistry Teaching Methods in Kenya

The teaching method used in any institution of learning is critical in helping students acquire practical skills. This is the reason why employers prefer graduates from colleges which train on practical orientation. The teaching done in most schools emphasize on teacher demonstration since students can observe as experiments are done by the teacher. It is less demanding compared with class experiments in both time and materials. However it is inferior to class experiments because it is teacher centred, allowing little or no participation from the students and lacks feedback (Agboola & Oleyede, 2007). Available literature has little to say on research on the effectiveness of constructivist approach in Chemistry in Kenya. This research study therefore was intended to fill in this gap in the body of knowledge in this area. According to Onwu (1981), teachers of Chemistry are expected to make Chemistry more relevant, enjoyable, easy and meaningful to students.

2.10.1 Students' Achievements in Secondary School Chemistry in Kenya

A steady decline in academic achievement scores of high school students in science as well as low enrolment has caused deep concerns in many countries (Lazarovitz 1996; Oguniyi 1996). The poor performance of students in science subjects has assumed a dangerous dimension. In the light of this, science educators need to seek for suitable ways of tackling the current mass failure if they are to halt the drifts of students to arts and social science subjects (WAEC Report, 1999). The relevance and importance of Chemistry amongst the science subject is formidable, hence the need for proper teaching of the subject in the secondary schools so that students scores in the internal and external examinations will be high, thereby making the candidates' entrance into higher institutions easy. According to Onwu (1981), teachers of Chemistry are expected to make Chemistry more relevant, enjoyable, easy and meaningful to learners. Teaching methods needs to be improved and appropriate teaching strategies employed as the teaching learning situations may demand. Most topics in chemistry are abstract in nature and students find difficulties in understanding them. They cannot relate microscopic world to macroscopic changes which may leads to poor achievement and negative attitude towards the subject (Coll & Treagust, 2003, Harrison & Treagust, 2000; Nicoll, 2001). Therefore, proper method of teaching chemistry is very necessary to enhance students' achievement and attitude towards the subject.

In Kenya for instance, the performance in chemistry in national examinations has remained below average since the year 2000, Table 1. Kithaka (2004) working for the Strengthening of Mathematics and Sciences in Secondary Education (SMASSE) project in Kenya argued that there is a general feeling among students that science subjects are difficult. This feeling according to Kithaka is a result of poor performance at National Examinations where anticipation of negative outcomes blocks or inhibits learning efforts. The saturation of the job market, socio-cultural attitudes and too much theoretical teaching of science are the major sources of discouragements to students. Similarly on the district level, the larger Baringo before it was split into North Baringo and Central Baringo has never achieved a mean score above 5.00, Table 2. Baringo North District had a mean score of 3.37, 3.89 and 3.61 in the years 2008, 2009 and 2010 respectively which has raised great concern among education stake holders.

2.11 Students' Attitude Towards Chemistry

One aim of science education is to help young people understand something of the key ideas in science and gain an appreciation of the importance and impact of science on society. However, pupils' feelings about the science they encounter in their lessons are just as important as the science ideas they learn for these feelings exert a significant influence on their dispositions towards science. Despite several advancement in science and technology, many students are still opting out of science because of their feelings rather than their thoughts. Linder (1992), argues that students perceptions of physics may be affected negatively by the way the subject is presented and this applies to all other subjects. The poor achievement of learners in Chemistry has been variously explained. According to Usman and Memeh (2007), the factors that negatively affect chemistry achievement include students' background problems, lack of interest and or negative attitude towards Chemistry. The teacher related factors includes teacher preparation, inadequate qualified Chemistry teachers, inadequate instructional materials and application of poor teaching methods.

The importance attached to these affective aspects of learning is illustrated by the regular revision and alterations teachers make to their teaching of topics and even of whole courses, in order to try and increase their pupils' engagement with science. This importance extends beyond the desire to make pupils respond more positively in lessons. There can be few people in science education today who are not concerned about the low numbers of student's taking science subjects particularly chemistry and physics in post secondary education. Much of the evidence points to affective factors as being particularly influential in determining subject choices. Research indicates that the instructional methods practiced by mathematics teachers are important predicators of the students' motivation to learn the subject and their mathematics self- concept (Githua, 2000). In a study to investigate the effect of using advanced organizers on student motivation to learn Biology, Shihusa and Keraro (2009) found that the use of advanced organizers increased students' motivation unlike the conventional teaching methods commonly used in classrooms. It is therefore not surprising that a considerable amount of research effort has been devoted to exploring this area. Attitudes boil down to values and the two concepts are very important in daily life because they determine the direction of many activities. If individuals have a favorable attitude towards something they approach it, otherwise they avoid it. Attitudes are properly learned through negative and positive experience and modeling. Pakinson (1994), stressed that it is up to the teachers to ensure that they make science as inviting as possible.

2.11.1 Importance of the Research on Attitudes Towards Chemistry

The findings of research on attitudes will help teachers and curriculum planers to use strategies that can satisfy the natural curiosity of students to enroll in chemistry subjects and science-related courses. Research indicate that curricula which use applications as starting points and which help pupils to see how science relate to their lives is likely to make more pupils respond more positively to science. For instance, pilling (1999) in a study found out that schools moving from a more traditional A-level chemistry course to a context-led course, "The Salters Advanced Chemistry" reported significant increase in numbers choosing chemistry . It is of great significance to note that, there is evidence which demonstrate that pupils see their teachers and the teaching in their science lessons as being important factors in determining how they feel about science (Pitburn & baker, 1993; Woolnough, 1994). Therefore, the way the teacher handles the instructional process has a great impact on the students' attitude towards the subject (Prokop, 2007). Students who go on to study science are likely to cite their teachers and their experiences in science lessons as being the most significant factors in stimulating their interest in science.

2.11.2 How to Gather Information on Attitude Towards Chemistry

Being one of the constructs of the affective domain, attitudes have been researched deeply for more than forty years (Aiken & Aiken, 1969; Koballa & Crawly, 1988). The need for conducting studies related to attitude was undertaken for two main reasons; namely the attitudes' feasible power to predict future behaviours like subject and career preferences of students (Koballa, 1988; Osborne, Simon & Collins, 2003), and the correlation existing between attitude and academic achievement (Shibeci, 1984; Shrigley, 1990; Weinburg, 1995; Osborne & Collins, 2000). In their meta-analysis of attitude related factors that predict future behaviours, Glasman and Albarracin (2006) concluded that there is a correlation between attitude and future behaviours; that is attitudes has a potential for predicting future preferences, especially if there is a direct interaction between participants and the attitude objects (objects that are related to attitude like science lessons). Actually, study that examined the correlation attitudes and academic achievement did not provide consistent results. Schibeci (1984), for instance, found a strong relationship between attitude and achievement. Shrigley (1990), on the other hand, argued that there is only a moderate relationship between attitude towards science and science achievement.

Gardner (1975) made a distinction between a scientific attitudes and attitudes towards science describing the former as a scientific thinking and questioning strategy that can be treated under cognitive domain whereas the latter as a learned tendency to evaluate in certain ways which was the aspect of the present study. The attitude towards science is related to negative or positive feelings about scientific objects and enable prediction of scientific attitude (Koballa & Crawley, 1985). Schibeci (1983) argued that various objects can be related to attitudes like science lessons, scientists or science in real life. Attitudes should be considered as an outcome of science education. Since attitude form and change during a life time of a person, facilitating this process should be an important part of the work of science teachers (Koballa, 1992).

Attitudes are normally a state of readiness or predisposition to respond to a certain stimuli. Attitudes are reinforced by beliefs, often attract strong feelings which may lead to particular behavioral intents. In other words, attitudes are a function of what one knows, feels about it and how it influences likely behaviour.

In order to gather data on attitudes of students towards Science we need to focus on the following strands or constructs as pointed out by (Smith1994, pp. 191-200)

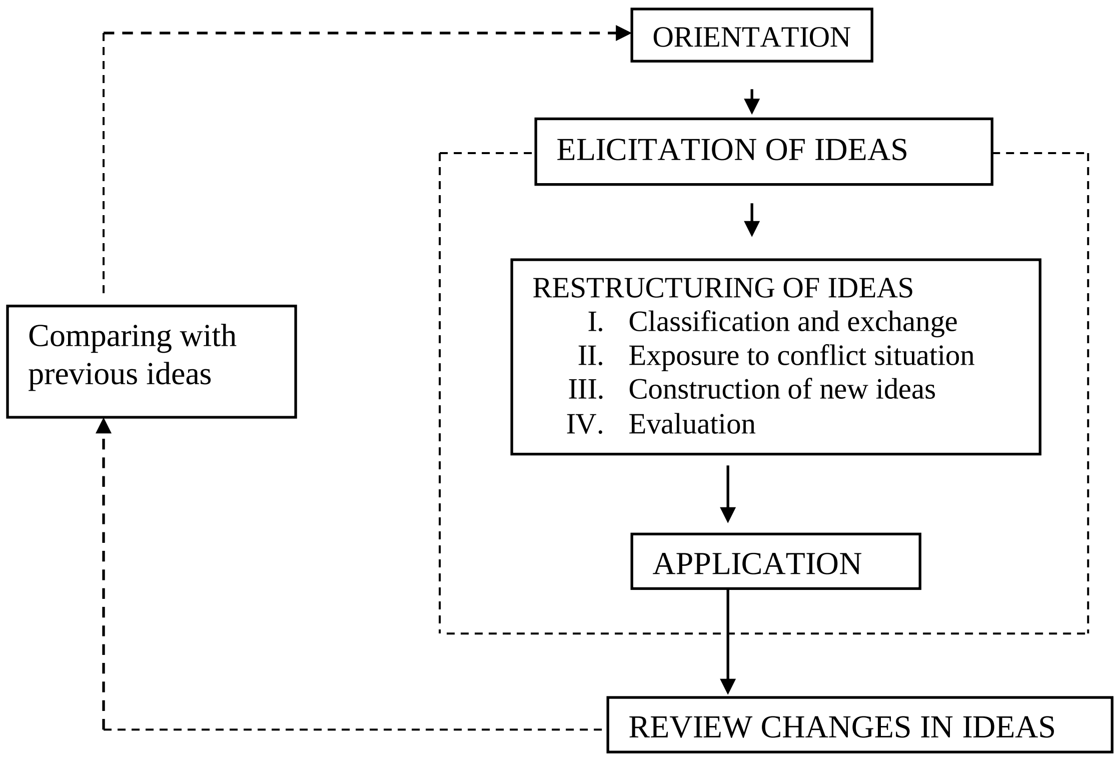
(i) Disposition towards school science (chemistry)
(ii) Disposition towards science outside the school (chemistry outside school)
(iii) Disposition towards the relevance and importance of science (chemistry) to everyday life
(iv) Disposition towards scientists (chemists)
(v) Disposition towards scientific careers (chemistry careers)

A number of different methods may be used to gather data on attitudes. A fairly consistent feature of attitude research has been the use of instruments called attitude inventories, designed to gather written, fixed response data which lend itself to quantitative analysis (Hadden & Johnstone, 1983; Koballa, 1984; Qualter, 1983 & Hendley., 1985). For the purpose of this research, the Likert type scales was used which invites responses on a 5-point scale because it can accurately address the issues of reliability and validity.

2.12 Theoretical Framework

This study was based on the constructivist view of learning which emphasizes the active role of learners in constructing their own knowledge (Glasersfield, 1989). In this view learners construct knowledge by integrating existing knowledge with new experiences. Therefore learning involves processing of information as the learners try to use what they already know to construct meaning of new experiences (Driver, 1989). In the constructivist classroom where students are encouraged to make meaning, they are generally involved in developing and restructuring their knowledge schemes through experiences with phenomena through exploratory talk and teacher interventions (Driver, 1989). Knowledge is constructed within an interactive environment where students interact with one another or with the teacher to come up with new meanings.

Figure 1, illustrates the teaching sequence where learners through small interactive groups negotiate meanings of concepts captured in the topic "Structure and Bonding".



Source: Driver (1986) in Keraro (2002)

Figure 1: Teaching sequences of constructivist approach

The sequence of the approach captures the various stages in which the constructivist teaching approach enhances the construction of new knowledge or understanding. The level of students' achievement in knowledge acquisition is determined by a number of factors; the nature of interactions between the learners, their prior learning, the new information to be learned and the learners' readiness to learn. This approach is considered relevant to the study because the research investigates the meanings of "Structure and Bonding" that learners bring to the classrooms. An attempt was made to make students alter their meanings of "bonding" where necessary through negotiations and discussions. The overall effect of the approach was assessed through asking learners to apply "Structure and Bonding" concepts in various contexts. The success of the application was assessed by the teachers whose roles were diagnostic. All these activities are suggested by the constructivist model.

Phases in the Teaching Sequence

The teaching sequence proposed by Driver (1989) consists of five major phases; orientation, elicitation of ideas, restructuring, application and review.

(i) Orientation

This is the introductory phase. For introduction to be effective, relevant and appropriate set of ideas are presented. Here, students are motivated to learn the topic and prepares them for the activity by creating interest, curiosity and connections (Lawson, 1995).

(ii) Elicitation of Ideas

In this phase the learners' prior knowledge is brought out. The learners' ideas on the topic to be covered are brought out. This can be made possible through the use of open–ended questions. In this phase, ideas are clarified through discussions (Driver & Oldham, 1986). This gives the learners the chance to relate what is taught to what they already know. The teacher accepts the learners' ideas for they form the basis for further discussion and other activities aimed at the construction of meaning. In other words provide learners with situations which challenge their existing thinking.

(iii) Restructuring of New Ideas

The teacher presents activities aimed at enabling the learners to construct new meanings on the topic under discussion (Appendix D). This can be done through the use of external experience or use of alternative models. This is in line with the suggestions made by Demirel (2001) who said that teachers in the constructivist learning environment should support their teaching with interactive teaching materials. These teaching materials enable the construction of meaning, strengthen teaching / learning process and ease the learner's understanding as well (NCSS, 1994). The students' activities would be conducted through discussions in collaborative groups and then ideas presented by one of the group members to the rest of the class. The teacher acts as a facilitator in the exchange of views among the students. The teachers' role is to keep the discussion focused and orderly. In this phase the teachers lead the learners through discussions and clarifications to change their initial ideas in the light of new outcomes (Driver & Oldham, 1986).

(iv) Application of Ideas

The students at this phase attempt to apply the constructed knowledge in new contexts. The teacher can further explain the new ideas using relevant examples. According to Banet and Nuňez, (1997), this phase is intended to consolidate and validate changes in student thinking. It involves applying concepts to real life situations.

(v) Review of Changes in Ideas

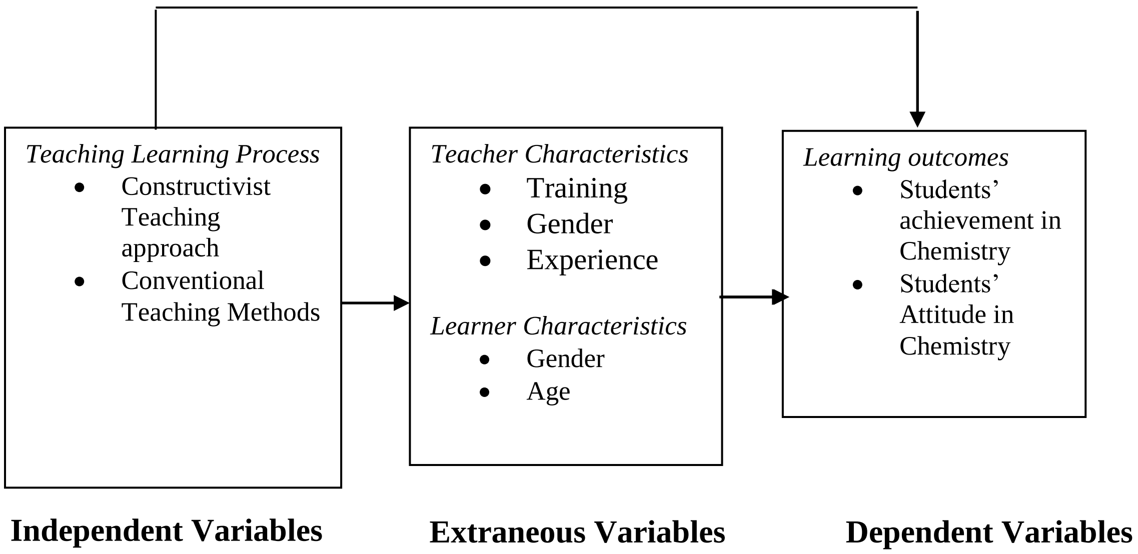
The students' earlier ideas are compared with the new constructions. This phase helps to determine the context to which new knowledge has been constructed. A proper implementation of this teaching sequence will enhance the achievement of meaningful learning. Learners through small interactive groups will negotiate meaning of particular concepts effectively. This phase gives the learners opportunity to reflect on how their ideas have changed (Driver & Oldham, 1986).

2.13 Conceptual Framework.

The conceptual framework that guided the study is based on the Systems Approach (Joyce & Weil, 1980) which holds that the teaching and learning process is dynamic and has inputs and outputs. The best results are achieved when the most suitable materials are fed into the teaching - learning system in the best possible way. The study is based on the assumption that a teaching method that involves students' cooperation and activity was more likely to lead to worthwhile learning than a transmission teaching method (Haurahan, 1998). The failure of students to learn concepts rests on the quality of instructions and not due to their abilities (Bloom, 1981; Levine, 1985). The study therefore involved the guided discovery approach in which the teacher plays a role in planning and facilitation of learning.

The framework is represented diagrammatically in Figure 2. The figure shows the relationship of variables for determining the effect of using constructivist approach on secondary school students' achievement and attitude in chemistry. The extraneous variables which include teacher characteristics, learner characteristics and classroom environment were controlled. The teacher training determines the teaching approach a teacher uses and how effective the teacher will use the approach. The learners' age and hence their class, determine what they are taught. The type of school as a teaching environment affects the learning outcomes. The study involved trained chemistry teachers so as to control for the teacher experience. The type of school was co-educational to control the effect of the environment. Form two boys and girls who were approximately15 years of age were involved in the study.

In this study therefore the teaching method used was expected to influence the learning outcomes.



Source: Adopted from Chepchieng (2004)

Figure 2: Conceptual Framework for determining the effect of Constructivist teaching Approach.

The dependent variables are achievement and attitude while the independent variables are the conventional teaching method and the constructivist teaching approach. The extraneous variables are teacher training, teacher's gender, teaching experience, learners' age and gender. These variables have the potential to influence the independent variables which in turn would affect achievement and attitude towards chemistry. These variables were controlled by having experienced trained teachers at degree level who had taught for at least three years. The schools considered were co-educational so as to control gender variation. The age of students was controlled by taking Form Two students which were assumed to be of the same age. The gender of the teachers was controlled by ensuring that the teachers involved were all males of equivalent training and experience. This was achieved by using purposive sampling method.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter focuses on the methodology used in the research study, population of study, sampling procedures, sample size, instrumentation, data collection, and data analysis procedures. The items on “Structure and Bonding” topic are cited as among the most poorly performed by candidates in Kenya Certificate of Secondary Examinations. This may be attributed to the limited understanding of concepts in the topic, hence the focus of the present study.

3.2 Research Design

The study involved the Solomon Four Non-Equivalent Control Group Research under quasi experimental research design as shown in Figure 3. In secondary schools in Kenya, once classes are constituted they exist as intact groups and school authorities do not normally allow them to be broken up and reconstituted for research purposes (Borg & Gall, 1989; Fraenkel & Wallen, 2000). This design has advantage over others since it controls the major threats to internal validity except those associated with interaction of selection and history, selection and maturation and selection and instrumentation (Cook & Campbell, 1979). In this study no major event was expected in the sampled schools to introduce the threat of history and interaction. The conditions under which the instruments was administered was kept as similar as possible across the schools in order to control instrumentation and selection. The schools was randomly assigned to the control and treatment groups to control for selection, maturation and interaction (Aryl; Jacobs & Razavich, 1992).

Group I	O_1	X	O_2
Group II	O_3	_	O_4
Group III	_	X	O_5
Group IV	_	_	O_6

Source: Fraenkel and Wallen (2000 p.291)

Figure 3: Solomon Four Non-Equivalent Control Group Research Design.

Where O_1 and O_3 were pre-test; O_2, O_4, O_5, O_6 were the post -test; X was the treatment where students were taught using the constructivist approach. The dotted line implies involvement of intact groups. Group I was the experimental group which received the pre-test, the treatment X and the post-test. Group II was the control group, which received a pre-test followed by the control condition and then the post-test. Group III received the treatment X and post-test but did not receive the pre-test. Group IV received the post-test only since it was a control group. Groups I and III were taught using constructivist approach while Group II and IV were taught using the conventional methods. The pre-test measured the students' initial concepts on the structure and bonding topic while the post-test measured the students' achievement in the topic after being taught by either the constructivist or the conventional teaching approaches.

3.3 Population of the Study

The target population consisted of all Form Two students in Baringo North District while the accessible population consisted of all Form Two students in the district co-educational public secondary schools category. There are 25 secondary schools in Baringo North District of which 12 are district co-educational public secondary schools. The performance in chemistry in the district has been very low which means many students finishing secondary schools may not go on to enroll in chemistry related courses in institutions of higher learning.

3.4 Sampling Procedures and Sample Size

The study involved public co-educational secondary schools because they are the majority in the district and their performance has been low. The unit of sampling was the secondary school rather than the individual learners because secondary schools exist as intact groups (Borg & Gall, 1989). This therefore meant, that each school was considered as one group. The list of the co-educational schools in the district formed the sample frame. The researcher made a visit to the schools to ascertain their suitability for the research. During the visit the researcher established the training level of the teachers, gender and the number of students per class. Purposive sampling technique was used to select four secondary schools that formed the sample of the study. The four schools provided the four groups. This sampling method was used so as to minimize experimental contamination (Fraenkel & Wallen, 2000). The four schools were randomly assigned to treatment and control groups. For schools having more than one Form Two streams, all the streams were taught using similar method of teaching because of ethical reasons and then simple random sampling was used to pick one stream for the study. The sample size constituted four co-educational schools purposively selected. Each school provided about 40 students making a total sample size of 160 students, Table 3. Fraenkel and Wallen (2000) recommends at least 30 subjects per group. Hence this number was adequate for the study. The schools were then randomly assigned to treatment and control groups.

Table 3

Distribution of Students' Sample by Teaching Method

Group	N	%
Control 1(C_1)	43	26.9
Experimental 1 (E_1)	38	23.8
Control 2 (C_2)	39	24.4
Experimental 2 (E_2)	40	25.0
Total	**160**	**100**

3.5 Instrumentation

Two instruments were used to collect data to meet the objectives of the study. The instruments were Chemistry Achievement Test (CAT) on "Structure and Bonding" topic (Appendix A) and Students Attitude Scales (SAS) (Appendix B), to determine the students' attitude towards Chemistry. The Chemistry Achievement Test (CAT) was constructed by the researcher based on the KCSE Chemistry questions of the previous years on Structure and Bonding topic and moderated by two Chemistry teachers who were Chemistry National markers and then validated by three experts in the Curriculum Instruction and Education Management Department of Egerton University. It contained twenty multiple choice items to measure students' achievement in Chemistry. Each item contains only one single answer and three distracters. The Students' Attitudes Scales (SAS) consisted of 44 close ended Likert type items. A score of 1(lowest) was awarded to Strongly Disagree (SD) response while a score of 5 (highest) was awarded to Strongly Agree (SA) response.

3.5.1 Validation of Instruments

The instruments were pilot-tested in a secondary school within Baringo North District but in a Division that was not included in the study but having similar characteristics as the sample schools. This was done after being validated by the candidates' Supervisors and other experts from the Curriculum Instruction and Educational Management Department of Egerton University.

3.5.2 Reliability of Instruments

The Chemistry Achievement Test (CAT) was pilot tested on an independent group of Form Two students in Baringo North District to ascertain its reliability. The reliability coefficient was calculated using the Kuder-Richardson formula 21(K-R 21) (Gronlund, 1981). This is because items were scored zero (0) for wrong response and one (1) for correct response. This method was appropriate because the data is continuous and the instruments is administered only once. It yielded a reliability coefficient of 0.7823. The Cronbach's coefficient alpha was used to estimate the reliability coefficient of Students' Attitude Scales (SAS). This is because the items were of Likert type and also the instrument is administered once. It yielded a coefficient of 0.7591. Both CAT and SAS were used during the study because their reliabilities were well above 0.70 threshold as recommended by Fraenkel and Wallen (2000).

3.6 Data Collection Procedures

The researcher got an introductory letter for the research from Egerton University Board of Post Graduate studies and thereafter sort for permit from the National Council of Science and Technology, District Commissioner and District Education Office Baringo North to carry out the research. Consequently the researcher got in touch with the school Headteachers who then introduced the researcher to the Chemistry teachers. The content of the study used in this research was based on the revised Chemistry syllabus (KIE, 2005). A guiding manual based on the above syllabus was constructed for the teachers involved in administering the constructivist teaching approach and was used throughout the treatment period (Appendix C). The teachers of the experimental groups was each trained by the researcher for one day on how to use the manual. Each of these teachers taught using the constructivist approach on a different topic other than "Structure and Bonding" for one week to enable them to master the skills. After that period the pre-test was administered to Group I and Group II by the researcher assisted by the Chemistry teachers in the respective schools. Treatment period took three weeks as recommended in the syllabus. At the end of the treatment period a post-test was administered to all the groups by the same teachers assisted by the researcher. In this study CAT was used to collect data on students' achievement in chemistry while SAS was used to collect data on students' attitude. The researchers then scored the pre-test and the post-test and generated quantitative data which was analyzed.

3.7 Data Analysis Procedures

Items in CAT was scored (1) for correct response and (0) for wrong response while items on SAS (5) was the highest score while (1) was assigned to the lowest score. The data collected from this study was analyzed using descriptive and inferential statistics. Through descriptive analysis raw data were summarized using means, standard deviations frequencies and percentages. The two hypotheses were tested using t-test, ANOVA and ANCOVA using KCPE scores as covariates at 0.05 alpha level of significance. This was to determine whether the differences between the experimental and control groups were significant. ANOVA was used to determine if the four groups differed significantly among themselves on experimental variables, while t-test was used to test differences between pre-test and post-test mean scores because of its superior quality in detecting differences between two groups. These tests were done using SPSS computer package.

Table 4

Summary of Data Analytical Procedures for the Study

HYPOTHESES	**INDEPENDENT VARIABLE**	**DEPENDENT VARIABLE**	**STATISTICAL TEST**
$H_0 1$ – There is no significant difference in students' achievement in structure and bonding topic in Chemistry between those exposed to constructivist approach and those exposed to conventional teaching methods.	**Teaching approach.** - Constructivist - Conventional	Students' means score in CAT.	ANCOVA ANOVA t-test
$H_0 2$ – There is no significant difference in students' attitude towards structure and bonding topic in Chemistry between those exposed to the constructivist approach and those exposed to conventional teaching methods.	**Teaching approach.** - Constructivist - Conventional	Students' means score in SAS	ANCOVA ANOVA t-test

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results of the study. It begins with a summary of the characteristics of the sample. This is followed by CAT and SAS pre-test analysis, effect of Constructivist Teaching Approach (CTA) on CAT and effect of Constructivist Teaching Approach (CTA) on students' attitudes measured by (SAS).

4.2 Characteristics of the Sample

The target population of the study consisted of all Form two students in Baringo North District while the accessible population was Form Two students in the district co-educational public secondary school category. The sample size was 160 students as shown in Table 3. The average age of the students was 15 years, which makes the sample a true representative of Form Two students in Kenyan secondary schools.

4.3 CAT Pre- test Analysis

A pre- test was conducted to find out whether the students selected for the study had similarities before being exposed to the topic Structure and Bonding. Students in Experimental group (E_1) and Control group (C_1) were subjected to pre-test on the Chemistry Achievement Test (CAT) and Students' Attitude Scales (SAS). Pre-test analysis was done using t- test, Table 4.

Table 5

Pre-test Analysis by Teaching Approach

Scale	Group	N	Mean $\bar{X}$	SD	df	t- value	p-value
CAT	C_1	43	5.40	1.62	79	2.30	0.02*
	E_1	38	4.55	1.67			
Attitudes	C_1	42	2.69	0.27	79	1.79	0.08
	E_1	39	2.81	0.31			

(t_{CAT} df = 79, t critical = 1.66, $p < 0.05$)

(t_{SAS} df = 79, t critical = 1.66, $p > 0.05$)

* Denotes significant at $P < 0.05$, otherwise not significant

From the pre-test analysis on CAT, the mean score ($\overline{X}$=4.55, SD=1.67) of group E_1 is less than ($\overline{X}$=5.40, SD=1.62) of C_1. It was found out that both groups' achievement levels in this unit were law before the experiment. Also the results in the table revealed that E_1 and C_1 are not similar since their mean scores are significantly different at t (79)=2.301, P<0.05. On the other hand the SAS mean scores ($\overline{X}$=2.81, SD=0.31) of Group E_1 is greater than ($\overline{X}$=2.69, SD=0.27) of group C_1. The results on attitude also are very low before the experiment with regard to chemistry. This results, however reveal that the two groups E_1 and C_1 are similar at entry point since their mean scores are not significantly different at (t (79) = 1.79, P > 0.05). Ideally, at the start of a programme, groups should be similar. However, when dealing with intact classes, the ideal situation is not usually realized. This implies that these differences have to be taken care of with appropriate statistical tools which are ANCOVA and covariates during post-test analysis. The differences in CAT achievement at entry point could be due to the variations in the availability of teaching and learning resources.

4.4 Effects of CTA on Students Achievement in Chemistry

The effect of CTA on CAT was established by conducting a post-test and gain analysis. The purpose of gain analysis is to show which of the groups E_1 and C_1 gained more after undergoing the course. Post-test analysis tested the differences among the groups, thus revealing which one performed better. The gain analysis involved finding out the gain of each group by determining the differences between post-test and pre-test out of a maximum of 20. It tests the differences in gain between the two groups, Table 6.

Table 6

CAT Post-test Mean Gain by Teaching Approach

Scale		**C1**	**E1**
Pre-test	N	43	38
	$\overline{X}$	5.40	4.55
	SD	1.62	1.67
	Post-test N	43	38
	$\overline{X}$	9.35	11.37
	SD	2.35	1.87
	Mean Gain	3.95	6.82

Pre-test CAT score of C_1 was found to be 5.40 while that of E_1 was found to be 4.55, each out of a maximum score of 20. This shows that C_1 mean score was higher than that of E_1. On the other hand, the post-test CAT mean score of C_1 was found to be 9.35 while that of E_1 was 11.37 out of a maximum of 20. The mean gain of E_1 is greater than that of C_1 which means the experimental group E_1 improved more than the control group C_1. However, the results in the table do not show whether this difference in improvement is significant. Consequently, it was necessary to check whether the difference was statistically significant at 0.05 alpha level of significance. The results of the comparison of the mean gain of E_1 and C_1 are shown in Table 7.

Table 7

Comparison of Mean Gain of E_1 and C_1 Groups on CAT

Group	N	Mean Gain	df	t-value	P-Value
C_1	43	3.95	79	5.37	0.00*
E_1	38	6.82			

(t_{table} = 1.66, df = 79, $p < 0.05$)

From Table 7, the mean gain by using t-test is significant at 0.05 alpha level of significance. This significance in mean gain of Experimental group E_1 over the Control group C_1 is attributable to the treatment. This means, despite the fact that E_1 had lower mean score on the pre-test than the C_1, they managed to score higher in the post- test on CAT. This implies exposure to treatment enhanced learning. This can be explained by the fact that the constructivist teaching approach allows students to actively interact in small groups, solve problems and construct their own knowledge. Under the CTA, the teacher acts as a facilitator. These results are in agreement with the findings of Wells and Mejia -Arauz (2006) who pointed out that there is increasing agreement among those studying classroom activities that learning is likely to be most effective when students are actively involved in the dialogue and construction of meaning that are significant to them.

4.4.1 CAT Post-test Analysis by Teaching Approach

The gain analysis in the previous section involved C_1 and E_1 only. Its results suggested that the use of CTA was moderately effective in enhancing learning in the experimental group E_1. After being taught the (Structure and Bonding) topic, all the four groups E_1, C_1, E_1 and C_2 were post-tested. The CAT post-test mean scores of each group is given in Table, 8.

Table 8

Post-test Analysis

Group	N	Mean $\bar{X}$	SD
C_1	43	9.35	2.45
E_1	38	11.37	1.87
C_2	39	8.77	1.98
E_2	40	10.30	2.00

The data shows that the Experimental group E_1 had the highest mean score ($\bar{X}$=11.37, SD=1.87) followed by E_2 ($\bar{X}$=10.30, SD=2.00). The results show that the Experimental groups did better than their control counterparts. This findings show that the constructivist teaching approach enables students to better understand scientific concepts related to structure and bonding. This results are in agreement with earlier findings. In studies where constructivist teaching approach was used, it has been shown that constructivist teaching strategies were effective in enhancing students' understanding and achievement. For example, Niaz (1995) studied on dialectic constructivist framework based on cognitive conflict for freshman chemistry students. The researcher noted that students exposed to cognitive conflict method were more successful than those exposed to the traditional methods of instructions. However the results in Table 8 do not show whether these differences are significant or not. There was need for ANOVA analysis, Table 9.

Table 9

One-way ANOVA of Students' post-test CAT Mean Scores

Scale	SS	df	Mean Score	F- values	P-values
Between groups	151.17	3	50.39	11.80	0.00*
Within groups	665.93	156	4.27		
Total	**817.10**	**159**			

($p<0.05$, df = 3, f = 11.80)

One-way ANOVA was used on students' post-tests CAT scores to estimate the effects of constructivist teaching approach on students' achievement in Chemistry, Table 9. The differences in achievement among the four groups were significant ($F(3,156) = 11.804$, P<0.05). However, the results do not reveal where the differences are. It was therefore necessary to carry out the post hoc analysis (multiple comparison test), Table 10.

Table 10

Multiple Comparison Test (Sceffes' Post hoc Analysis) using ANOVA

(1) Learning Approach		(J) Learning Approach	Mean differences	p- value
E_1	V/S	C_1	2.02*	0.00*
E_1	V/S	E_2	1.07	0.16
E_1	V/S	C_2	2.60*	0.00*
C_1	V/S	C_2	0.58	0.66
E_2	V/S	C_2	1.53	0.02*
C_1	V/S	E_2	-0.95	0.23

* (p<0.05 represents a statistical significant difference)

From Table 10, the E_2 mean is greater than that of C_1 but not significant contrary to expectations. The reason is that the mean score of C_1 at entry point was found to be higher as compared to the mean score of $E_{1,}$Table 5.

Ideally, at the point of entry, all the four groups are suppose to be similar. However, the design (Solomon Four) only C_1 and E_1 are pre-tested. It is thus not possible to know the entry behaviour of E_2 and C_2. In the Post test analysis, using ANOVA, the entry behavior was not taken into consideration. In order to take care of entry behaviour differences of the four groups, the ANCOVA test was done using KCPE mean scores as covariate. The groups mean score after being adjusted by the covariate is given in Table 11.

Table 11

The Adjusted Post-test CAT Mean Scores Using K.C.PE Marks as Covariate

Group	**Mean** $\bar{X}$	**SD error**
C_1	9.35	0.32
E_1	11.35	0.36
C_2	8.78	0.34
E_2	10.32	0.34

The mean scores of the Experimental groups are higher than those of the Control groups as expected (E_1 = 11.35, E_2 = 10.32, C_1 = 9.35 and C_2 = 8.78). These mean scores alone cannot show whether they are significant or not. To determine whether the differences amongst the groups were statistically significant, the ANCOVA test was conducted using the KCPE mean scores as covariates. ANCOVA analysis is able to neutralize any initial differences that may have existed before the treatment. The results of the tests are shown in Table 12.

Table 12

Test of Differences Using Analysis of Covariance (ANCOVA)

Scale	SS	df	Ms	F-value	P- value
Contrast	141.11	3	47.04	10.95	0.00*
Error	665.82	155	4.30		

(F = 10.95, df = 3, p<0.05)

The results above shows that the differences between the Experimental and the Control groups are significant (F(3,155) = 10.950, P< 0.05). The ANCOVA results show that the students taught by the constructivist approach achieved significantly higher than their control counter parts. In the constructivist approach, the students constructed their own knowledge as they interacted with each other, with their teachers and with material presented. The students were active, their roles being to organize knowledge and the learning environment. They also carry out learning activities and monitor their own learning (Iran - Nejad, 1995). In the traditional learning, information cannot be permanent because it is only memorized for exams and is easily forgotten. In the traditional teaching approaches, information is understood either imperfectly or wrongly hence cannot be applied to real life situation (Deryakulu, 2000; Gaglon & Gollay, 2001). These results however do not reveal where the differences are. It was therefore necessary to carry out the multiple comparison analysis, Table13.

Table 13

Table of CAT Post- test Mean Scores Multiple Comparison using ANCOVA

(I) Learning Approach		(J) Mean learning Approach	Mean Differences	p- value
E_1	v/s	C_1	2.00	0.00*
	"	E_2	1.03	0.05*
	"	C_2	2.57	0.00*
C_1	"	C_2	0.57	0.22
C_1	"	E_2	-0.97	0.04*

* p< 0.05 represents a statistical significance difference.

The results in Table 13 showed that the use of constructivist teaching approach resulted in higher student achievement compared to the conventional teaching methods since E_1 and E_2

mean score obtained were significantly higher. Therefore, the null hypothesis (Ho1) was rejected which states that there is no statistically significant differences in students' chemistry achievement between those exposed to constructivist teaching approach and those not exposed to it.

4.5 Pre-test Analysis of Students' Attitudes

A pre- test was conducted to find out whether the students selected for the study had similar attitudes towards the learning of chemistry before being exposed to the topic Structure and Bonding. Students in experimental group E_1 and control groupC_1 were subjected pre- test on the Student's Attitude Scales (SAS) which has a maximum of 5 points and 1 point being the least. Pre- test analysis was done using t- test, Table 5. From the results, it can be seen that the students mean scores on attitudes E_1 ($\overline{X}$=2.81, SD = 0.31) is higher than that of the control group C_1 ($\overline{X}$=2.69, SD = 0.28). This alone does not reveal whether the difference is significant. However, from the t-test analysis, at 0.05 alpha level of significance, it can be seen that $t(79) = 1.79$, $P>0.05$ which shows the difference is not significant. This means that the two groups were similar at the start of the programme. This means the two groups were appropriate for the study.

4.6 Effects of CTA on Students' Attitudes Towards Chemistry

The effects of CTA on Students attitudes was established by conducting a gain and post-test analysis. The purpose of gain analysis was to show which of the groups E_1 and C_1 gained more on attitude after undergoing the course. Post-test analysis tested the differences among the groups thus revealing which one performed better. The gain analysis involved finding out the gain of each group by determining the difference between post-test and pre-test mean scores. It tests the differences in gain between the two groups, Table 14.

Table 14

Post-test and Mean Gain Analysis on SAS by Learning Approach

Scale	C1	E1
Pre-test		
N	42	39
$\overline{X}$	2.69	2.81
SD	0.27	0.31
Post- test		

N	42	39
$\overline{X}$	2.98	3.11
SD	0.32	0.26
Mean Gain	0.28	0.31

Pre-test SAS mean scores of C_1 was found to be 2.69 while that of E_1 was found to be 2.81. This shows that C_1 mean score was lower than that of E_1. On the other hand, SAS post-test mean score of C_1 was 2.98 while that of E_1 was 3.11, showing that the experimental group, E_1 gained more in attitude (mean gain 0.31) than the control group, C_1 (mean gain 0.28). This result however does not reveal whether the difference between the groups is significant or not. It was therefore necessary to carry out a t-test analysis, Table 15.

Table 15

A Comparison of Mean Gain of E_1 and C_1 Groups on SAS

Group	N	Mean Gain	df	t-value	p-value
C_1	42	0.28	79	0.24	0.81
E_1	39	0.31			

(t_{table} = 1.66, df = 79, p> 0.05)

The t-test results on mean gain, Table 15, t(79) = 0.236, P>0.05 shows that the mean gain difference is not significant at 0.05 alpha level of significance. This means that the two groups gained similarly. This is contrary to expectations because E_1 was expected to gain significantly more than C_1 on attitude after the course (Ethuk, 2011 & Uzuntiryaki, 2004). The reason for this contradiction may be due to the implementation of the CTA. For instance, the favourbale conditions may not have been provided fully like proper grouping of students, availability of facilities and adequate teacher guidance.

4.6.1 SAS Post-test Analysis by Teaching Approach

The gain analysis of SAS in the previous section involved C_1 and E_1 only. Its results suggested that the use of CTA led to more gain in students' attitudes in the Experimental group E_1 than the Control group C_1. However, this gain was not significant contrary to expectations. This necessitated further analysis by use of ANOVA. After being taught the "Structure and Bonding" topic, all the four groups E_1, C_1, E_2 and C_2 were post-tested. The SAS post-test mean scores of each group are given in Table 16. The table shows the post test mean scores of the 4 groups and their standard deviations

Table 16

Students' SAS Post-test Mean Scores

Groups	**N**	**Mean** $\bar{X}$	**SD**
C_1	42	2.98	0.32
C_2	49	2.97	0.30
E_1	39	3.11	0.26
E_2	38	2.78	0.54

These results show that out of a maximum of 5, the Experimental group E_1 ($\bar{X}$=3.11, SD= 0.26) had the highest mean score on attitude followed by Control group C_1($\bar{X}$=2.98, SD=0.32) then C_2($\bar{X}$=2.9, SD=0.30). The Experimental group E_2($\bar{X}$ =2.78, SD=0.54) had the lowest mean scores on attitude. Contrary to expectation, the mean of the experimental group E_2 was lowest on attitude. The possible reason that can account for this is the availability of resources. For instance CDF funded schools have better resources hence expected to have better achievement and consequently higher students' attitudes towards science than those which are not supported. This is in agreement with Etuk & Etuk, (2011) who found out that the constructivist teaching approach led to a higher achievement in science among primary school students in urban schools than in rural schools because the former had better science resources. Another possible reason is that, the experimental group E_2 might have been a low ability class as compared to either E_1, C_1 or C_2. This can be a possibility because E_2 was not pre-tested, hence little is known about the groups' entry point. Other factors that can account for this observation include the implementation of the CTA, the general nature of the school and the learning environment. The results in table 16 however, did not reveal whether the difference was significant. To determine this, one-way ANOVA was used on students' post-test SAS mean scores to estimate the effect of CTA on students' attitudes towards Chemistry, Table 17.

Table 17

One-way ANOVA of Students' Post-test SAS Mean Scores

Scale	Sum of squares	df	Mean scores	F-ratio	P-value
Between group	1.82	3	0.61	4.95	0.00*
Within groups	18.89	154	0.12		
Totals	20.71	157			

* ($p<0.05$, df = 3, F = 4.95)

The results in table 17 reveal that the difference in attitudes among the four groups were significant ($F(3,15) = 4.95$, $P<0.05$). However, the results did not reveal where the differences are. It was therefore deemed necessary to carry out the post hoc test (multiple comparison test), Table 18.

Table 18

Multiple Comparison test (Scheffes' Post hoc) using ANOVA

Groups	Mean difference	P- value
C_1 V/S C_2	0.01	1.00
C_1 V/S E_1	-0.14	0.36
C_1 V/S E_2	0.19	0.16
C_2 V/S E_1	-0.15	0.28
C_2 V/S E_2	0.19	0.17
E_1 V/S E_2	0.33	0.00*

* $p< 0.05$ represents a statistical significant difference

The results show that there are no significant differences in students' attitudes towards chemistry between the groups except between E_1 and E_2 in favour of E_1. This means E_2 did poorly compared to E_1. This was not expected. The results however were not considered conclusive as the entry behavior of E_2 was not determined hence it was not pre-tested. The weakness of ANOVA is that it cannot deal with differences at entry point. This necessitated the adjustment of the post-test mean scores using the ANCOVA with K.C.P.E scores as covariate before comparison. The adjusted means are given in the Table 19.

Table 19

The Adjusted SAS Post-test Mean Scores

Group	Mean $\bar{X}$	SD

C_1	2.98	0.06
C_2	2.97	0.06
E_1	3.09	0.06
E_2	2.80	0.07

The adjusted means score of E_1 ($\overline{X}$=3.085, SD=0.06) was the highest followed by those of C_1 ($\overline{X}$=2.98, SD=0.06) and C_2 ($\overline{X}$=3.97, SD=0.06) respectively. E_2 ($\overline{X}$=2.80, SD=0.07) had the lowest mean score. The possible explanation for this reason is because of the nature of the school in terms of the facilities and the implementation of the CTA approach. E_2 was not pre-tested and must have been a low class academically. The results did not however reveal whether the difference among the means were significant or not. This was determined using ANCOVA analysis with K.C.P.E marks as covariate, Table 20.

Table 20

Test of Differences Using ANCOVA

Scale	SS	df	Means score	F- ratio	P-value
Contrast	1.21	3	0.40	3.21	0.03*
Error	18.22	145	0.13		

(F=3.21, df = 3, $p<0.05$, * represents a statistical difference)

Using ANCOVA analysis, the results showed that the difference between the groups were significant ($F(3,145) = 3.21$, $P<0.03$). The results however do not reveal where the differences are. It was therefore deemed necessary to perform the multiple comparison test, Table 21.

Table 21

Multiple Comparison test (Scheffes' post hoc) using ANCOVA

Group	Mean difference	P-value
C_1 V/S C_2	0.010	0.968
C_1 V/S E_1	-0.110	0.176
C_1 V/S E_2	0.180	0.045*
E_2 V/S E_1	-0.290	0.002*
C_2 V/S E_2	0.170	0.048*

C_2 V/S E_1	-0.110	0.183

* (p<0.5 represents a statistical difference)

The results in Table 21 reveals that the difference between the mean scores of the paired groups; C_1 versus E_2, (p=0.045), E_2 versus E_1, (p= 0.002) and C_2 versus E_2, (p=0.048) were significant at 0.05 level. However, the difference between the paired groups C_1 versus C_2, (p=0.968), C_1 versus E_1, (p=0.176) and C_2 versus E_1, (p=0.183) were not significant. From the results, the groups C_1 and C_2 were similar as measured by SAS Post-test. On the other hand, E_1 and E_2 are not similar since E_1 had a higher mean score than E_2. Also C_1 is not similar to E_2 but C_1 is similar to E_1. Generally, this shows that the experimental groups were similar to the control groups as far as SAS Post-test is concerned.

Further tests were done using t-test to establish whether there was a difference between mean scores of the control groups (C_1 and C_2 combined) and the experimental groups (E_1 and E_2 combined). The mean scores of the two groups; control and experimental groups are given in Table 22.

Table 22

Comparison of the Combined Mean Scores of the Control and Experimental Groups

Group	N	Mean $\bar{X}$	SD	df	t-value	p-value
Control C_1 and C_2	91	2.98	0.30	156	0.27	0.79
Experimental E_1 and E_2	77	2.96	0.44			

(df=79, p>0.05)

The results in table 22 show that the difference between the control groups combined and the experimental groups combined is statistically not significant at 0.05 level of significance. These results show that the experimental group E_1 performed better than all the other groups (C_1, C_2 and E_2). However, E_2 performed poorly compared to the other groups. This could only imply this group was very low academically as it was not pre-tested. The good performance of some schools can be attributed to recourse availability funding. Another reason why E_2 performed poorly may be attributed to the implementation of the CTA which includes grouping of students and availability and use of teaching facilities during the teaching process. This is supported by Etuk and Etuk (2011) who pointed out that the constructivist instructional strategy enhanced primary school students' achievements and attitudes in science and that students in urban schools performed better than the rural counterparts because they had better science facilities. From the findings of this study on attitude, we can conclude that, the attitude of students taught by the constructivist approach was similar to that of the students taught by the conventional teaching method as measured by SAS Post-test. This means the null hypothesis (Ho2) is accepted.

Research indicate that teachers of science play an especially critical role in the formation and reorganization of students' conceptions and attitudes towards science and scientists (Turkman, 2008), and since most teachers were not trained on the constructivist approach in colleges, they can fail to improve students' attitude towards chemistry. Many teachers also have inadequate understanding of the nature of science and hence failure to introduce coherent and compelling teaching practices. These could be some of the reasons that can account for the above findings. Therefore, teachers' views and attitudes towards science have an impact on the respective views and attitudes of their students. Previous studies have confirmed that teachers with a positive view towards science tend to inspire analogous positive stances in their students (Koch, 1990).

DISCUSSION

4.7 The Effects of Constructivist Teaching Approach on Students' Achievement in Chemistry.

The findings showed that there was statistically significant difference in pre-test mean scores between the E_1 ($\overline{X}$=4.55, SD=1.67) and C_1 ($\overline{X}$=5.40, SD= 1.62) groups with respect to the topic "Structure and Bonding" suggesting that the students were not similar before the treatment. This meant that the two groups were not equal in terms of their prior knowledge. Consequently measures were put in place in the post test so as to adjust for those differences. Similarly at the post- test level, there was statistical significance difference in the mean scores and standard deviations between the students in the Experimental group, E_1($\overline{X}$=11.37, SD=1.87) and Control group, C_1($\overline{X}$=9.35, SD=2.35), suggesting that students in the Experimental group gained significantly higher after treatment compared with their counter parts in the control groups.

From the mean gain analysis it was found out that the Experimental group E_1 gained more (Mean Gain = 6.82) than the control group, C_1 (Mean Gain = 3.95). This implies that the constructivist teaching approach is more effective than the convectional teaching approaches in enhancing students' achievement in Chemistry. It can be said that the students learn more meaningfully in an active learning environment and become more successful. These findings are in line with several earlier studies by Marshall (1992); Ormrod (2004); Caprio (1994); Andima (2004); Nicholas; (1996); Kersh (1998); Omwirhiren (2002) and Akinbobola;(2006) to the effect that the constructivist teaching approach involves the learners more in the instructional process both individually and in groups. The students would remember better what they participated in doing because they involve more sense organs than just their prior knowledge in knowledge construction. Wells and Mejia-Arauz (2006) pointed that there is an increasing agreement among those studying classroom activities that learning is likely to be more effective when students are actively involved in dialogue and construction of meanings that are significant to them.

The findings of this study are also in line with the research findings of Saigo (1999), White (1999) and Brad (2000), Yager (1991) and Esen (2004) who found that the constructivist teaching approach led to a higher students academic achievement than the traditional lecture methods. The results indicated that students taught by the constructivist instructional approach had a significantly better acquisition of scientific conceptions related to chemical bonding and less misconceptions than the students taught by the traditionally designed Chemistry instruction. Structure and Bonding is very abstract topic that also required some knowledge of physics concepts for the learner to fully comprehent chemical bonding concepts. Evidently teachers should focus on their students' conceptions when teaching the topic. Students should became aware of their existing ideas and teachers should provide experiences and appropriate scaffolding that help students to restructure their cognitive schemas.

In a similar study to investigate the effect of constructivist teaching approach on students' understanding of acid-base concepts, Akar (2005) found that the constructivist approach enabled students to perform better in Chemistry Achievement Test than the traditional lecture method. This is because, the students in the constructivist group benefited from discussion and interaction with peers. In this way, the teacher also provided a learning environment where students could use their prior knowledge and become aware of their already existing conceptions. During discussions with the peers, the students tried to make connections between their existing knowledge and the new concepts. They analyzed, interpreted and predicted information. In this way, they actively constructed knowledge instead of being passive recipients. Teaching and learning was an interactive process that engaged the learners in knowledge construction. Information does not become knowledge automatically until learners have been actively involved in its processing (Akinleye, 2010). However, in the control group, the teachers' thoughts and meanings were transferred to the passive learners. The teacher provided information without considering the students' prior knowledge. Another reason why the students were not successful in the control group was that they lacked the opportunity to develop their thinking, reasoning and communication skills. The students did not become confident in the understanding of chemistry hence meaningful learning did not occur.

In this study students in the constructivist class worked together in groups to resolve dilemmas, hence a co-operative activity. This is in agreement with a study by Wachanga and Mwangi (2004), who found out that students taught through the Cooperative Class Experiment (CCE) method performed significantly better in Chemistry than those taught by the regular teaching methods. Learning in co-operation with others is an important source of motivation, support, modeling and coaching (Feden, 1995). In this research, the teacher initially raised questions (invitation stage), to activate students prior conceptions that were subsequently discussed within groups of students (exploration). Thus the teacher created a learning environment where students could use their prior knowledge and became aware of their existing conceptions. During discussion with their peers, the students tried to make connection between their existing knowledge and the new concept. For example students' knowledge of the structure of an atom helped them to understand why atoms bond to each other. On realizing that their existing ideas were not effective in explaining the new situation, the students took their new knowledge into serious consideration. The students in the experimental group E_1 were encouraged to apply their experiences to the new situations and through group discussion and appropriate guidance by the teacher they tried to find appropriate answers to their questions. They took responsibility for their own learning rather than passively accepting their teacher's explanations as in the control groups. In the experimental group, social interaction was also emphasized and the teacher encouraged students to work together, to explain what they were doing and reflect during the learning process, hence meaningful learning occurred (Alesandrini & Larson, 2002).

4.8 The Effect of CTA on Students' Attitudes Towards Chemistry

This study has established that there is no significant difference in students' attitude between those taught by the constructivist approach and those exposed to the convectional teaching methods. These findings seem to contradict earlier findings of Kizito (2003) and Okoli (2006) which reported the existence of a significance difference in attitude in favour of the constructivist approach. Furthermore, Achilangua and Awodeyi (2005) in their studies found that the constructivist teaching strategy enhanced students' achievements and attitudes in the learning of secondary school science. Kempa and Dude (1974) reported that pupils' interest in science is associated with achievement in Science. Corroborating these reports, Olatoye (2001) found that students' attitudes towards science have significant direct effect on students' achievement in the subject. Furthermore, Adesokan (2002) and Onwu (1981) asserted that in spite of the recognition given to Chemistry among the sciences, it is evident that students still show negative attitude towards the subject thereby leading to poor performance and low enrolment. In a study of the influence of students' attitude towards Mathematics, Bolaji (2005) found that the teaching method and the teachers' personality greatly accounted for the students' positive attitudes towards Mathematics.

Researchers assert that the constructivist teaching approach allows students to actively participate in the manipulation of objects and discussion of ideas related to science leading to increased positive attitude towards science. This is supported by Treagust (1996), who after his studies concluded that constructivism allows for greater learning success since active participation leads to greater understanding and greater interest in the subject. Caprio (1994), examined the effectiveness of the constructivist approach by comparing it with the traditional lecture-lab method and concluded that students taught by the constructivist approach seemed confident of their learning. Teacher centred approaches which places the teacher as the sole possessor of knowledge and students as passive recipients may not enhance achievement nor positive attitude (Nwagbo, 2006).

Keeves (1992), asserted that attitude towards science are known to decrease as students progress through schooling years. This researcher further submitted that attributes such as enthusiasm, respect for students and personality traits have been shown to influence students' attitude towards science as well as other subjects. The implications of Keeves findings is that attention should be given to science teaching early so as to enable students to have favourable disposition towards science later in life. In the constructivist classroom, the teacher should relinquish responsibility and control to the students for their own learning so that achievement in chemistry and higher positive attitude towards the subject can be realized. However, most of the teachers are slow to adopt the constructivist approach. Most teachers are still traditional in their own approaches hence they should be encouraged to adopt the constructivist teaching approach.

However, there are researchers whose findings are in line with the findings of this study. Oguz (2008) in a study to investigate the effect of constructivist learning activities on trainee teachers academic achievement and attitude found that though the constructivist teaching approach enhanced students' academic achievement, it did not have any significant effect on attitude. Similarly, Karaduman and Gultekin (2007) in the study to investigate the effect of constructivist learning principles on students' attitudes, success and retention in social studies found that the approach leads to a significant increase in students' academic success and retention but no significant effect on the attitudes. These researchers both held the view that attitudes develop early in life and there are no quick ways of changing them. Therefore, to realize a better improvement in students' achievement and attitude in Chemistry, teachers and students must be trained in the implementation of the constructivist approach early enough. This study took only three weeks which meant that students might not have fully appreciated the use of the constructivist teaching approach. Therefore, there is need to use the approach as early as the primary school so that its full potential can be attained. Furthermore, research should be done to investigate the attitudes of different ages of students towards chemistry.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

5.1 Introduction

This study was carried out to investigate the effects of the constructivist teaching approach on students' achievements and attitudes in the learning of "Structure and Bonding" topic in chemistry. It involved the development and application of a constructivist teaching approach in the teaching of Form Two students in selected schools. The instruments used were Chemistry Achievement Test (CAT) and Students Attitude Scales (SAS).

5.2 Summary of the Findings

CAT pre-test analysis showed that there was a significant difference between experimental group E_1 and the control group C_1 in favour of C_1. This means that the groups were not similar at the entry point hence, measures were put in place to address it at the post-test. On the other hand, the pre-test analysis of SAS showed that the difference was not statistically significant meaning the two groups were similar on attitude at the start of the programme. Post-test analysis using ANCOVA on CAT showed that the experimental groups and control groups were statistically different in favour of the experimental groups indicating that the experimental groups performed better than their control counter parts hence, (H_{O1}) was rejected. On the other hand, SAS post-test analysis using ANCOVA show that there was no significant differences on students' attitude between the experimental and the control groups hence, (Ho_2) was accepted.

5.3 Conclusion

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

1. The instruction based on the Constructivist Teaching Approach caused a significantly better students' achievement in "Structure and Bonding" topic in chemistry than the Conventional Teaching methods.
2. Teaching students by the Constructivist Teaching Approach does not lead to better attitudes towards chemistry as compared to those taught by the Conventional Teaching methods.

5.4 Implications of the findings

The following educational implications can be deduced from the findings of the study.

i. Constructivist teaching approach enables learners to interact freely in knowledge construction. This created a conducive environment for learning. It is therefore necessary for teachers of science to use constructivist approaches but must pay more attentions on students' prior knowledge to build on subsequent learning.

ii. The teachers of science should not emphasize on drills and exercise, but allow learners in small interactive groups to engage each other in knowledge construction.(weaver,1996)

iii. Students' prior knowledge help them to construct knowledge as Driver (1989) put it and this has been demonstrated by the constructivist teaching approach. Therefore, teachers of science and other subjects should use the approach to enhance teaching and learning.

iv. The constructivist approach used in this study shows that learning took longer time than the conventional methods. Hence teachers need thorough planning during the constructivist lessons. Therefore, more time is needed to implement the approach.

v. More research needs to be done in other areas of chemistry topics to find out the effect of the constructivist approach on students achievement and attitude in chemistry.

5.5 Recommendations

Based on the findings of this study, it is evident that the constructivist teaching approach is an effective method for teaching chemistry.

5.5.1 Suggestions and Recommendations for Further Research

Based on the findings of this study, the following recommendations can be deduced:

i. The findings of this study can only be generalized to Form Two students in Baringo North District. For it to be generalized to all the schools in the district, more research should be done in other district.

ii. For more generalization the research should be extended to Form Two in District, Provincial and National schools in the whole Country.

iii. Constructivist teaching approach should be extended to other topics in Chemistry not only "Structure and Bonding".

iv. More research involving the constructivist teaching approach should be done on Chemistry, Physics and Mathematics so that more knowledge on the approach can be generated.

v. Further research can also be done for single sex schools using the constructivist teaching approach to determine its effectiveness.

vi. The constructivist teaching approach should be emphasized in teacher education curriculum at all levels to enable teachers have a good background of the approach.

vii. Text books authors should expose the readers more to the use of constructivist approach in writing about it in their books.

viii. More studies should be done to investigate the effect of age and gender on students' achievement and attitude towards Chemistry.

ix. More research findings are needed to educate qualified teachers based on constructivist teaching approach.

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APPENDIX A

CHEMISTRY ACHIEVEMENT TEST (CAT)

School: ___________________________________

Age (Yrs): ________________________________

Gender: ___________________________________

Adm. No. _________________________________

Instructions

Please answer ALL the questions. Read each question carefully to ensure that you understand it before writing your answer. Circle the letter you think best represents the choice to the item. (Circle only one letter per item).

Example

Which one of the following is the strongest reducing agent?

A. Na (B.) K C. Cu D. Zn

1. An element R (not the actual symbol of the element) has atomic number 11 and element T has atomic number17. Name the type of bond present in a compound of R and T.

   A. Co-ordinate Bond B. Ionic Bond C. Covalent Bond
   D. Metallic Bond.

2. Fluorine has atomic number 9. Write the valency of fluorine.

   A. +1 B. 7 C. +7 D. 1

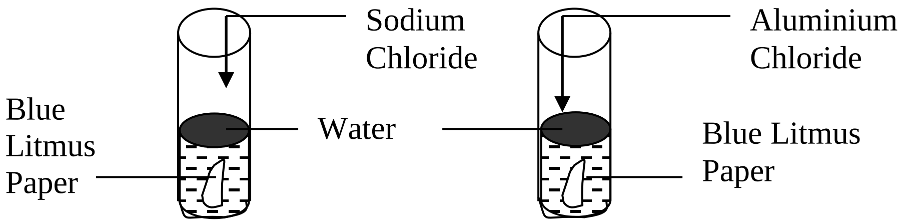
3. State the structure of water with respect to atomic structure and bonding.

   A. Giant atomic B. Simple molecular C. Giant Covalent
   D. Giant Molecular.

4. Which electrons are responsible for bonding in an atom of an element.

   A. Inner most B. Outermost C. Middle ones D. Second innermost

5. Two chlorides were put in two different test tubes with water as shown below



State the effect of the resulting solution on a blue litmus paper.

A. Bleached B. Turns red C. Remain Blue D. Turns colourless

6. Ethanol (C_2H_6OH) having molecular mass 46 boils at 78.4^0C while dimethyl ether (C_2H_6O) with the same molecular mass boils at -24^0C. Give reason for this difference

A. Ethanol is acidic B. Dimethy ether has no vanderwaals Forces

C. Ethanol has hydrogen bonds. D. Ethanol has simple molecular structure

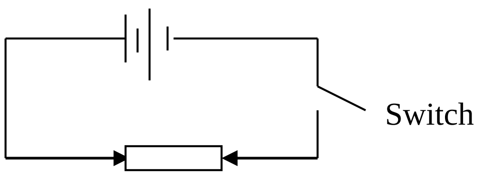
7. One Covalent bond is made up of _____________ electrons.

A. One electron B. Three electrons C. Two electrons D. Four Electrons.

8. Which of the following elements is the most electronegative.

A. Chlorine B. Sodium C. Silicon D. Oxygen

9. A student used the set up below to investigate the electrical conductivity of four elements, aluminium, magnesium, sodium and sulphur. Which element will give the brightest light? Explain



A) Magnesium. It is a shiny metal

B) Sulphur. Because it is in powder form

C) Aluminium because it is has three valency electrons

D) Sodium because it is a reactive alkali metal

10. An atom of an element Z (Not the actual symbol of the element) has four energy levels. In which energy level do the electrons experience the greatest attraction effect from the nucleus?

A. In the 2nd energy level B. In the 1st energy level

C. In the 3rd energy level D. In the 4th energy level

11. Aluminium oxides react with both acids and alkalis. State the name given to such oxides.

   A. Basic oxides B. Acidic Oxides

   C. Soluble Oxides D. Amphoteric Oxides

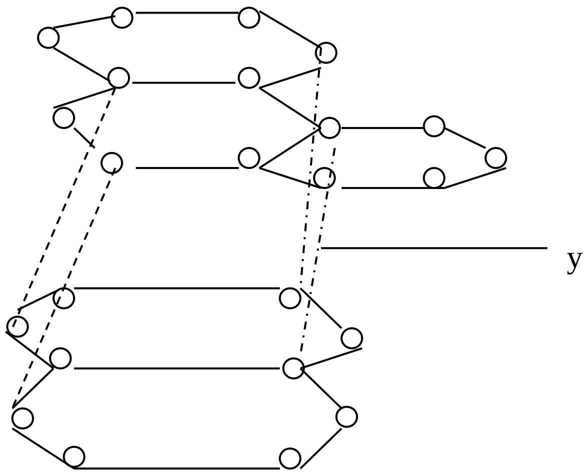
12. Ionic compounds have _____________melting and boiling points.

   A. Low B. High C. Moderate D. Very low

13. Which of the following chlorides is likely to be a liquid at room temperature

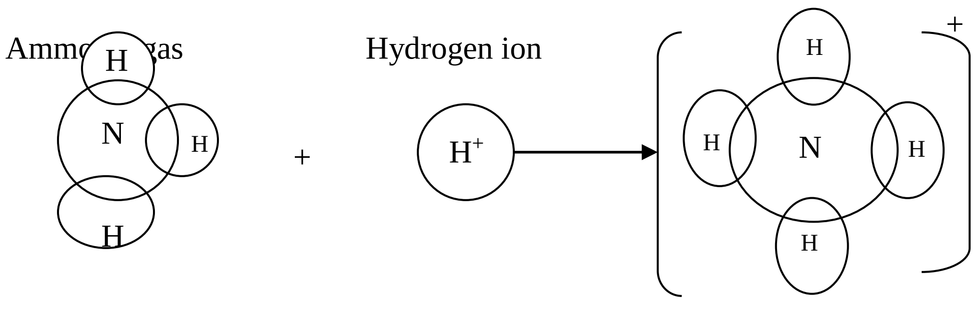
   A. PCl_3 B. $AlCl_3$ C. $MgCl_2$ D. Nacl.

14. The diagram below shows the structure of graphite. Name the bond marked Y.



   A. Covalent Bond
   B. Metallic Bond
   C. Hydrogen Bond
   D. Van der Waals

15. An ammonia gas reacts with an hydrogen ion as shown below to form an ammonium ion.



Name the type of bond formed between the hydrogen ion and the nitrogen atom.

A. Covalent B. Co-ordinate Bond C. Van der Waals force D. Hydrogen Bond

16. Atoms are usually electrically neutral Explain this phenomenon

   A. They have equal number of electrons and neutrons

   B. They have protons and neutrons in the nucleus

   C. They have equal number of protons and electrons

D. They have a moving cloud of electrons along the energy levels.

17. Which bonds enable water to remain a liquid at room temperature

A. Covalent Bond   B. Dative Bond   C. Giant covalent bond   D. Hydrogen bond

18. Study the table below containing information on substance A, B, C, and D and use it to answer the questions that follow: -

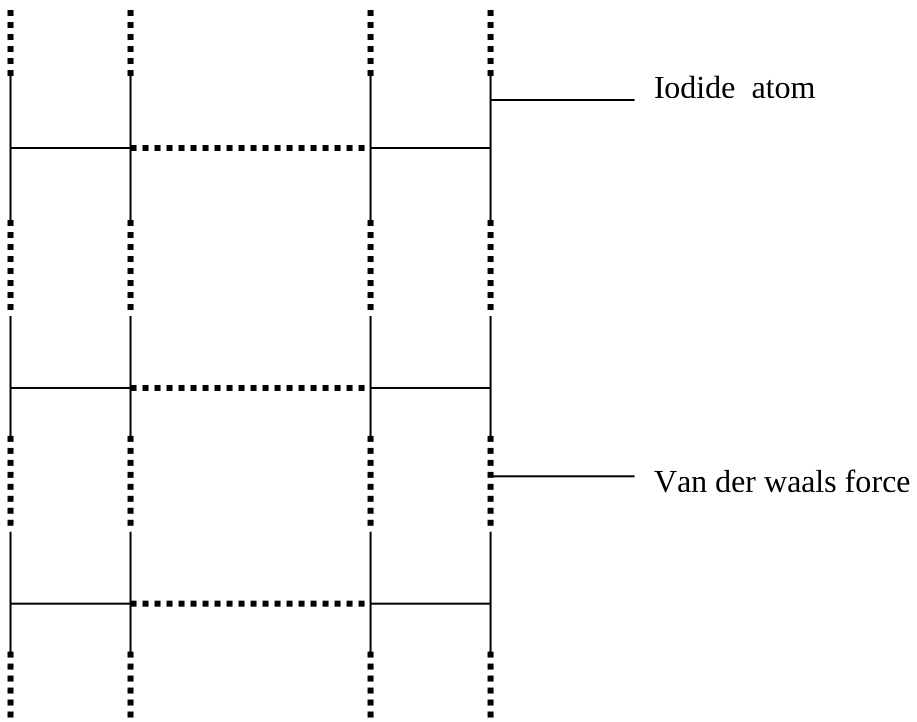
Substance	Reaction with Oxygen at 25^0C	M.P	Electrical Conductivity	
			Solid	Molten
A	Unreactive	High	Poor	Good
B	Unreactive	High	Poor	Poor
C	Unreactive	High	Good	Good
D	Reactive	High	Good	Good

Which substance is likely to have giant atomic structure?

A. Substance B   B. Substance D

C. Substance A   D. Substance

19. The structure of iodine crystal is shown below



State the name of the bonds broken when an iodine crystal sublimes

A. molecular bond

B. Van der waals force

C. Co-ordinate bond
D. Covalent bond

20. Graphite is often used as a lubricant for some machine instead of oil .Explain this because
    A. It has delocalised electrons
    B. It is not a good conductor of heat
    C. It has a high mp due to strong covalent bonds
    D. It is insoluble in water.

Source: self

APPENDIX B

STUDENTS' ATTITUDE QUESTIONNAIRE (SAS)

School ____

Date of Birth ____

Gender ____

Adm. No. ____

The purpose of this questionnaire is to find out what you feel about the Chemistry course in relation to how it is taught and learned. Please indicate what you feel about each item.

Instructions

1. Read the items carefully and try to understand before choosing what truly agrees with your feeling.
2. Circle the choice after each statement that corresponds with how you really feel towards the Chemistry course. Circle only one of the choice.
3. The choices are SD -Strongly Disagree, D - Disagree, U - Undecided, A- Agree, SA - Strongly Agree,
4. If you change your mind about an answer, you may cross it neatly and circle another one.

Example

A student who agrees with the following statement would answer as follows: -

Performing the Chemistry experiment in the group was stimulating.

SD D U (A) SA

Items

Learning Chemistry course with the teacher performing all the experiments and activities was: -

1.	Fun	SD	D	U	A	SA
2.	Satisfying	SD	D	U	A	SA
3.	Informative	SD	D	U	A	SA
4.	Useful	SD	D	U	A	SA
5.	Boring	SD	D	U	A	SA
6.	Frustrating	SD	D	U	A	SA
7.	Hard	SD	D	U	A	SA
8.	challenging	SD	D	U	A	SA

Learning the Chemistry course by performing the experiments and activities ourselves was:

1. A pleasure SD D U A SA
2. A source of anxiety SD D U A SA
3. Fearful SD D U A SA
4. Too stressful SD D U A SA
5. Too demanding SD D U A SA
6. Exiting SD D U A SA

Performing experiments collaboratively was

1. Stimulating SD D U A SA
1. Rewarding SD D U A SA
2. Time-wasting SD D U A SA
3. Boring SD D U A SA
4. Useful SD D U A SA
5. Interesting SD D U A SA
6. Well organized SD D U A SA

Learning Chemistry by making use of prior knowledge made me

1. Feel confident about the chemistry course

   SD D U A SA

2. Feel eager to learn the Chemistry course

   SD D U A SA

3. Doubt my ability to learn Chemistry

   SD D U A SA

4. Want to apply my knowledge to solve practical problems

   SD D U A SA

5. Happy SD D U A SA
6. Exited SD D U A SA
7. Feel as if it was wasting my time

   SD D U A SA

8. Frustrated SD D U A SA
9. Unhappy. SD D U A SA

The apparatus used in structure and bonding topic made me:

1. Appreciate Chemistry SD D U A SA
2. Dislike Chemistry SD D U A SA
3. Interested SD D U A SA
4. Scared of Chemistry SD D U A SA
5. Like Chemistry SD D U A SA

Learning Chemistry in a class which is less threatening made me

1. Feel confident about the Chemistry course
   SD D U A SA
2. Feel eager to learn the Chemistry course
   SD D U A SA
3. Doubt my ability to learn Chemistry.
   SD D U A SA
4. Want to apply my knowledge to solve practical problems.
5. Happy SD D U A SA
6. Excited SD D U A SA
7. Feel as if I was wasting time SD D U A SA
8. Frustrated SD D U A SA
9. Unhappy SD D U A SA.

Source: Modified from Wachanga, S.(2002).

APPENDIX C

CONSTRUCTIVIST TEACHING – LEARNING MODULE

Topic: Structure and bonding

Objectives:

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

i. Describe the role of the outer electrons in determining chemical bonding.
ii. Explain quantitatively the formation of ionic bond.
iii. Illustrate the formation of ionic bond.
iv. State and explain the physical properties of ionic bond and giant ionic structures.
v. State some applications of ionic compounds (giant ionic) based on their physical properties.
vi. Explain qualitatively the formation of a covalent bonds.
vii. Illustrate the formation of covalent bond.
viii. State and explain the physical properties of covalent bond.
ix. Name the types of structures resulting from covalent bonding
x. State and explain the physical properties of simple molecular and giant atomic structures.
xi. State the application of simple molecular and giant atomic structures.
xii. Describe the formation of co-ordinate (dative bond).
xiii. Describe the formation of hydrogen bond and state and explain the physical properties of hydrogen bonding.
xiv. Describe the unique nature of metallic bond.
xv. State and describe the physical properties of metallic bond.
xvi. State the uses of giant metallic structure.

STRUCTURE AND BONDING

LESSON 1. The Atom

Introduction

The teacher uses Q/A technique to elicit learners ideas about the atom, the sub-atomic particles, their masses of each particles, their charges and their location in the atom; atom no., mass and atomic symbol.

- The teacher uses Q/A technique to bring out the learners ideas of the concept of bonding.
- The teacher presents learners with various models of atoms on chart, periodic table.
- The teacher presents the students with activities on bonding e.g broken glass, cup, plasticin, water and learners construct the knowledge on the idea of bonding.
- The teacher / learners review their ideas on the concept of bonding in the light of what was discussed.
- Through Q/A answer, teacher summarizes lesson and gives assignment on the ideas of the atom and bonding.

LESSON 2 and 3: The Ionic Bond and Giant Ionic Structures

- Through Q/A technique, the teacher elicits learners ideas on the concept of ionic bond (Activity 1 and 2).
- The students are then presented with activities involving formation of ionic bond (use models of atoms) so that they can construct knowledge (activity 3) in groups of 3 or 4.
- Teacher / Learners restructure the ideas of ionic bonding by open discussions and arrive at types of ionic structures and their physical properties.
- Other relevant examples of situations involving ionic bond are presented to the learners so that they can compare and apply their constructed knowledge of ionic bond.
- Through Q/A method, the teacher and learner review their ideas on the concept of ionic bond and assignment given.

LESSON 4: Application of Concept Bond of Ionic Compounds in every day life.

- Through Q/A method, teacher and learners discuss the application of ionic compounds e.g solubility fertilizers dissolving in soils.
- The ionic bond and its influence on the physical properties of ionic compounds e.g melting points, boiling points, solubility, ionization and electoral conductivity.

<u>LESSON 5</u>: The Covalent Bond.

- The teacher introduces by using Q/A method to elicit learners' ideas on the concept of the covalent bond.
- The students in groups of 4 are then presented with various compounds which have covalent bonds for them to observe their physical properties and compare them with those of ionic compounds e.g solubility, electrical conductivity (Activity 4).
- The teacher and learners restructure their knowledge on the basis of the differences observed in the formation of covalent bond.
- Other compounds are presented as assignment for learners to classify if they are covalent compounds or not.

<u>LESSON 6 and 7</u>: The Formation of the Covalent Bond, Simple Molecular and Giant.

- Through the use of open ended questions, the teacher leads learners to bring out their ideas on the concepts of covalent bonding and its influence on the physical properties of covalent compounds.
- The learners are presented with various compounds having either simple molecular or giant atomic structures e.g graphite, diamond, water, ethanol and asked to describe the physical properties, appearance, solubility.
- Learners are then presented with worksheets and models / plasticine perform (activity 5) to construct the covalent bond and to show simple molecular and giant atomic and structures (Graphite and Diamond).
- Teachers and learners review their ideas on the nature of the covalent bond and how it affects the physical partners of compound.

<u>LESSON 8: Application of Covalent Bond</u>

- The ideas of covalent bond and alternative frameworks are corrected and applied to other unique situations. This is done by the teacher leading an open discussion with the students as they write notes.
- Assignment on covalent bond given to learners.

<u>LESSON 9 & 10</u>: Co-ordinate bond / Dative Bond

- Through Q/A technique, the teacher leads learners to elicit their ideas on concept of dative bond.
- Teacher presents learners with models to perform activities in groups of 3 to 4 to construct the co-ordinate bond and discuss how it differs with the covalent bond

(Activity 6). Discussion on how the co-ordinate bond influence the physical properties of the compounds formed.

- Teacher leads learners in an open discussion to reviewing their ideas on the concept. Covalent – co-ordinate bond.
- The teacher presents students with situations where the learners can apply their learnt knowledge or concepts in new contexts.

LESSON 11: The Hydrogen Bond.

- Through Q/A method, the teacher elicits learners' ideas on the concept hydrogen bond.
- The teacher presents learners with atomic models of plasticin or fruits to construct the hydrogen bond (Activity 7) so as to restructure their ideas on the hydrogen bond.
- The teacher leads learners to review their ideas on the hydrogen bond. Misconception are then corrected.

LESSON 12: Application of Hydrogen Bonds

- The teacher presents learners with unique situations involving the hydrogen bond and the teacher helps the learners to restructure the their ideas and concepts.
- The teacher gives the learners the assignments involving the above concepts.

LESSON 13 & 14: The Metallic Bond

- Through Q/A method, the teacher introduces the sub-topic by eliciting learners ideas on the concept of metallic bond.
- The teacher presents learners with various metals to compare their physical properties e.g appearance, m.p and b.p.
- The teacher elicit learners ideas on the properties of metals in relation to the metallic bond.
- Learners are presented with materials to construct the metallic bond (in groups of 3; Activity 8) to restructure the ideas.
- Teacher leads open discussion on reviewing the ideas learners have constructed on the metallic bond and how the new knowledge constructed affect physical / properties of metals.
- The concept of metallic bond is applied in solving simple problems.
- Assignment is issued.

<u>LESSON 15:</u> Giant Metallic Structures.

- Teacher elicits learners' ideas on how the metallic bond affects the physical properties of giant metallic structures.
- Tabulated data on various metals presented to learners to analyze and use to solve problems as they restructure the ideas on the effect of metallic bond on physical properties of metals.
- The teacher leads an open discussion and presentation as they review their ideas on the physical properties of metals and apply to new and unique situations.

APPENDIX D

(CONSTRUCTIVIST CLASS ACTIVITIES)

Ionic Bonding

Activity 1:

Investigating the state in which ionic compounds conduct electricity.

Apparatus

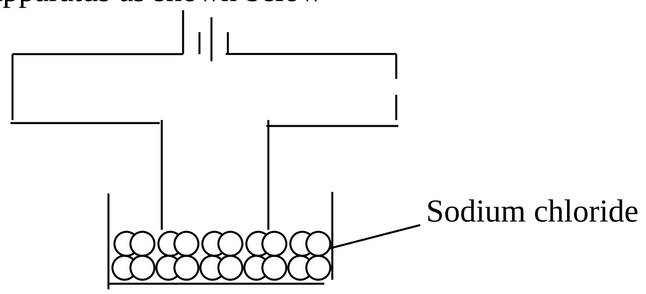
- Ammeter or improvised conductivity tester.
- Connecting wires
- Beakers (100 M/S)
- Stirring rods

Materials

- Table salt
- Water

Procedure 1

Set the apparatus as shown below



- Remove one wire from the salt

- Connect it again and note any observation on the conductivity

Procedure II

- Now disconnect one wire of the same set up
- Add some water into salt and stir for it to dissolve
- Complete the circuit with the solution as the conductor
- Note any change in the conductivity.

Activity 2

Investigating solubility of ionic compounds

Apparatus:

- 2 Beakers (100mm)
- Stirring rod
- Measuring cylinders

Materials:

- Water
- Kerosene
- Table salt

Procedures:

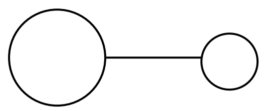
- Place 10mm of distilled water in a beaker
- Add 2 spatula – endfuls of table salt and stir. Note down your observations.

Activity 3 Construction of ionic compounds

- Apparatus and materials:
- Atomic models

Procedures:

Using different types of atomic models to represent sodium and chlorine atoms connect the two using the joinery provided.



Covalent Bonding

Activity 4.

Students are presented with various compounds having covalent bonds e.g. ethanol, graphite, sulphur, water so that they can observe their physical properties.

Activity 5

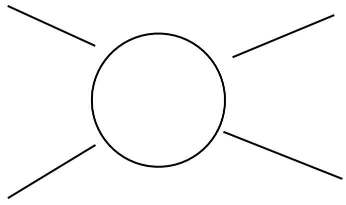
Modeling covalent structure; Diamond

Apparatus

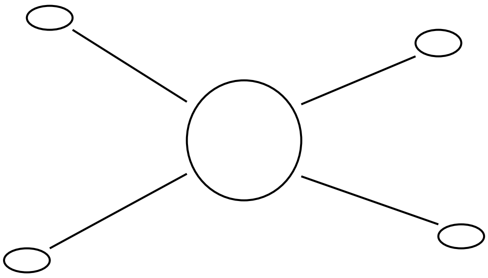
- Sticks (Sharpened both sides)
- Seeds or small fruits or molded plasticine

Procedure:

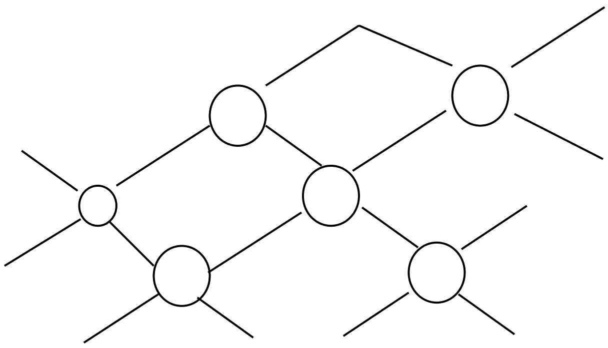
- Take one seed or round modeled plasticine ball
- Pierce it with a stick slightly so that the stick remains embedded.
- Using the other three sticks, repeat the process from the other three plans as shown below:



At each end of the stick, attach another seed as shown below:



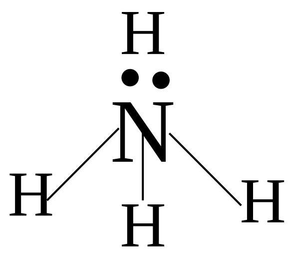
Proceed with the same process of attaching other seeds to form a large structure, such that every seed is surrounded with four others.



Activity 6

Co-ordinate (dative bond)

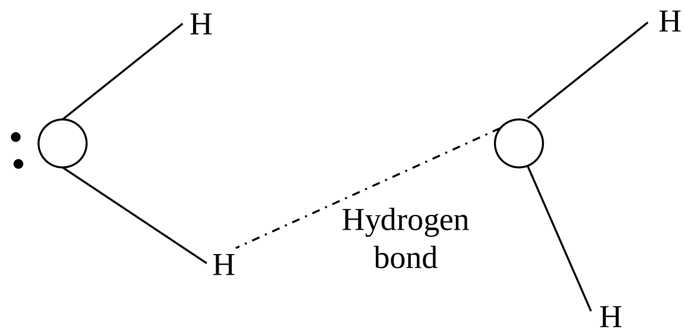
Students in groups of 4 are presented with models of atoms using plasticine and atomic models to construct the co-ordinate bond in ammonium ion. Use small grains to represent electrons.



Hydrogen Bonding.

Activity 7: To investigate how hydrogen bonding is formed.

Procedure: Use molecular models to demonstrate how hydrogen bond is formed. Students work in groups of 4 to show how formation of hydrogen bond in wate molecule.



Metallic Bonding

Activity 8

Bubble raft model

Apparatus and materials:

- Beakers
- Syringe
- Water
- Detergent

Procedures:

(i) Put water in a beaker and add a little detergent to make a dilute solution

(ii) Suck in air into the syringe

(iii) Expel the air out of the syringe while holding the syringe under the detergent solution.

Observation

Bubbles will arrange themselves in a way similar to the arrangement of the metallic atoms.