

UNIVERSITY OF EDUCATION, WINNEBA

**USING COOPERATIVE LEARNING TO IMPROVE THE
PERFORMANCE OF STUDENTS IN QUALITATIVE ANALYSIS IN
TUMU SENIOR HIGH TECHNICAL SCHOOL**



MARIFA ALHASSAN HUARU

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**A THESIS IN THE DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF
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EDUCATION (SCIENCE EDUCATION) DEGREE**

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DECLARATION

STUDENT'S DECLARATION

I, MARIFA ALHASSAN HUARU, declare that this thesis, with the exception of quotations and references contained in published works, which have all, to the best of my knowledge, been identified and acknowledged, is entirely my own original work. It has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE:

Marifa Alhassan Huaru

Date:



SUPERVISORS' DECLARATION

I hereby declare that the preparation and presentation of this thesis were supervised in accordance with the guidelines for supervision of thesis laid down by the University of Education, Winneba.

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Date:

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DEDICATION

This study is dedicated to the Almighty Allah for good health, and my family for their continuous support, prayers and encouragement to me at all levels of my education. To my father Alhaji Abdul – Karim Marifa for your continuous prayers and care, Mother Karimu Ramatu and my uncle Bawa Siiguma and all my brothers and Sisters especially, sister Hadima Abdul- Karim Asia, Marifa Fuseini Hilliah, Marifa Abdul- Aziz Benin and Kuborro Karim Samira.



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ABSTRACT

The study sought to improve the achievements and attitude of students in qualitative analysis through the cooperative teaching and learning approach. The study used action research design. A total of 71 S H S science Students (participants) were selected from Tumu Senior High Technical School and Kanton Senior High School for the study. Data for the study were collected using achievement tests and the Treatment Verification Checklist. The Treatment Verification Checklist sought response on the attitudes towards cooperative learning shown by students in the experimental group during the intervention stage. Two tests, that is pre-test and post-tests were administered before and after intervention respectively to determine the academic achievement of the students in Qualitative analysis. Descriptive statistics was used to organise the data from the Treatment Verification Checklist into means from the responses. A paired t-test statistic was used to establish the significance of the Cooperative approach on students' academic achievement. Results from the treatment verification check list showed the attitude of students towards the use of cooperative learning. It came to light that there was significant and steady improvement from the first to the fifth week. This means that the students appreciated the method. The post-intervention findings indicated positive attitudes and a significantly improved performance of the students. It is recommended among other things that cooperative teaching and learning should be employed in teaching chemistry at SHSs to help instil positive attitudes in students by addressing the various factors responsible for poor attitudes towards the subject. Implementation of the Cooperative approach should help teachers identify the weaknesses of students and address them to improve their academic achievement.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter includes the background to the study, purpose of the study, objectives of the study, research questions, significance of the study, limitations of the study, and definition of terms.

1.1 Background to the study

Several researchers have conducted studies on the effective ways of teaching and learning science in our schools. These effective ways of teaching and learning revolves around the relationship between students' academic achievement and teachers' pedagogical approaches (Caldderhed, 1996). The world we live in today is being controlled and ruled by science and technology. Therefore, for the needed social and economic transformation of our country, effective methods of teaching and learning science are required in our classrooms. Some nations have utilized the opportunities offered by the current innovations in science, mathematics and technology to develop. For this reason, the relevance of science cannot be over emphasized.

Our schools and institutions need to develop future generation of thinking and committed citizens, capable of making good decisions to keep Ghana vibrant and successful in future.

Therefore, a research dominated, rather than a memorizing and giving concrete information, type of educational system has to be encouraged, so that students can consider scientific idea

as a life style in all lessons. Students should adopt positive approaches to learning, for the purpose of improving their skills and knowledge, especially in chemistry.

Chemistry is the study of matter and the changes it undergoes (Ameyibor & Wiredu, 1991). It is often called the central science, because a basic knowledge in chemistry is essential for students of Biology, Physics, Geology, Home economics and many other related programmes. Thus, students must be encouraged to develop a good and positive attitude towards it.

According to Driver, Asoko, Leach, Mortimer and Scott (1994), science is the construction of theories and laws that truly distinguishes the scientific endeavour and not the collection of facts. This implies that, chemistry is not a static body of knowledge but rather started from somewhere and is at present heading in various scientific directions (Morgil, Gungor, & Secken, 2001). Modern comprehensive practical chemistry manual was born out of several years of teaching and observing with dismay, the frustration students, tutors and laboratory technicians face in trying to obtain concise source of information on practical chemistry.

In the view of the researcher, in this age of applied science where knowledge without application has lost its value, there is no need for reinventing the wheel; the most important thing is to make students see themselves as people capable of producing results on a task given or produce something from resource present in their immediate surroundings. It is therefore essential to rebrand the tuition of science from where science practical appears to be so detached and remote from what is actually employed in industries. Again, in order to generate interest in the subject, it is imperative to relate knowledge acquired in the classroom directly to practical and industrial application with concrete examples to overcome the problem, where students find it difficult to appreciate the value of what is being learnt in terms of real life situations.

Literature shows that inappropriate methods of teaching and learning such as the lecture method, rote learning and lack of practical learning contribute immensely to the lack of interest and poor performance of students in science. The Government of Ghana through the Ministry of Education, the Ghana Education service and other stakeholders in education have made a lot of efforts to address science education issues in the country. However, it appears the continuous use of inappropriate teaching and learning methods continue to erode the diverse efforts put in by the bodies mentioned above.

The usage of the cooperative learning method, which is more successful than other techniques, increases day by day (Slavin, 1995; Webb, Trooper & Fall, 1995). With its basic hallmarks, the cooperative learning method was developed, in which each student is responsible for his own task at each stage of learning and is based upon positive mutual cooperation, cooperative skills, observing and methodology, (Johnson & Johnson, 1994) engages students in the teaching process actively. Also, it can be defined as a technique which helps students in and out of the class. This method fosters academic achievement and also gives self-esteem to pupils by creating small working groups, in which students help each other; improve their communication, problem solving and critical thinking skills (Acar & Tarhan, 2008; Gross & Davies, 1999; Gillies & Ashman, 1996; Mills, 2002). The basic aim of the cooperative learning group is to form a social relationship and improve learning techniques in all lessons, by using to a high degree, the effect of this social link (Sharan, 2010). Students help each other to enhance their academic success and practice their skills as a result. Therefore, the cooperative learning method is an effective teaching method in motivating low-skilled students and especially in helping them develop (Acar & Tarhan, 2008). In other words, students at all levels are able to learn with the cooperative learning method (Johnson & Johnson, 2000).

The study is aimed at finding out the effects of cooperative learning strategy on students' performance in qualitative analysis in chemistry. For some times now, it has been observed that Ghanaian students have problems with the Qualitative aspect of chemistry. This may not be connected with the way and manner they are taught this concept. In recent years however, evidence abounds shows that cooperative learning strategy tends to give students better ways of understanding concepts especially in subjects like the social sciences (Gillies, 2003). It is believed by many that when students work in groups they tend to understand each other better than when a teacher teaches them.

Qualitative analysis is a common practical exercise in chemistry to assess student's skills in chemistry. The unit covers solubility, precipitation of insoluble salts and identification of anions and cations in solution (CRDD, 2010). It is an integral and compulsory unit for all Senior High School chemistry students and undergraduates studying chemistry and related subjects. This group of students must possess the foundational experiences from the secondary level. Several factors account for students' performance in chemistry. The factors include, teachers' attitude to chemistry laboratory work, availability of chemistry laboratory materials, abstract nature of chemistry and students' attitude towards chemistry.

Senior High School students in Ghana do qualitative analysis practical work to prepare them for the Senior Secondary School Certificate Examination in chemistry. In qualitative analysis practical work, students are required to carry out procedures, record their observations, and identify the cations and anions present in unknown samples or deduce the properties of the substances present. To make sense of the procedures, reactions, and results in qualitative analysis practical work, students need to apply content knowledge which they have learnt in topics such as 'Acids, Bases and Salts', 'Oxidation and Reduction', 'Reactivity of Metals', '

solubility' and 'Periodicity'. However, studies have revealed that students have difficulties in understanding chemical concepts and reactions that underpin qualitative analysis.

Qualitative analysis is believed to be a difficult area in chemistry for students to learn as it involves both process skills as well as the understanding of many chemistry concepts (Goh, Toh, & Chia, 1989). Chemistry teachers in Singapore frequently complain that their students do not understand what they are doing in the qualitative analysis practical sessions (Tan, 2000). Many students adopt a recipe-approach, cannot carry out the experimental procedures properly, and do not understand the purpose of the experimental procedures. This is also experienced in Ghana. An example of students' lack of understanding of qualitative analysis was in chemistry chief examiners' report (2015) that, in procedures involving the addition of aqueous ammonia to unknown samples, many students wasted time testing for ammonia gas which, they were not able to detect. It further added that many candidates performed confirmatory tests for cations they had not identified earlier. They could not identify CO_2 (g), Zn^{2+} and Al^{3+} ions appropriately; they were not able to make correct observations and inferences. Some did not follow the procedures outlined in the question thereby messing up the answers. Some could not write observations correctly and even where the observations were correctly written they could not make any meaningful inferences. Some mistook gelatinous solutions for chalky precipitates. Others did not give the colour of the resultant solution/precipitate (Chief Examiners Report, 2015). However, at present, students can score high marks in qualitative analysis practical examinations without much understanding of qualitative analysis. This is because the examinations mainly assess students' ability to carry out procedures and write observations. Thus, there is a need for an alternative means to assess students' understanding of qualitative analysis. Hence, the need for the cooperative learning method to solve this problem.

Chemistry practical classes (experiments) are believed to help students in understanding theories and chemical principles which are difficult or abstract. Moreover, practical activity offers several opportunities to students. Some of these opportunities include handling chemicals safely and with confidence, gaining hands-on experience in using instruments and apparatus, developing scientific thinking and enthusiasm in chemistry, developing basic manipulative and problem solving skills, and giving opportunities to students as investigators of the experimental work. It also enables them to identify chemical hazards and learn to assess and control risks associated with chemicals (Ameyibor & Wiredu, 1991; Alexander, 2001; Bekalo & Welford, 1999; Berry, Mulhall, Gunstone & Loughran, 1999; Herron, 1996).

Furthermore, there is growing concern in all parts of the country over a decline in the quality of students who enrol in chemistry in our tertiary institutions as well as their performance in their WAEC chemistry examination (Chief Examiners Report, 2015). Therefore a study towards adopting an effective alternative method of teaching is necessary in order to contribute in searching for answers to this problem. It is in view of this that, the researcher decided, to investigate the effects of cooperative learning strategy on students' performance in Qualitative analysis in Chemistry.

1.2 Statement of the problem

A number of problems affect the teaching and learning of chemistry at the Senior High School level in Ghana. There is some evidence that, perceived instructional approaches, lack of teaching and learning materials, lack of qualified teachers and instructional materials affect the teaching and learning of chemistry. This has resulted in the abysmal performance of students in chemistry. In spite of the organization of extra classes/lessons for science

students, the performance of SHS students has not shown any significant improvement over the years.

In the case of chemistry, recent chief examiners' report (2015) indicates a downward trend in the performance of the candidates. The weaknesses reported on exceeded the strong points of candidates in Qualitative Analysis. These include; many candidates performed confirmatory tests for cations they had not suspected earlier, they could not identify CO_2 (g), Zn^{2+} and Al^{3+} ions appropriately. They were not able to make correct observations and inferences. Some did not follow the procedures outlined in the question thereby messing up the answers. Some could not write observations correctly and even where the observations were correctly written they could not make any meaningful inferences. Some wrote gelatinous solution instead of gelatinous precipitate. Others did not give the colour of the resultant solution/precipitate (Chief Examiners Report, 2015).

Perhaps the poor performance could partly be attributed to the teacher – centred approach of instruction often used by the teachers in their lesson presentation. Millar and Osborne (1998) in the literature reviewed in a study supported the argument by contending that science is usually presented as a rigid body of facts, themes and rules to be memorized and practiced rather than a way of learning about a natural phenomenon. It could also stem from the fact that students were not presented with frequent and challenging laboratory work. Instead, laboratory activities were centred on verification, rather than helping student to develop process skills (Morgil, Gungor & Seckem, 2001). It is likely that, the students interest might not be stimulated enough to enjoy science as a form of knowledge construction but function more as a validation of a given knowledge (Fredua – Kwarteng & Ahia, 2005). The result of all these are that students lack motivation and the requisite skills to pursue science, leading to their low performance and achievement. It is therefore necessary for science teachers to

develop teaching strategies to solve the problems mentioned as well as other difficulties that students face during laboratory work in chemistry.

Although the Chief Examiner (2015) has been offering suggestions to address the candidates' weaknesses, the situation appears to remain same. This points to the complex nature of factors that affects students' performance in Qualitative analysis in chemistry. The situation is the same in the study area where the researcher teaches chemistry.

Although studies have been conducted into aspects of the teaching and learning of some concepts in chemistry using cooperative learning and other strategies, no study to that effect has been conducted in the area of the present study.

The present study therefore sought to look at how cooperative learning instruction in the classroom can improve the students' conceptual understanding of abstract concepts and manipulative skills in Qualitative analysis (Basilli & Sanford, 1991; Slavini, 1997; Acar & Tarhan, 2008). Chemistry concepts cannot be taught in abstract. Students need to form groups and exchange ideas in the form of cooperation on any given concept for them to understand better. The importance of the student - centred method (like cooperative learning method) in science education is well known. It leads to functional knowledge/ meaningful knowledge. It is for this reason that this study has adopted cooperative learning as a method of improving the performance of students in Qualitative analysis in chemistry.

1.3 Research Questions

1. To what extent does cooperative learning help to improve the performance of students in qualitative analysis?
2. How does cooperative learning improve the manipulative skills of students in handling equipment in the laboratory?
3. What is the attitude of students toward the use of cooperative learning in qualitative analysis?

1.4 Objectives of the Study

The main objectives of the study :

1. To find the extent to which cooperative learning helps to improve the performance of students in qualitative analysis.
2. To find out how the cooperative learning method would enable students to gain manipulative skills in the handling of equipment's in the laboratory.
3. To find out about the attitude of students toward the use of cooperative learning in qualitative analysis

1.5 Hypothesis

The following hypothesis were tested in the study

1. H01: There is no significant difference between the performance of the experimental and control groups before the intervention.
2. H02: There is no significant difference between the mean manipulative skill gains of the experimental and control groups after the intervention.

1.6 Purpose of the Study

The purpose of the study was to evaluate the effect of the cooperative learning strategy on the performance of students in Qualitative analysis in Chemistry. The concept of Qualitative analysis was chosen among the several concepts in chemistry due to the several alternative conceptions and difficulties on the part of students.

Since students are examined on this in the WASSCE chemistry practical examination, teachers always teach it prior to examination, putting a lot of pressure on students due to its abstract nature. The topic is also practical – oriented but the lecture instructional method employed by most teachers allows students to end up memorizing facts, thus preventing them from getting hands – on experience.

1.7 Rationale of the Study

The concept of cooperative teaching and learning in improving students' performance in qualitative analysis is a very broad area and various issues can be looked at from different perspectives. Hence, there would be the need to bring this research into focus in order to effectively deal with the issues that will be of concern to the researcher.

The extent to which students accept science concepts, develop and use them is largely dependent on the mode of teaching and the instructional interventions put in place by the teacher. Studies have shown that students do not understand many chemical concepts even after they have been taught formally. In order to plan instruction for understanding, it is important for the teacher to be aware of students' conceptions and difficulties about chemistry concepts and hence, devise extensive efforts in teaching these concepts.

1.8 Significance of the Study

This research and its findings were considered important to provide insight into the effect of cooperative learning strategy in improving students' performance in chemistry.

Teachers and other stakeholders would also benefit from the findings and recommendations in order to improve upon their ideas, skills and zeal to teach.

In addition, the study would serve as a baseline for future studies on the effect of cooperative learning strategy in improving students' performance in chemistry (science) in Ghana.

Finally, the strategy would add to the existing literature on cooperative learning strategy in improving students' performance in chemistry and as a source of information for researchers in the academia.

1.9 Limitations

Selected science students from two schools out of a total of twenty one schools in the Upper West Region were chosen for the study. This was due to limited time, funds and accessibility. The other area of chemistry practical, that is, quantitative analysis could not be researched into due to the same reasons stated above.

1.10 Delimitation

Some students with a peer orientation are more predisposed to engage in cooperative learning than competitively oriented students and this may influence students performance in such groups (Champein, Sherwood & Cezikturk, 2003).

Closely related to the observer bias is observer effect- where persons being observed behave differently and pretentiously from usual, precisely for the simple reason that they are being observed. This possibly could not have been completely eliminated, though, some effort was made by blinding the subjects during the administration of the Treatment Verification Checklist to minimise the effect (pretence and self-adjustment).

1.11 Organisation of the Thesis

This write-up is divided into five chapters. The first chapter provides an introduction to the study. It also includes problem of the study, purpose of the study, research questions, and significance of the study, limitations and delimitations. The second chapter consists of a review of related literature from which was derived a theoretical framework for the study. The third chapter outlines the detailed information of research methodology employed in the study. The fourth chapter presents the data collected and their analysis and discussions. The fifth chapter presents the summary of the study, conclusions, and recommendations.

1.12 Definition of Abbreviations

CRDD	Curriculum Research and Development Division
WAEC	West African Examination Council
SHS	Senior High School
WASSSCE	West African Senior Secondary School Certificate Examination

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter includes the literature review under the following headings: nature and importance of cooperative learning, the concept of Qualitative Analysis, difficulties of Students in Qualitative Analysis, teaching and learning Qualitative analysis, improving performance in Qualitative analysis through practical activities in the laboratory and attitude of students towards laboratory activities.

2.1 The nature and importance of cooperative learning

Cooperative learning has been defined by Johnson and Johnson (1994) as a situation in which there is a positive interdependence among student's goal attainment; therefore, students perceive that they can only reach their learning goals if all the members of the group achieve the learning goals as well. Cooperative learning is an instructional methodology which splits class members into small groups in order for them to learn assigned material and make sure that all members of the group master the assignment (Johnson & Johnson, 1994).

According to Johnson and Johnson (2009) cooperative learning is more than just asking students to sit and work together. Research has identified some components that mediate the effectiveness of cooperative learning, such as:

- (a) *positive interdependence*, which allows students to perceive that they are linked with each other in such a way that one cannot succeed unless everyone succeeds,
- (b) *individual accountability*, which gives each member of the group a sense of personal responsibility toward goal achievement,

(c) *promotive interaction*, which takes place when students facilitate each other's efforts to learn through exchanging resources, help, motivation, and points of view,

(d) *interpersonal and small-group skills*, which means that students must be taught social skills for high quality cooperation, and

(e) *group processing*, which exists when group members discuss how well they are achieving their goals and maintaining their working relationships (Johnson & Johnson, 2009).

Cooperative learning has also been closely related to concepts such as collaborative learning or group learning. The broadest definition of collaborative learning is that it is a situation in which two or more people learn something together (Dillenbourg, 1999). Similarly group learning has been defined as the physical placement of students into groups and the usage of specific instructional strategies for the purpose of learning (Lou, Abrami, Spence, Poulsen, Chambers, & Apollonia, 1996). For the purpose of this review, cooperative learning is defined as: *a situation where students work together in small groups which allows everyone to participate in group tasks that have been clearly structured and defined*. This definition is broad and encompasses the concepts of collaborative as well as group learning (Cohen, 1994).

Cooperative learning differs from traditional whole-class instructions in which students are taught as a single large group by a teacher (Lou *et al.*, 1996). According to the study, traditional whole-class encourages teacher explanations over peer interactions, and encompasses benefits such as uniformity of instruction, since students are exposed to the same type of information and learning methodology (Lou *et al.*, 1996). Cooperative learning in contrast favours the division of whole classes into small group work, in order for students to challenge their individual knowledge and skills by developing structured group tasks.

Research on cooperative learning has paid special attention to the effects of cooperative learning in comparison to traditional teacher centred instruction (Johnson & Johnson, 1994).

Past research on cooperative learning has focused on a wide variety of outcomes that such as: academic achievement, motivation, social development, moral reasoning, social support, self-esteem, friendship and attitudes towards a task, among other outcomes (Johnson, Johnson & Stanne, 2000). However, special attention has been given to the effects of cooperative learning interventions on academic achievement, as this instructional methodology is considered to enhance learning gains and higher order thinking, due to the substantive conversations and active learning that it promotes (Cohen, 1994). Moreover, cooperative learning gives learners the opportunity to verbalize their individual knowledge, which may lead to higher cognitive elaboration, deeper reflections, awareness of individual knowledge and misconceptions, and expansion of knowledge (Van Boxtel, Van der Linden, & Kanselaar, 2000).

Various studies have also analyzed the effectiveness of cooperative learning on achievement in different educational levels and subjects areas. For example, Jensen, Johnson, and Johnson (2002), examined the effects of cooperative learning on students' achievement in physics in higher education, and found significant positive effects of cooperative learning interventions. Similarly, Doymus (2008) examined the effectiveness of the jigsaw cooperative learning method in teaching chemistry in a university context and found out that the students in the jigsaw group were more successful than those who received traditional instruction. Meanwhile, Smialek and Boburka (2006) investigated the effectiveness of cooperative learning on college students' development of musical skills and found that cooperative interventions proved to be more effective than traditional lectures or occasional group work.

Gilles and Ashman (1996) investigated the effects of cooperative learning on primary pupils' behavioural interactions and academic achievement (verbal comprehension, verbal reasoning, quantitative reasoning and figural reasoning) and found that children in the intervention group showed more autonomy and significant difference in higher academic achievement after the intervention.

Despite the positive effects of cooperative interventions on academic achievement in a variety of educational levels and academic subjects, Galton, Simon, and Croll, (1980) found that primary classroom teachers often placed children in groups, but children did not necessarily develop collaborative work. As previously mentioned, simply placing students together does not have positive effects on academic achievement. In order for cooperative learning interventions to be effective, teachers need to structure tasks which promote positive interdependence, individual accountability, promote interaction, interpersonal and small-group skills and group processing (Johnson & Johnson, 1994). Baines, Blatchford, and Kutnick (2003) have indicated that teachers often lack the proper training to implement cooperative learning interventions that encompass all the components that enhance effective interventions.

The aforementioned critics toward cooperative learning raise questions regarding the real effectiveness of cooperative learning on primary education exclusively. Additionally Kutnick, Ota, and Berdondini (2006) have indicated that many studies which analyse the effects of cooperative interventions have been conducted in the higher range of primary and secondary education. This is perhaps because it is believed that younger children have difficulties, showing the required social and communicative skills required for cooperative or

collaborative learning. These arguments call for attention to the need to better understand the effects of cooperative learning exclusively on education.

2.2 The concept of Qualitative analysis

Qualitative analysis is the process of determining the composition of a sample of matter by conducting chemical tests. By conducting the appropriate tests and applying logic, the identities of the ions present in an unknown solution or sample can be determined. The analysis performed are based upon the idea that no two ions produce the same set of chemical reactions. Each ion reacts in its own characteristic way. These reactions include a colour change, the production of a gas, and the formation of a precipitate (a solid product).

In Ghana, the topic qualitative analysis is tested mainly in the practical paper of the WASSCE chemistry examinations; a few questions also may appear in the theory papers. The syllabus for elective chemistry (CRDD, 2010) spells out the requirements for practical work. For qualitative analysis, students are required to follow a sequence of instructions, select and use techniques, apparatus and reagents, make and record observations, and interpret as well as interpret experimental results. In addition, to understand the purpose of the procedures and to interpret and evaluate these results, students need to apply what they have learned in topics such as Acids, Bases and Salts, Oxidation and Reduction, Reactivity of Metals and Periodicity.

Zubrick (1992) and Zieger (1993) believe that traditional 'wet chemistry' or qualitative analysis is still relevant in the age of powerful modern computer-controlled analytical instruments because students learn process skills as well as carry out many of the reactions that they learn about in their lessons and textbooks. Practical sessions are ideal for bringing

the macroscopic, microscopic and representational aspects of chemistry together (Johnstone, 1999). Thus qualitative analysis is very relevant and important to a chemistry course as it strengthens the students' understanding of chemistry (Cooley & Williams, 1999).

2.3 Students Difficulty in qualitative analysis

From the experiences of teachers, students find qualitative analysis one of the most difficult topics in their chemistry course. Students' difficulties may arise from not knowing explicitly what is required in qualitative analysis, the content of qualitative analysis, the lack of motivation, cognitive overload and the lack of mastery of the required process skills.

Many teachers find that Senior High Chemistry students frequently do not understand what they are doing in qualitative analysis laboratory sessions. The students do not seem to see the links between what they have learnt in class and what they do in practical work. This lack of understanding was also highlighted by chemistry examiners in various reports (Chief Examiners Reports 2012, 2013, 2014, 2015). Students frequently do not think for themselves and seem unaware of what they should be doing in the laboratory sessions (Tan, 2000). If students do not have the theory to guide their experiments, it is likely that they will not know what to think about and what to take note of in the experiments (Hodson, 1992).

Novak, Gowin and Johanson (1983) argue that school learning involves 'ritualistic use of procedural elements, without understanding the interplay between conceptual and methodological elements', and it appears that the situation still exists today as Domin (1999a) contended that many laboratory activities are designed to facilitate the development of lower – order cognitive skills such as rote learning and algorithmic problem solving. The typical qualitative analysis experiment is not different, so it seems unreasonable for teachers to expect students to do well in qualitative analysis when teachers do not make explicit what

students should think about in the first place, and do not design worksheets for such a purpose.

McDermott (1988) contends that one of the causes of students' lack of understanding of chemistry is the failure to integrate knowledge. This is seen in qualitative analysis where students either cannot or do not know the link between theory and practical work. Tasker and Freyberg (1985) pointed out that lessons were frequently seen by students as isolated events with no connections to the previous lessons or topics. In the laboratory, students tend to view each experiment as a single event, unrelated to other experiments or content knowledge that they have learned because they lack appropriate frameworks that could guide their investigations (Berry, Mulhall, Gunstone & Loughran, 1999; Duit & Treagust, 1995; Gunstone, 1991). This is shown in qualitative analysis where students demonstrate inability to use knowledge from topics such as 'acids, bases and salts', 'oxidation and reduction', reactivity of metals' and 'periodicity to make sense of their experiments. The students act as though they never encountered the concepts before, as if each lesson is encapsulated into a separate episode that has no relationship to anything that came before or that comes afterward (Costa, 1991).

Reif and Larkin (1991) believe that students view science knowledge predominantly as a valuable collection of facts and formulas, rather than as a conceptual structure enabling numerous predictions. Hence their goal is to memorise facts and formulas rather than learn a few basic principles and reasoning methods. The secondary school students have an instrumental understanding (Skemp, 1976) of qualitative analysis; they are unable to test for the various cations, anions and gases and the reactions involved. Reif and Larkin (1991) also believe that students do not fully perceive the need to organise their science knowledge in a

globally coherent and logically consistent manner because such organisation is not required for their everyday life knowledge. Students may have the facts but do not know how to organise and link them together, hence it is not surprising that they have difficulty in applying their facts and formulas.

Tasker and Fryberg (1985), and Fensham and Kass (1988) also pointed out that discrepancies in intent would lead to discrepancies in action. Students' actions are governed by the purpose they establish for an activity. Since the tasks in the practical work are often not clearly defined, students must often define the tasks for themselves and provide their own goals and structure (Pintrich, Smith, Garcia & McKeachie, 1993). However, students have difficulty establishing any meaningful overall purpose (in the experiments), hence their purpose and actions degenerate to simply following instructions which they do not understand (Tasker & Freyberg, 1985). The tasks of assembling apparatus and making required observations or measurements become the focus of student action (Gunstone, 1991). These actions result in qualitative analysis being reduced to a mechanical level which has little intellectual involvement.. The 'right' answer becomes the goal, undermining the importance of the process leading to the answer, resulting in little cognitive involvement (Pintrich *et al.*, 1993). Students also will be more inclined to ignore discrepant results, give up easily or ask the teacher for help rather than solve any problems encountered.

Another reason why students find qualitative analysis difficult could be the content of qualitative analysis. White (1994) described several properties of science content that influenced how the content should be taught and learned. These are openness to common experience, abstraction, complexity, presence of alternative models with explanatory power, presence of common words, mix types of knowledge, social acceptance, extent of links and

emotive power. Students do not encounter qualitative analysis in normal everyday life, only in the laboratory, so they have virtually no conception of it. The concepts behind the procedures in qualitative analysis and the reactions that occur are abstract, complex and extensively link to other concepts. For example, Fensham (1994) pointed out that, students observe what happens when substances are heated. The substance could dehydrate, decompose, change its state, or undergo a combination of the processes. Qualitative analysis also involves a mix of knowledge and skills such as propositional and procedural knowledge, and manipulative and inferential skills. Thus, it is not surprising that students find qualitative analysis very demanding and difficult.

2.3.1 Motivation to understand qualitative analysis

Pintrich, Marx and Boyle (1993) pointed out that, students' motivational beliefs about themselves, and their learning contexts could facilitate or hinder conceptual change in learning. In Ghana, it seems that the goal of many students and teachers is to obtain good results rather than understand what they are learning. Thus the goal of students in qualitative analysis is mainly to do well in the practical examination paper, contributing to the student's overall grade in chemistry. This explain the effect of examinations against the aim of understanding what one learns – especially if understanding is not essential for doing well in the examinations. Goh, Toh and Chia (1987) highlighted that 'drill and practice' in qualitative analysis practical work was pervasive in schools to prepare students for the practical examinations as good results can be obtained by doing the experiments and writing the right answers. This drill and practice practical work demands little cognitive effort but pays off handsomely in terms of results. Since there is no incentive for students to spend time and effort understanding qualitative analysis concepts, they tend to follow instructions

without much thought and little useful learning is likely to occur (White, 1991). Thus it can be seen that the assessment procedures distort and narrow instruction in qualitative analysis (Treagust, 1995).

2.3.2 Memory Overload

Nakhleh and Krajcik (1994) contend that a laboratory experiment is a complex learning environment and students may become so overwhelmed with the task at hand that, they literally have no memory space left to think conceptually. Similarly, Johnstone and Wham (1982) describe practical work in general as having too much noise and argue that student's working memory is bombarded with information of various kinds, such as, written and verbal instructions, new manipulative skills, unfamiliar labelling of reagents, and inputs from the experiment itself. In addition, the students have to recall manipulative skills and background theory, and associate names with apparatus and reagents. Thus, practical sessions seem to consist of an avalanche of things to do and little time is left for thought (Johnstone, 1999), a situation which is exacerbated when there are time constraints (Johnstone & Letton, 1991). What has been described so far is true for qualitative analysis. Students need to read instructions, carry them out, prepare additional tests, observe, record and interpret their results, as well as, being mindful of the time left to complete the experiments and their reports. The result is overloading of the working memory which leaves no space for thought and organisation, and hence no learning takes place (Johnstone, 1984).

2.3.3 Lack of Mastery of Required Skills

Another complaint that teachers make is that students do not know how to carry out the procedures in qualitative analysis experiments properly. Unfortunately, many teachers do not spend time in helping students develop such procedural skills. Consistent with this situation

Herron (1996) commented: “*We seldom make deliberate efforts to teach laboratory skills, that much to our disappointment, students have never learned. By teaching, I do not mean telling students what to do or performing a quick demonstration in front of the class. I mean carefully prepared lessons, with clear statements of expectation, feedback to individual students so that they can correct errors, and evaluation at the end of instruction to be sure that the lesson is learned. I am talking about doing what any good coach would do in teaching a psychomotor skill*” (p. 20).

Woolnough and Allsop (1985) also stressed the need for students to develop practical scientific skills and techniques. Hodson (1990) succinctly summed up the situation by stating that, it is not that practical work is necessary in order to provide children with certain laboratory skills. Rather, it is that skills that are necessary if children are to engage successfully in practical work.

In qualitative analysis, teachers need to explicitly teach students skills such as how to dissolve substances, add reagents, test gases, and heat substances, as well as how to make valid observations and inferences (Gunstone, 1991). They also need to ensure that their students practice and master these skills. Goh *et al.* (1989) found that many students lack mastery of process skills in qualitative analysis, so, it would seem that this aspect of qualitative analysis has been neglected. Bekalo and Welford (1999) believed that teachers might not have sufficient training and guidance in conducting practical work. Thus teachers might not know what to teach or how to teach during the practical sessions.

2.4 Teaching and Learning Qualitative Analysis

Woolnough and Allsop (1985) offered some suggestions which could improve the teaching and learning of qualitative analysis. Firstly, they believe that tacit knowledge is important;

students should gain first-hand knowledge of the materials and a feel for the phenomena involved in qualitative analysis. This instinctive knowledge will help students to build up personal constructs which will help them in acquiring theoretical understanding of the underlying concepts later. Hodson (1992, 1993) claims that familiarisation of the physical world proceeds making sense of it, and Gabel (1999) believes that if students are unfamiliar with the materials used in chemistry instruction, learning becomes abstract and conceptual understanding is hindered.

Examples of experiences in the book of Woolnough and Allsop (1985), relevant to qualitative analysis, include studying chemical changes due to colour changes, precipitate formation and gas evolution. Costa (1991) contends that students should use all senses to learn as those whose sensory pathways are open and alert absorb more information from the environment than those whose pathways are oblivious to sensory stimuli. Barrow (1991) believes that students need to be exposed to reagents and the transformation of the reagents to make them part of the body of experience that can be drawn automatically, when higher level thoughts are processed. White (1991) also considers episodes or the recollection of events important to illuminate knowledge and make it more comprehensible. In the introductory sessions, students should spend some time experiencing relevant phenomena, thinking and discussing about them. The teacher could then introduce the theory behind the phenomena, and students should be better able to construct meaning from what the teacher says after experiencing the phenomena, thinking and talking about them. This method is similar to the orientation, elicitation of ideas and restructuring of ideas sequences in the constructivist teaching sequence outlined by Driver and Oldham (1986) to draw students inside the problem (Driver & Scott, 1996).

The teacher also can use different methods in laboratory instruction to make explicit the relevant concepts and theories involved in the experiments (Novak, Gowin & Johansen, 1983). In the case of qualitative analysis, students should have studied the relevant content knowledge before they start the series of experiments, hence the task of the teacher is to help students make the links between the content knowledge that they have already learned and what they are doing in the experiments (McDemott, 1988). This should help students to understand the rationale behind the procedures and reagents used in the experiment (Gabel, 1999), and issues on which current practice places insufficient emphasis (Novak *et al.*, 1983; Osborne, 1993). Another advantage of explicitly linking what is taught in the classroom to what is done in the laboratory is the enhancement of students' attitudes towards chemistry (Wong & Fraser, 1996). Fensham, Gunstone and White (1994) and Berry *et al.* (1999) believe that better learning occurs when students understand why they need to make links between what they learned and then actively seek these links for themselves. However, students may not know where to start, or may not even know that they have to make links; hence, the teacher has to bring it to their attention. Unfortunately, teachers seldom show how the topics fit together (Bodner, 1992).

Woolnough and Allsop (1985) also advocate exercises to develop practical skills and techniques as well as investigations to give students opportunities as scientists. Hodson (1990) believes that students are often put in situations where their inadequate skill level acts as a considerable barrier to learning. Exercises on the process skills required in qualitative analysis should be designed for its own sake as it would be difficult for students to cope if they try to master certain skills and at the same time, attend to other aspects of the experiments (Hodson, 1990; Woolnough & Allsop, 1985). The skills required in qualitative analysis include how to add reagents to unknown samples, how to heat samples, how to

determine whether a precipitate is formed, and how to test for gases. White (1991) contends that constant laboratory practice in qualitative analysis creates knowledge of procedure and precautions, thus teaching students how to behave in the laboratory. However, Herron (1996) believes that teachers often neglect to teach these laboratory skills.

Investigations must be the heart of practical work, as it gives the students practice and opportunity to develop competence in working like real problem-solving scientist (Woolnough & Allsop, 1985) and to reflect on what they are doing (White, 1991). Driver and Oldham (1986) believe that investigations or what they call the application phase in their constructivist teaching sequence consolidates and reinforces new learning by extending the contexts within which they are seen to be useful. Marzano and Pickering (1991) contend that ultimately learning must involve the meaningful use of knowledge and that science inquiry is very suited for this purpose. So after students have experienced all the relevant phenomena and mastered the manipulative skills required, they can be given unknown samples to determine the cations and anions present without being given instructions on what to do. This could make them mentally active (Shiland, 1999) as they engage in higher order thinking in order to plan their own experiments (Domin, 1999a). Cooley and Williams (1999) reported that students who had to plan the qualitative analysis experiments themselves confirm that, they enjoyed the experiments and learned much from them. This supports Hodson's (1990, 1993) beliefs that older students will be motivated by practical work if the tasks focused on the conceptual aspects of the experiments and students are allowed to design the procedure to be adopted. Thus, conducting investigations paves a way of developing conceptual understanding. To make qualitative analysis more relevant and interesting to students, real life or practical experiments can be given to students (Hodson, 1992). However, Berry *et al.* (1999) caution that open investigations may not lead to improved learning as students have

done their planning, they may proceed with minimal engagement in the task, that is, without considering the quality of their data and how it relates to the procedures they have chosen.

Goh *et al.*, (1989) developed a schema, the Modified Laboratory Instruction (MLI), for improving the mastery of process skills. This schema involves the systematic building up and the formative monitoring of students' manipulative and process skills, assisting students to comprehend the meaning and purpose of each instructional procedure, and the use of Piagetian-based worksheets. Emphasis is also placed on mental preparation (Beasley, 1985), the cause of wrong results and the process of getting correct ones. Goh *et al.* (1989) found that students with MLI experiences, generally did better in a practical tests and alternative to practical tests (theory) than those who were taught using traditional methods. These students also showed more positive attitude toward laboratory work, as well as greater confidence in their own manipulation of laboratory apparatus. Similar results were obtained by Tsoi (1994), who extended the study of MLI to include computer-assisted instruction.

2.5 Improving performance of students in Qualitative analysis through practical activities in the laboratory

Chemistry is an experimental science. The laboratory is an ideal environment for both active and cooperative learning (Hass 2000). Active engagement in laboratory exercises promotes a thorough understanding of the concepts described at lectures. A further enhancement of the laboratory experience can be gained by encouraging students to interact with each other during the practical activity process. Experiments or laboratory work are very important for students not only for understanding qualitative analysis but also for increasing the students' ability to solve problems.

Laboratory work is both time consuming and expensive compared with other models of instruction. Hence, the efficiency of such a method of learning should justify the additional time and cost of using it. In other words, the increase in the educational budget for using laboratories as a model of teaching should be more efficient in accomplishing the objectives of teaching sciences than other models of instruction. Teaching Qualitative analysis through laboratory's needs, therefore, to be constantly evaluated using the cooperative teaching method.

In traditional teaching approaches, students do experiments without understanding why they are using the apparatus provided for them or understanding many of the experimental steps. The teamwork learning format has a definite advantage in overcoming this weakness. The teamwork learning laboratory is more focused on research work and designing laboratory activities and requires more collaboration between students and the development of teamwork. Teamwork learning methods also require students to have more imagination, more planning and to accept more challenging tasks. It places more emphasis on active learning and extra skills development. Before each laboratory session, students need to plan and design the detailed laboratory steps. During the laboratory session, they need to check their plan and design and revise the laboratory project. After the laboratory session, they need to analyse the data and experimental phenomena and write the experimental reports (Hagen 2000). Therefore, students need to be encouraged to become deeply involved in their laboratory work so as to develop their skills.

According to Farounbi (1998), students tend to understand and recall what they see more than what they hear because of using laboratories in the teaching and learning of science. However, the findings of Hofstein and Lunetta (1982; 2004); Bryce and Robertson (1985);

Hodson, (1990; 1993); Lazarowitz and Tamir (1994), concluded that laboratory experience had no relationship with student learning outcomes.

In the laboratories, the students work cooperatively in small groups (2–4 students each) on inquiry tasks, namely: asking relevant questions, planning an investigation, hypothesising, observing and recording phenomena. Lazarowitz and Tamir (1994) characterise cooperative learning in the science laboratory as peer tutoring in small investigative groups. They suggest that, in such laboratories, the learning environment is highly affected by the fact that, the students are free to study at their own pace, ask questions, interact with each other and with their teachers, and seek information from various sources.

On the other hand, the traditional chemistry laboratory is very task-oriented and thus leaves the students with very few opportunities to engage in the mentioned activities.

Research indicates that student achievement and motivation for the study of science improves dramatically if students are active participants in constructing their own knowledge and in learning to use that knowledge to analyse scientific processes. Practical activities are designed to make the students active participants. Such methods are now extensively used in physics education and also in chemical education (Alexander, 2001).

All science curricula in Ghana, present a list of practical activities that should go with each topic item listed. The current West African Examinations Council syllabus (WAEC, 2014) and the Ghana Education Service syllabus (CRDD, 2010), recommended that the teaching of all science subjects listed in the syllabus should be practical based, perhaps, to demonstrate its importance. Also, Bajah (1984) said, all science teachers and students know that practical work is the 'gem' of science teaching.

According to Blosser (1980) science laboratory works are the factors that contribute to students' achievement. Likewise, the findings of Raimi (2002) and Adeyegbe (2005) indicated that laboratory adequacy affected the performance of students in chemistry. Furthermore, Farounbi (1998) also indicated that the effective use of the science laboratory may have a significant effect on students' performance.

2.6 Attitudes of students towards chemistry laboratory work

Students' attitude toward the learning of chemistry through laboratory activities is a factor that has long attracted attention of researchers and there is a great agreement among science theorists and practitioners on the importance of students' attitudes toward chemistry practical lessons in school (Osborne, Simon, & Collins, 2003). Koballa (1988) noted that affective variables are as important as cognitive variables in influencing learning outcomes, career choices, and use of leisure time. The development of students' positive attitudes toward chemistry laboratory work as a school subject is an important issue. Unfortunately, research has established that much of what goes on in chemistry classrooms and laboratories is not particularly attractive to students across all ages (Stark & Gray 1999).

Enhancement of students' positive attitudes to chemistry laboratory work is very important due to two main reasons. First of all, research on the link between attitudes and academic achievement has proved that these variables were closely related to each other. For example, in a meta-analysis study (Weinburgh, 1995) it was found that the correlation between attitude toward science practical and achievement is 0.50 for boys and 0.55 for girls, indicating that attitude can account for nearly 30% of the variance in achievement. Similarly, Feedman's (1997) study demonstrated that there was a positive correlation between attitude toward science practical and achievement. On the other hand, Salta and Tzougraki (2004) reported

that the correlation between chemistry achievement and positive attitudes toward chemistry ranged from 0.24 to 0.41. Bennett, Rollnick, Green and White (2001) and Cheung (2009), also determined that undergraduate students who had a less positive attitude to chemistry almost invariably obtained lower examination marks. The second reason that makes attitudes important is that attitudes predict behaviours (Glasman & Albarracín 2006).

Research has indicated that the majority of science students like laboratory work (Dhindsa & Chung, 1999; Hofstein, Ben-Zvi & Samuel, 1976; Jones, Gott & Jarman, 2000). However, a student may like chemistry laboratory work but hate theory lessons. Thus, this dimension is needed in order to separate students' affective responses to laboratory work from those of theory lessons. Students show a positive attitude to chemistry laboratory work if they like to do chemistry experiments and feel that doing chemistry experiments is important and fun. The chemistry laboratory activities have been explained as learning experiences in which students interact with materials and /or with models to observe and understand the behaviour of matter in the natural world (Tobin, 1990). In view of this, learning science in the laboratory is associated with models, argumentation, scientific justification of assertions, students' attitudes, conditions for effective learning, social interaction, and difference in learning styles and cognitive abilities (Hofstein & Lunetta 2002).

White and Gunstone (1992) suggested that meaningful learning in the laboratory would occur if students were given sufficient time and opportunity for interaction and reflection. Gunstone (1991) further wrote that students generally did not have the time or opportunity to interact or reflect on the central ideas in the laboratory since they are usually involved in technical activities with few opportunities to express their interpretation and belief for metacognitive

activities. The inability of students to manage their study time effectively will adversely affect their performance academically.

Tobin (1990) wrote “we are entering an era when we will be asked to acknowledge the importance of affective imagination, intuition and an attitude as outcomes of science instruction as it is important as their cognitive counterparts” pp 406. Nevertheless, the second research within the 1980s has proven that science and for that matter chemistry education has moved from the affective to cognitive domain in general and towards conceptual change in particular. All these explained the fact that personal involvement in the chemistry laboratory is the most effective instrumental method for promoting the interest of students in chemistry studies when contrasted with teachers’ demonstrations, filmed experiments, and classroom discussions. Ben-Zvi, Hofstein, Samuel, and Kempa (1976) reported that in general, filmed experiments are effective substitutes to students’ own experimentation, regard to the cognitive, and to a considerable extent, the psychomotor outcomes resulting from them. It is clear from this study that this does not apply to students’ perceptions of the learning approaches and their liking for them but on their attitudes and habits.

However, Hofstein & Lunetta (2002) used the investigation method in Israel to analyse students’ responses on their interest and attitudes towards chemistry laboratory work. The study revealed that the students’ interest and attitudes towards chemistry laboratory work was not one-dimensional, as it was assumed to be for science disciplines. The following attitudinal dimensions were obtained: learning in the science laboratory, the amount of laboratory work expected to be done, and the value of laboratory. These findings are in line with recent trends to enhance the involvement of students in the learning process and in constructing their knowledge of science concepts and processes.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Overview

This chapter includes the research design, the study population, sample and sampling techniques, research instrument, reliability of instrument, validation of instrument, data collection procedure and data analysis procedure.

3.1 Research Design

A research design comprises the steps that are used to collect data. Research design deals with specific data analysis techniques or methods that the researcher used (Fraenkel & Wallen, 2000). According to Polit and Hungler (1995), the design of a study gives a picture of events and assists in explaining people's opinion and behaviour on the basis of data gathered at a point in time. The research design that was adopted for this study was experimental design using the action research approach. In this type of design, two groups were formed with one, as an experimental group and the other, as a control group. Both groups were assessed with same test items to establish a standard. The experimental group was then given treatment while the control group was not treated. Both groups were assessed again with another test items administered at the end of the meeting (post-test items) to ascertain the impact of the treatment. Amedahe (2002) explained that the design was potentially useful in that it controlled all threats to validity and all sources of bias such as history and maturation. The research was based on three main research questions which were about the effect of cooperative learning on academic performance and manipulative skills of students, as well as students' attitudes in studying qualitative analysis.

3.2 Population

The study targeted all science students in the government owned Senior High Schools in Sissala East District Assembly of the Upper West region of Ghana. These schools were selected due to their proximity to the researcher. The study population of the students was divided into two groups, the experimental group and the control group. The entire population was selected from two schools; the Tumu Senior High Technical School and Kanton Senior High School.

3.3 Samples and Sampling Techniques

Sampling is the process of selecting units (e.g., people, organizations) from a population of interest so that by studying the sample we may fairly generalize our results back to the population from which they were chosen (Trochim, 2006). Deflem (1998) also indicated that sampling refers to the systematic selection of a limited number of elements (persons, objects or events) out of a theoretically specified population. Sampling, according to Amoani (2005), is the procedure whereby elements or people are chosen from a population to represent the characteristics of that population.

According to Cohen, Manion, and Morison (2007), purposive sampling is the selection of sample on the basis of their judgment of their typicality or possession of the particular characteristics being sought. Ball (1990) noted that purposive sampling is done for those who have in-depth knowledge about the issue and by virtue of their experience. This study used purposive sampling technique to select the required sample for the study.

A sample is a smaller group which is drawn from a larger population and studied (Robson, 2002; Punch, 2006). According to Fraenkel and Wallen (2000), a sample is any group on which information is obtained for study.

The sampling technique used for the study was purposive sampling. Patton (2002) defines purposive sample as the type in which the researcher handpicks the people to be included in the sample on the basis of their judgment of their typicality. They build a sample that is satisfactory to their specific needs. Patton (2002) said this type of sample focuses on selecting information-rich participants whose study illuminates the questions under study. It is also considerably less expensive to use such participants and is perfectly adequate since the findings will not be generalized beyond the sample. This study used purposive sample type to select a sample of seventy-one (71) form 3 chemistry students of Tumu Senior High Technical School and Kanton Senior High School for the study. The Researcher used purposive sample because among the accessible population they are the only group that has knowledge in elective chemistry and have studied it for more than a year.

The experimental group was made up of forty (40) students from Tumu Senior High Technical School. The control group numbered thirty-one (31) students from Kanton Senior High School.

There were two different treatment patterns applied during the study. The control group was taught through the lecture method with laboratory sessions by the researcher. The experimental group was taught using cooperative teaching method by allowing the students to perform many open ended and semi - structured practical activities by the researcher. The achievement scores of the sample were obtained from a post-test.

Throughout the studies, the topics studied were selected in conformity with the Senior High School chemistry syllabus. The topics taught include: States of Matter; Preparation and collection of gases; Acids, Bases and Salts; Oxidation and Reduction Reactions; Reactivity of Metals; solubility and periodicity.

3.4 Research Instrument

A research instrument is a device used to collect data to answer the research questions. Data collection is an essential component in conducting research. O’Leary (2004), remarks that “collecting credible data is a tough task, and it is worth remembering that one method of data collection is not inherently better than another”. Therefore, the data collection method use would depend upon the research goals, and the advantages and disadvantages of each method. The research instruments used were achievement test based on the course content, practical activities and Treatment Verification Checklist. The questions of the achievement test were set from the course content (States of Matter; Preparation and collection of gases; Acids, Bases and Salts; Oxidation and Reduction Reactions; Reactivity of Metals; solubility and periodicity) and structured in order to achieve the stated objectives at the end of the lesson. Student academic achievements in both groups were evaluated using the researcher-created Qualitative Analysis Achievement Assessment Test (QAAAT). The QAAAT consisted of two (2) compulsory practical questions (for manipulative skills) and two subjective questions (for knowledge in qualitative analysis). The practical activities were designed to measure the performance of the experimental and control groups in the qualitative analysis.

Pre-test and Post-test:

Pre-test were administered during the first week of the instruction period and post-test were administered after treatment periods. One Pre-test and two post – tests were administered to the control and experimental groups. The pre-test was used to put the experimental groups into mixed ability groups depending on the results of the participants.

A Treatment Verification Checklist was also used for data collection. The Treatment Verification Checklist was applied to observe the teaching and learning process during the implementation of the intervention for the experimental group.

3.5 Reliability of instrument

A major portion of the QAAAT was extracted and modified from the West African Examinations Council past questions (from 1993 to 2017). This was to ensure that their appropriateness measured up to the West African Examination academic content standards in chemistry. The test items were carefully analysed to ensure their reliability.

In order to ensure that the research instruments produced scores that were stable and consistent and their test items were devoid of any ambiguities (Creswell, 2008) as much as possible, the QAAAT was pilot-tested using 35 SHS elective chemistry students in Queen of Peace Senior High School, Nadowli District in the Upper West Region of Ghana. Data from the pilot test were statistically analysed to determine the reliability of the test instruments using the Spearman-Brown Prophecy formula since all items on both the QAAAT and Treatment Verification checklist were dichotomously scored. The analysis yielded reliability coefficients of 0.59 and 0.62 for the QAAAT and Treatment Verification Checklist respectively. According to Ary, Jacobs and Asghar (2002), if measurement results were to be used for making a decision about a group or for research purposes, or if an erroneous initial decision was to be easily corrected, then scores with modest reliability coefficients in the range of 0.50 to 0.60 were acceptable. The above reliability coefficients for the QAAAT and Treatment Verification Checklist therefore, signify that both test instruments were considerably reliable.

3.6 Validation of instruments

An instrument is considered valid when there is confidence that it measures what it is intended to measure in a given situation (Punch, 1998). The test items prepared were on the following selected topics; concept of Qualitative analysis, main steps in qualitative analysis, decomposition of salt by heat, reactions of samples with acids and alkalis, flame test, identification of gases, identification of anions, identification of cations, identification of cations and anions in a sample salt. The test items were submitted to some experience chemistry teachers in two Senior High Schools and the researcher's supervisor for scrutiny. The necessary corrections were made and so the items were certified adequately.

Based on their comments and suggestions the questions were moderated to achieve the purpose of the study.

Bell (2004) echoed that, validity of any instrument is important because it determines whether an item measures or describes what it is supposed to measure or describe.

3.7 Intervention procedure

In implementing these, letters were sent to the schools selected for the study to ask for permission to carry out the research work. Lesson notes and laboratory activity procedures were developed for the students. The subjects of the study were assessed using pre-test and post-test results after a number of lessons in the class and laboratory activities in the laboratory. The pre-test administered by the researcher was to measure the performance of the students with regards to their understanding of some topics like solution, solubility, acids, bases and salts related to qualitative analysis. The pre – test results helped the researcher to put the experimental group into mixed ability groups based on the marks.

After the pre-test, the experimental group was taught using cooperative teaching method whereas the control group was taught using traditional method of teaching. Both groups were taught using the laboratory based method.

The selected topics treated under the study included: concept of Qualitative analysis, main steps in qualitative analysis, decomposition of salt by heat, reactions of samples with acids and alkalis, flame test, identification of gases, identification of anions, identification of cations, and identification of cations and anions in a sample salt.

After going through the lessons, both groups were given post - test to measure their performance based on teaching-learning outcomes. The purpose of the post-test was to evaluate the achievements of the two groups in the learning of qualitative analysis. During the implementation of the intervention to the experimental group, a Treatment Verification Checklist, developed by Reid, Forrestal and Cook , (1989) and adapted by the researcher was applied to observe the teaching and learning process. This was done to decide if the cooperative learning method was implemented as intended.

The Treatment Verification checklist touched on students' attitudes towards cooperative learning shown by pupils in the experimental groups during the intervention stage.

The observation provided more information which could not have been done with other methods (Eastably-Smith, Thrope & Lowe, 1991). It also offered firsthand information without relying on the reports of others. Observation was further useful to discover whether or not people do what they say they did or behave in a way they claim to behave (Amadahe 2002). After the data collection, there was collation and data analysis.

3.8 Tests

Two teacher-made tests were developed and administered before and after the intervention (Appendix B, C and E). The tests consisted of essay type items. These were constructed by the researcher and the questions drawn from the topics taught on solution, solubility, acids, bases and salts and states of matter (preparation and collection of gases) related to qualitative analysis (pre –test) while the post – test was on identification of ions in a given salt. The Pre – test had eight (8) compulsory short structured questions while the post – test (1 and 2) had two essay type practical questions which were all compulsory. The content of the items were validated based on the existing instructional objectives stipulated in the chemistry syllabus for Senior High Schools in Ghana (CRDD, 2010).

The pre- test and post-test scripts were scored out of 100 marks each. The pre –test scores were used to categorise the students into three ability groups, low, average and high achievers. The low achievers were those who scored less than 40 marks out of 100 on the pre-test, while the average and the high average were those who scored between 40 and 65; and above 65 out of the 100 marks respectively. Each group comprised of 4 students. That is, the experimental group of 40 students was put into 10 groups each group with 4 students each.

The post-test was administered to the students after the intervention. Time allotted for students for pre – test and post - test was 1 hour. The post-test was in two forms; post –test 1 (Appendix C) based on identification of ions in a given salt and post-test 2 (Appendix E) which was on subjective in qualitative analysis. Each test was scored over 20 with a total mark for both being 40 and converted to 100 percent.

3.9 Data Analysis

The statistical tools used to analyse the pre-test, post-test and experiment results and the Treatment Verification Checklist in the study were frequencies, mean, mean differences, and *t*-test. Data obtained from both pre-test and post-test of QAAAT were analysed using a paired *t* – test (assuming equal variance) to determine whether there was any significance difference in the QAAAT among the two groups. SPSS was used to determine the mean scores of the tests performed by the experimental and control group. The null hypothesis was tested at 0.05 level of significant or 95% certainty of prediction. Responses from students' attitudes towards the study of qualitative analysis were collected and analysed using means.



CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Over view

This chapter presents the results that evaluated the impact of cooperative learning approach on mental and manipulative skills as well as attitudes towards qualitative analysis of students in Tumu Senior High Technical School. The results were analyzed at the 0.05 (95%) significant level. The results obtained are presented and discussed to follow the order in which research objectives were posed in chapter one.

4.1 Presentation of Results and Discussion

Research question 1: To what extent does cooperative learning help to improve the knowledge of students in qualitative analysis?

Tests were conducted before and after the intervention to determine how much knowledge and skills that the experimental and control groups subjects had achieved with respect to qualitative analysis. The following data in Table 1 shows the frequency distribution of their percentage scores for knowledge acquisition.

Table 1: Test scores for knowledge acquisition for the experimental and control groups

Scores (%)	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
Experimental										
Pre Test	1	5	10	10	9	3	1	1	0	0
Post Test	0	2	4	4	14	10	4	1	1	0
Control										
Pre Test	1	4	5	6	5	8	2	0	0	0
Post Test	2	6	5	4	9	5	0	0	0	0

Table 1 shows that in the experimental group majority of the students scored between 21 – 30 percent and 31 – 40 percent. None of the students scored above 80 percent in the pre – test. In comparison with the post – test scores, it can be seen that the students performed better as 16 students scored above 50 percent which was the pass mark for the study.

In the control group 8 students scored between 51 – 60 percent. Ten students scored above 50 percent in the pre – test. A comparison between the pre – test and that of the post – test scores showed very little improvement as just 5 students scored above 50 percent.

HO1: There is no significant difference between the performance of the experimental and control groups after the intervention.

The above hypothesis was tested at 95% (0.05) significant level and the result showed that there was significant difference between the performance of experimental and control groups.

The table for the t-test is shown as Table 2.

Table 2: Mean Scores in the Pre - test and Post-test on performance for Experimental and Control groups

Test	Mean Scores		Mean Difference	P-value
	Experimental	Control		
Pre - Test	35.45	40.86	5.41	0.154
Post - Test	47.55	36.83	10.72	0.0097

Results from Table 2 shows that the experimental group had a mean Pre-test score of 35.45 and the control group had a mean pre - test score of 40.55. This gave a mean difference of 5.41 which is 5.32 less than the post – test scores which had a mean difference of 10.72 from the mean post-test score of 47.55 for the experimental group, and mean post- test score of 36.83 for the control group.

The p-value of 0.0097 in the post - test indicates that the mean difference (the difference between the mean score of the post-test for experimental and control groups) is highly significant since the p-value is less than 0.05 (95%). On the other hand, the p-value of 0.154 in the pre - test indicates that the mean difference in the mean scores of the experimental and control group was not significant since it was higher than 0.05.

This implies that the intervention had a positive effect on the experimental group thereby improving their performance in qualitative analysis compared with their counterparts that used the traditional approach (control group).

Analysis of the data in Table 2 indicates that, the scores of students from the experimental group was statistically significant after the use of cooperative learning approach in their science lessons. The post-test scores implied that the experimental group benefited greatly, thus, their ability to outscore the control group in the post-test achievement test. This strongly confirms the findings of Pintrich, Smith, Garcia and Mckeachie (1993) and Vermunt (1998) that, the use of relevant learning strategies allow students to actively process information, thereby influencing their mastery of material and subsequent academic achievements. This means that the experimental group achieved better results after the cooperative learning approach was implemented.

In cooperative learning, the use of extra exercises such as assignments significantly contributed to the good performance in the post-test scores. This confirms the findings of Vermunt (1998) which stressed on the achievement of good results through interesting extra exercises. When students are successful, learning becomes interesting and permanent. Consequently, students view the subject matter with a very positive attitude which was exhibited in the outcome of checklist results. Positive attitudes enhance self-esteem of students.

On knowledge retention, Mills, McKittrick and Feteris (1999) and Gross and Davis (1999) also argued that, higher concept gain and knowledge retention of students involved in small group activities is better than those who perform only in competitive or individualistic environments.

Through group interactions, learners get the opportunity to share ideas and provide feedback to each other, as well as make use of different perspectives and alternatives in learning (Mills, 2002). In Gilles' (2003) view, situations where students assist their peers to learn through explaining topics to each other have been correlated with academic achievement. This was experienced in the case of the present study where students who did not understand concepts contacted their colleagues for assistance.

The findings suggest that, small group learning can be used to assist pupils to find solutions to problems in science even in deprived areas. This research also confirms the findings of Narrow (1998), who reported that, team work and collaboration is beneficial to female students. Potthast (1999) also mentioned that, using a series of small groups in learning experiences increased students' scores on tests as compared to a group not using small group format. The findings also gives credence to Freedman's (2002) assertion that, participating in cooperative groups during scientific investigations had positive outcomes in attitudes and achievement levels for students.

Research question 2: How does cooperative learning improve the manipulative skills of students in the usage of qualitative analysis instruments?

Data gathered to show how cooperative learning improved students' manipulative skills is shown in Table 3.

Table 3: Test scores for manipulative skill development for both the Experimental and Control groups

Scores (%)	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
Experimental										
Pre Test	2	5	9	11	7	4	2	0	0	0
Post Test	0	3	3	5	7	15	3	2	2	0
Control										
Pre Test	1	5	5	5	7	4	3	1	0	0
Post Test	2	7	5	2	8	5	2	0	0	0

Table 3 shows that in the experimental group 9 students scored between 21-30 percent while 11 students scored between 31-40 percent. Six students scored above 50 percent in the pre-test. Compared with the post test scores, 15 students scored between 51-60 percent while a total of 22 students scored above 50 percent. This was an improvement over the pre-test.

In the control group, 7 students scored between 41-50 percent with 8 students scoring above 50 percent in the pre-test. In comparison with the post test, 7 students scored between 11-20 and 8 students between 41-50 percent. Seven students scored above 50 percent. There was little improvement in performance but not very significant.

H02: There is no significant difference between the mean manipulative skill gains of the experimental and control groups after the intervention.

The above hypothesis was tested at 95% (0.05) confidence level and the result showed that there was significant difference between mean manipulative skill gain of the experimental and control groups. The table for the t-test is shown as Table 4.

Table 4: Mean scores on manipulative skill achievement for the Experimental and Control groups

Test	Mean Scores		Mean Difference	P-value
	Experimental	Control		
Pre - Test	34.25	38.23	3.99	0.301
Post - Test	48.60	33.61	14.99	0.00049

The results from Table 4 show that the experimental group had a mean pre-test score of 34.25 and the control group had a mean pre-test score of 38.23. This gave a mean difference of 3.99 which is 11.00 less than that of the post – test scores which had a mean difference of 14.99 from the experimental post-test mean score of 48.60 and control post-test mean score of 33.61. The p-value of 0.0005 for the post – test scores shows that the mean difference is significant. On the contrary, the p-value of 0.301 for the pre - test which is greater than 0.05 indicates that the mean difference is insignificant. This implies that the cooperative method adopted as intervention here helped to improve the manipulative skills of the students whereas the traditional method used in the control group did not make any significant impact on acquisition of manipulative skill in Qualitative analysis.

Some students from the experimental group statistically improved their manipulative skills significantly through the use of cooperative learning as compared with their counterparts who used traditional method. Cooperative learning which is a form of student centred learning gave the students the opportunity to involve themselves actively in the practical activities: handling and using the available equipment. This is in line with Austin's (1993) group learning report that students' involvement through group learning is one of the most important predictions of success in college.

Another factor that leads to improvement in manipulative skills in qualitative analysis is the interactive engagement of students in cooperative learning. Hake's (1998) finding attests to this. He found that, pre-test and post-test data for over 6000 students in an introductory physics course showed significant improvement for students' test scores that measured conceptual engagement through the use of cooperative learning than in traditional method.

In cooperative learning, the use of active engagement contributed to the achieved high performance. This is supported by Redish, Saul and Steinberg's (2004) study. In their study, they found that, improved learning gains can be due to the nature of active engagement of group members and individuals as found in cooperative learning and not in extra time spent on a given topic. Laws, Sokoloff and Thornton (1997) further confirmed that the use of cooperative learning surpasses the use of traditional method for improving conceptual understanding of basic scientific concepts. Cooperative learning has the tendency to do away with misconceptions. Hake (1998) provided considerable support for active engagement through cooperative learning for addressing students' fundamental misconceptions.

The improvement in the manipulative skills could also be attributed to the appropriate frequency of practical work organized for students on cooperative learning setting (Springer, Stanne & Donovan, 1999). This means, when students are constantly engaged in practical activities over a period of time they develop a positive attitude towards it and always wish to go to the lab for practice.

Research Question 3: What is the attitude of students toward the use of cooperative learning in qualitative analysis?

The students' observational guide was used to determine the changes in attitude that occurred as a result of the use of cooperative learning method on students in their science classes. Some of the indicators used were, perseverance, ability to ask and answer questions,

cooperation with one another to solve problems and respect for evidence from group members.

Attitude of students obtained from Treatment Verification checklist

The student observational guide checklist (Appendix A) was used twice a week for a period of five weeks after which mean scores of marks accumulated were calculated. Attitudinal scale on the pupils' observational guide were: 4 indicating very good, 3 indicating good, 2 indicating fair and 1 indicating poor in the measurement of the attitudes exhibited.

Table 5: Mean scores of Attitude of students in experimental group from Treatment Verification Checklist

Week	mean score
week 1	2.92
week 2	3.26
week 3	3.23
week 4	3.38
week 5	3.64
Average mean score	3.29

Table 5 above shows that, the mean scores of the attitudes of students in the experimental group from the Treatment Verification checklist towards cooperative learning approach improved steadily from the first week to the fifth week. The experimental group has an average total mean score of 3.29 out of a maximum of 4. This might imply that attitudes of students in the experimental group towards cooperative learning approach were better.

The study also revealed that, generally the experimental groups recorded higher achievements in the post-test than their control group counterparts hence, the realization of the development of positive attitude. Tesser (1993) explained the term 'attitude' as a hypothetical construct that represents an individual's degree of like or dislike for an item. He further argued that,

attitudes are expected to change due to knowledge and skills acquired, observation and involvement as this research sought. There is indication that the higher achievements obtained during the post-test could partly be as a result of positive attitudinal change. To support this argument, Smith and McNelis (1993) also confirmed that, students with negative feelings towards science education always received lower grades. It can therefore be concluded that, the high achievement recorded in the experimental groups' achievement test scores may be due to the positive opinion they developed towards science. Also, learners in the average performance level obtained a greater mean gain than those in high performer level. Further research by Haris and Tarwater (1996) also suggested that, learners with previously average achievement welcome working in small groups as their grades improve through group effort.

On the other hand, Mills (2002) stressed that, there is evidence that, high achieving students often dislike group work due to their dependence on others to obtain marks. However, there was no sign of resentment by very good pupils in the various groups in this present study. There was willingness by all students to come to the classroom with a strong readiness to work in smaller groups. This commitment to work created a bonding among the pupils which in turn leads to higher academic self-esteem and positive feelings towards peers and the teacher. According to Johnson and Johnson (1989), small group learning experiences are preferred by students as compared to competitive, individualistic and most traditional instructional methods. Opportunities for science learning arise when children attempt to reach consensus as they work together (Barnes & Todd, 1977).

In this situation, each student was obliged to explain and justify his or her observation to the group and to listen to the explanations of other members in the group before a consensus was built. The cooperative learning approach seemed to make students understand scientific concepts better. The learning setting provided students with greater opportunity to work

through engaging with each other in an interactive way. They also learned to treat each other with respect and appreciate the contribution of others, speaking clearly, turn taking, and giving time to make points. This was true regardless of differences in ability level, sex, ethnic membership or task orientation.



CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This chapter deals with the summary of the main findings and conclusion derived from the study as well as recommendation and suggestions for further studies.

5.1 Summary of the main findings of the study

The main aim of the research was to find out the skills that students lacked in carrying out qualitative analysis and to develop interventions that would help them to acquire the needed skills to improve upon their manipulative and mental performance using cooperative learning approach.

The specific objectives of the study were:

1. To find the extent to which cooperative learning helps to improve the performance of students in qualitative analysis.
2. To find out how the cooperative learning method would enable students to gain manipulative skills in the handling of equipment's in the laboratory.
3. To find out about the attitude of students toward the use of cooperative learning in qualitative analysis

The study was based on the premise that cooperative learning could help improve performance of students in qualitative analysis. The target of the study was therefore to improve the performance of students in qualitative analysis through cooperative learning. An experimental design using action research approach was adopted for the study. The instrument used in the study was achievement tests and observation.

Purposive sampling was employed to select two senior high schools. Seventy- one (71) students were used for the sampling comprising of forty (40) students from Tumu Senior High Technical School and Thirty – one (31) students from Kanton Senior High School.

The control group was taught using the lecture method with laboratory sessions and the experimental group with cooperative teaching method by the researcher.

The statistical tools used to analyse the pre-test, post-test and experimental results and the Treatment Verification Checklist in the study were frequencies, mean, mean differences, and t-test.

The mean scores obtained in the pre – test and post – test for experimental group and their respective control groups were compared for the various skills tested for; students' performance and manipulative skills in qualitative analysis with reference to P – values at 0.05 (95%) level of significance. It was revealed that in all cases there was significant difference between students' performance in the post-test and pre-test with respect to the experimental groups compared to the control groups. This implies that, there was improvement in their performance.

From the above revelation, it could be said that the intervention used, that is, cooperative learning was effective since it was able to bring about significant improvement in all the areas of skills tested for.

From the treatment verification check list showing the attitude of students towards the use of cooperative learning, it came to light that there was significant and steady improvement from the first to the fifth week. This means that the students appreciated and identified with the method.

5.2 Conclusion

There are different methods of teaching and learning used to impart knowledge to students in the classroom. Based on the statistical analysis and the findings of the study, the researcher concluded that:

Cooperative learning is effective as a technique for enhancing students' understanding of qualitative analysis in chemistry.

The Cooperative learning approach promotes better retention of chemical concepts when it is used as a technique for teaching science, especially chemistry.

Students' attitude towards the learning of qualitative analysis in chemistry was positive after using cooperative learning as a teaching strategy.

Cooperative learning encouraged perspective sharing and negotiation of meaning among the students, which resulted in higher performance and retention in the study.

Cooperative learning, from the result of this study should be given much attention by teachers, incorporated as much as possible into any approach of teaching since in addition to having the ability to improve the performance of the students academically, it also makes them develop positive attitude towards learning in general.

Since the results of this study have shown that the students prefer cooperative learning in the classroom, teachers in basic and senior high schools should be motivated to use the cooperative learning techniques in the classroom.

Cooperative learning also has the potential to broaden students' knowledge and improve interpersonal relationships among students as well as between students and their teachers through effective interactions.

5.3 Recommendations

Based on the outcome of the study and conclusions drawn, the researcher made the following recommendations:

1. That, cooperative teaching and learning approach is effective as a technique for enhancing students' understanding and retention of chemical concepts in science and so science teachers must endeavour to use it in science teaching or incorporate it in any method of teaching in order for the students of basic and senior high schools to reap the benefit.
2. The study examined only the academic achievement and retention of students in qualitative analysis, as well as attitude of students towards the cooperative learning approach. Thus, further studies are needed to examine the effectiveness of cooperative learning on much content coverage of chemistry and any science related subject.
3. This study was carried out in Tumu Senior High Technical School. A larger scale study should be carried out to compare the effectiveness of cooperative learning on students' understanding of chemistry from other SHS in the upper west region and the country as a whole.

REFERENCES

- Acar, B., & Tarhan, L. (2008). Effects of cooperative learning on students understanding of metallic bonding. *Research in Science Education*, 38, 401-420.
- Adeyegbe, S. O. (2005, May 7th). In search of indices for measuring the standard of education: a need for a shift in Paradigm. Lagos: A special seminar by West African Examination Council.
- Alexander, M. D. (2001). *Inquiry-Based Methods of Instruction in Chemistry*. Retrieved July 8th, 2017, from http://spacegrant.nmsu.edu/NMSU/2001/D_alexander.pdf
- Amedahe, F. K. (2002). *Fundamentals of Educational Research: Mimeograph*. Cape Coast: University of Cape Coast.
- Ameyibor, K., & Wiredu, M. B. (1991). *Chemistry for Senior Secondary School*. London and Basingtoke: Unimax Publishers.
- Amoani, K. (2005). *Research methodology and review*. Accra: Pentecost Press.
- Ary, D., Jacobs, C. L. & Asghar, R. (2002). *Introduction to Educational Research*. USA: Wadsworth Group Press.
- Austin, A. (1993). *What matters in college? Four critical years revisited* . San Francisco: Josey-Bass.
- Baines, E., Blatchford, P., & Kutnick, P. (2003). Changes in grouping practices over primary and secondary school. *International Journal of Educational Research*, 39, 9-34.
- Bajah, S. T. (1984). Continuous assessment and practical work in science teaching: A plea for pragmatism. *Journal of the Science Teachers' Association of Nigeria*, 22(2), 43-48.
- Ball, S. J. (1990). *Politics and policy-making in Education: explorations in Policy Sociology*. London: Routledge.
- Barnes, D., & Todd, F. (1977). Communicating and learning in small-group. *Journal for Research in Mathematics Education*, 22(5), 390-408.
- Barrow, G. M. (1991). Intellectual integrity or mental servility. *Journal of Chemical Education*, 68(6), 449-453.
- Basilli, P. A., & Sanford, J. F. (1991). Conceptual change strategies and cooperative group work in chemistry. *Journal of Research in Science Teaching*, 28(4), 293-304.
- Beasley, W. (1985). Improving school laboratory performance: How much practice makes perfect? *Science Education*, 69(4), 567-576.
- Bekalo, S. A., & Welford, A. G. (1999). Secondary pre-service teacher education in Ethiopia: Its impact on teachers' competence and confidence to teach practical work in science. *International Journal of Science Education*, 21(12), 1293-1310.
- Bell, J. (2004). *Conducting small scale investigations in education management*. London: Sage Publication.

- Bennett, J., Rollnick, M., Green, G., & White, M. (2001). The development and use of an instrument to assess students' attitude to the study of chemistry. *International Journal of Science Education*, 23(8), 833-845.
- Ben-Zvi, R., Hofstein, A., Samuel, D., & Kempa, R. F. (1976). The educational effectiveness of filmed experiments in high school chemical education. *Journal of Chemical Education*, 53, 581-520.
- Berry, A., Mulhall, P., Gunstone, R., & Loughran, J. (1999). Helping students learn from laboratory work. *Australian Science Teachers' Journal*, 45(1), 27-31.
- Blosser, P. (1980). *A critical review of the role of the laboratory in science teaching*. Columbus OH: Center for Science and Mathematics Education.
- Bodner, G. M. (1992). Why changing the curriculum may not be enough. *Journal of Chemical Education*, 69(3), 186-190.
- Bryce, T. G., & Robertson, I. J. (1985). What can they do? A review of practical assessment in science. *Studies in Science Education*, 12, 1-24.
- Calderhead, J. (1996). Teachers; beliefs and knowledge. In D. C. Berliner, & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 709-725). New York: Macmillan.
- Champein, A., Sherwood, S., & Cezikturk, K. (2003). *Bringing the Science assessment standards to the classroom*. Retrieved, May 26, 2017 from <http://cela.albani.edu/publication.science.htm>.
- Cheung, D. (2009). Students' attitudes toward chemistry lessons: The interaction effect between grade level and gender. *Research in Science Education*, 75-91.
- Cohen, E. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research*, 64(1), 1-35.
- Cohen, L., Manion, L., & Marrison, K. (2007). *Research methods in Education* (6th ed.). London: Routledge.
- Cooley, J. H., & Williams, R. V. (1999). Qualitative analysis in the beginning organic laboratory. *Journal of Chemical Education*, 76(8), 1117-1120.
- Costa, A. L. (1991). The search for intelligent life. In L. A. Costa (Ed.), *Developing minds: A resource book for teaching thinking* (Vol. 1, pp. 100-105). Alexandria, VA: Association for supervision and Curriculum.
- CRDD. (2010). *Teaching syllabus for chemistry*. Accra, Ghana: Ministry of Education.
- Creswell, J. W. (2008). *Educational Research: Planning, Conducting and Evaluating Qualitative and Quantitative Research*. New Jersey: Pearson Education Inc., Upper Saddle River.
- Deflem, M. (1998). *An Introduction to Research Design*. Retrieved June 20, 2017, from <http://WWW.mathieudeflem.net/>

- Dhindsa, H. S., & Chung, G. (1999). Motivation, anxiety, enjoyment and values associated with chemistry learning among form 5 Bruneian students. *MERA-ERA Joint Conference*. Malacca, Malaysia.
- Dillengourg, P. (1999). *Collaborative learning: Cognitive and Computational approaches*. Oxford: Elsevier Science Ltd.
- Domin, D. S. (1999a). A content analysis of general chemistry laboratory manuals for evidence of higher -order cognitive tasks. *Journal of Chemical Education*, 76(1), 109-112.
- Domin, D. S. (1999b). A review of laboratory instruction styles. *Journal of Chemical Education*, 76(4), 543-547.
- Doymus, K. (2008). Teaching chemical bonding through jigsaw cooperative learning. *Research in Science and Technology Education*, 26(1), 47-57.
- Driver, R., & Oldham, V. (1986). A constructivist approach to curriculum development in science. *Studies in Science Education*, 13, 105-122.
- Driver, R., & Scott, P. H. (1996). Curriculum development as research: A constructivist approach to science curriculum development and teaching. In D. F. Treagust, R. Duit, & B. J. Fraser, *Improving teaching and learning in Science and Mathematics* (pp. 94-108). New York: Teachers College Press.
- Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing Scientific knowledge in the classroom. *Educational Researcher*, 23(7), 5-12.
- Duit, R., & Treagust, D. F. (1995). Students' conceptions and constructivist teaching approaches. In B. J. Fraser, & H. J. Walberg (Eds.), *Improving science education* (pp. 46-69). Chicago, Illinois: The National Society for the Study of Education.
- Easterby-Smith, M., Thorpe, R., & Lowe, A. (1991). *Management research: an introduction*. London: Sage Publications.
- Farounbi, M. (1998). *Resource concentration, utilization and management correlates of students' learning outcomes: a study in school quality in Oyo State*. Ibadan: Unpublished Ph. D. Thesis, University of Ibadan.
- Feedman, M. P. (1997). Relationship among laboratory instruction, attitude towards science and achievement in science knowledge. *Journal of Research in Science Teaching*, 34, 343-357.
- Fensham, P. J. (1994). Beginning to teach chemistry. In P. J. Fensham, R. F. Gunstone, & R. T. White, *The content of science: A constructivist approach to its teaching and learning* (pp. 14-28). London: Falmer Press.
- Fensham, P. J., Gunstone, R. F., & White, R. T. (1994). Introduction Part I. Science content and constructivist views of learning and teaching. In P. J. Fensham, R. F. Gunstone, & R. T. White (Eds.), *The content of science: A constructivist approach to its teaching and learning* (pp. 1-8). London: Falmer Press.
- Fensham, P., & Kass, H. (1988). Inconsistent or discrepant events in science education. *Studies in Science Education*, 15, 1-16.

- Fraenkel, J. R., & Wallen, N. E. (2000). *How to design and evaluate research in education* (4th ed.). New York: McGraw-Hill Inc.
- Fredua-Kwarteng, Y., & Ahia, F. (2005). *Mathematics and Science analysis*. Retrieved June 20, 2017, from <http://www.ghaaweb.com/GhanaHomePage/NewsArchive/artikel.php?ID>
- Freedman, S. W. (2002). *Inside City Schools: Investigating Literacy in Multicultural Classrooms*. New York: Teachers College Press.
- Gabel, D. L. (1999). Improving teaching and learning through chemistry education research: A look to the future. *Journal of Chemical Education*, 76(4), 584-554.
- Galton, M. J., Simon, B., & Croll, P. (1980). *Inside the primary classroom*. London: Routledge & Kegan Paul.
- Gillies, R. M. (2003). The effects of cooperative learning on Junior High School students During small group learning: Learning and Instruction. *Journall of Education Psychology*, 14(2), 197-213.
- Gillies, R. M., & Ashman, A. (1996). Teaching collaborative skills to primary schools children in classroom-based work groups. *Learning and Instruction*, 6(3), 187-200.
- Glasman, L. R., & Albarracin, D. (2006). Forming attitudes that predict future behavior: A meta-analysis of the attitude-behavior relation. *Psychological Bulletin*, 132(5), 778-822.
- Goh, N. K., Khoo, L. E., & Chia, L. S. (1993). Some misconceptions in chemistry: A cross - cultural comparison and implications for teaching. *Australian Science Teachers Journal*, 39(3), 65-68.
- Goh, N. K., Toh, K. A., & Chia, L. S. (1987). *The effect of modified laboratory instruction on students' achievement in chemistry practicals*. Singapore Institute of Education.
- Goh, N. K., Toh, K. A., & Chia, L. S. (1989). Use of modified laboratory instruction for improving science process skills acquisition. *Journal of Chemical Education*, 66(5), 430-432.
- Gross, S., & Davis, B. (1999). *Cooperative learning: students working in small groups*. London: Stanford University.
- Gunstone, R. F. (1991). Reconstructing theory from practical experience. In B. E. Woolnough (Ed.), *Practical Science: The role and reality of practical work in school science* (pp. 67-77). Milton Keynes: Open University Press.
- Hagen, J. P. (2000). Cooperative learning in organic chemistry: Increase retention on a commuter campus. *Journal of Chemical Education*, 77(11), 1441-1444.
- Hake, R. R. (1998). Interactive engagement versus traditional methods: a six-thousand student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66(13), 64-74.
- Harris, G. A., & Tarwater, J. T. (1996). *The nine - hour sequence for the general pre - service elementary teacher*. Houston: Texas Technical University.

- Hass, M. A. (2000). Student-Directed learning in organic chemistry laboratory. *Journal of Chemical Education*, 77(8), 1035-1038.
- Herron, J. D. (1996). The chemistry classroom: Formulas for successful teaching. *American Chemical Society*.
- Hodson, D. (1990). A critical look at practical work in school science. *School Science Review*, 71(256), 33-40.
- Hodson, D. (1992). Redefining and reorienting practical work in school science. *School Science Review*, 73(264), 65-78.
- Hodson, D. (1993). Re-thinking old ways: Towards a more critical approach to practical work in school science. *Studies in Science Education*, 22, 85-142.
- Hofstein, A., & Lunetta, V. N. (1982). The laboratory in science education: Neglected aspects of research. *Review of Educational Research*, 52, 201-217.
- Hofstein, A., & Lunetta, V. N. (2002). *The Laboratory in Science Education: Foundation for the twenty-first century*. Retrieved July 8th, 2017, from www.adelaide.edu.au/clpd/sessional/
- Hofstein, A., & Lunetta, V. N. (2004). The role of the laboratory in science teaching: foundation for the 21st century. *Science Education*, 88, 28-54.
- Hofstein, A., Ben-Zvi, R., & Samuel, D. (1976). The measurement of the interest in and attitudes to laboratory work amongst Israeli high school chemistry students. *Journal of Science Education*, 60(3), 401-411.
- Jensen, M., Johnson, D. W., & Johnson, R. T. (2002). Impact of positive interdependence during electronic quizzes on discourse and achievement. *Journal of Educational Research*, 95, 161-166.
- Johnson, D. W., & Johnson, R. (1994). *Learning together and alone, cooperative, competitive and individualistic learning* (4th ed.). Massachusetts: Allyn and Bacon.
- Johnson, D. W., & Johnson, R. T. (2000). *Cooperative Learning Methods*. Retrieved May 24, 2017, from <http://www.cooperation.org/pages/cl-methods.html>
- Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story - social interdependence theory and cooperative learning. *Educational Researcher*, 38(5), 365-377.
- Johnson, D. W., Johnson, R., & Stanne, M. B. (2000). Impact of goal and resource interdependence on problem - solving success. *The Journal of Social Psychology*, 129(5), 621-629.
- Johnson, D., & Johnson, R. (1989). *Cooperation and Competition, Theory and Research*. Edina: Interaction Book Company.
- Johnstone, A. H. (1984). New stars for the teacher to steer by ? *Journal of Chemical Education*, 61(10), 847-849.
- Johnstone, A. H. (1999). The nature of chemistry. *Education in Chemistry*, 36(2), 45-47.

- Johnstone, A. H., & Letton, K. M. (1991). Practical measures for practical work. *Education in Chemistry*, 28(3), 81-83.
- Johnstone, A. H., & Wham, A. J. (1982). The demands of practical work. *Education in Chemistry*, 19, 71-73.
- Jones, M. E., Gott, R., & Jarman, R. (2000). Investigations as part of the key stage for science curriculum in Northern Ireland. *Evaluation and Research in Education*, 14(1), 23-37.
- Koballa, T. R. (1988). Attitude and related concepts in science education. *Science Education*, 72(2), 115-126.
- Kutnick, P., Ota, C., & Berdondini, L. (2006). Improving the effects of group working in classrooms with young school-aged children: Facilitating attainment, interaction and classroom activity. *Learning and Instruction*, 18, 83-95.
- Lagowski, J. J. (1990). Retention rates for student learning. *Journal of Chemical Education*, 67, 811-812.
- Laws, P., Sokoloff, D., & Thornton, R. (1997). Promoting Active Learning, Using the Results of Physics Education Research. *Uni-serve science news*, 13, 140-155.
- Lazarowitz, R., & Tamir, P. (1994). Research on using laboratory instruction in science. In D. L. Gabel, *Handbook of research on science teaching and learning* (pp. 94-130). New York: Macmillan.
- Lou, Y., Abrami, P., Spence, J., Poulsen, C., Chambers, B., & Apollonia, S. (1996). Within-class grouping: A meta-analysis. *Review of educational research*, 66(4), 423-458.
- Marzano, R. J., & Pickering, D. J. (1991). Dimensions of learning: an integrative instructional framework. In L. A. Costa (Ed.), *Developing minds: A resource book for teaching thinking* (pp. 94-99). Alexandria, VA: Association for Supervision and Curriculum Development.
- McDermott, D. P. (1988). Chemistry and the framework of learning. *Journal of Chemical Education*, 65(6), 539-540.
- Miller, R., & Osborne, J. (1998). *Beyond 2000: Science Education for the Future*. London: King's College.
- Mills, B. J. (2002). Fulfilling the promise of the 'seven principles' through cooperative learning: Action agenda for the University Classroom. *Journal on Excellence in College Teaching*, 2, 139-144.
- Mills, B., Mckittrick, P., & Feteris, S. (1999). Cooperative learning that works. *Physical Education*, 34, 11-16
- Morgil, I., Gungor, H., & Secken, N. (2001). Investigating the effect of project oriented chemistry experiments on some affective and cognitive field components. *Journal of Turkish Science Education*, 6(1), 108-114.
- Nakhleh, M. B., & Krajcik, J. S. (1994). Influence of levels of information as presented by different technologies on students' understanding of acid, base and pH concepts. *Journal of Research in Science Teaching*, 31(10), 1077-1096.

- Narrow, S. (1998). Attitudes towards science and mathematics. A review of the literature and its implications in schools. *International Journal of Education*, 25(9), 1039-1045.
- Novak, J. D., Gowin, D. B., & Johansen, G. T. (1983). The use of concept mapping and knowledge vee mapping with junior high school science students. *Science Education*, 67(5), 625-645.
- O'leary, A. (2004). *The essential guide to doing research*. London: SAGE Publications.
- Osborne, J. (1993). Alternatives to practical work. *School Science Review*, 75(271), 117-123.
- Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, 25(9), 1049-1079.
- Patton, M. Q. (2002). *Qualitative evaluation and research methods* (3rd ed.). Thousand Oaks, CA: Sage Publications Inc.
- Pintrch, P. R., Smith, D., Garcia, T., & McKeachie, W. (1993). Reliability and predictive validity in psychometrics. *Educational and Psychological measurment*, 58, 801-900.
- Pintrich, P. J., Marx, R. W., & Boyle, R. A. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research*, 63, 167-200.
- Polit, D. F., & Hungler, B. P. (1995). *Nursing Research: Principles and Methods* (5th ed.). Philadelphia: Lippicott Company.
- Potthast, M. J. (1999). Outcomes of using small group cooperative learning experiences in introductory statistics courses. *College Student Journal*, 33(10), 34-42.
- Punch, K. (1998). *Introduction to social research: Quantitative and qualitative approaches*. Thousand Oaks, CA: Sage.
- Punch, K. F. (2006). *Developing Effective Research Proposals* (2nd ed.). London: Sage Publication Ltd.
- Raimi, S. M. (2002). *Problem-solving Techniques and laboratory skills as supplements to laboratory teaching in senior secondary students learning of volumetric analysis*. Ibadan: Unpublished Ph. D. Thesis, University of Ibadan.
- Reddish, E., Saul, J., & Steinberg, R. (2004). On the effectiveness of active engagement microcomputer-based laboratories. *American Journal of Physics*, 65(1), 45-49.
- Reid, J., Forrestal, P., & Cook, J. (1989). *Small group learning in the classroom*. Portsmouth: Heinemann.
- Reif, F., & Larkin, J. H. (1991). Cognition in scientific and everyday domains: Comparison and learning implications. *Journal of Research in Science Teaching*, 28(9), 733-760.
- Robson, C. (2002). *Real World Research* (2nd ed.). Singapore: Best-Set Tyesetter Ltd, Hong Kong.
- Salta, K., & Tzougraki, C. (2004). Attitudes toward chemistry among 11th grade students in high schools in Greece. *Science Education*, 88, 535-547.

- Sharan, Y. (2010). Cooperative Learning for academic and social gains: valued pedagogy, problematic practice. *European Journal of Education*, 45(2), 300-313.
- Shiland, T. W. (1999). Constructivism: the implications for laboratory work. *Journal of Chemical Education*, 76(1), 107-109.
- Skamp, K. (1999). Are atoms and molecules too difficult for primary children? *School Science Review*, 81(295), 87-96.
- Skemp, R. R. (1976). Relational understanding and instrumental understanding. *Mathematics Teaching*, 77, 20-26.
- Slavin, R. (1995). *Cooperative Learning: Theory, Research and Practice* (2nd ed.). Boston: Allyn & Bacon.
- Slavini, R. E. (1997). Development and Motivational Perspective on Collaborative Learning. *A Reconciliation Child Development*, 58, 1161-1167.
- Smialek, T., & Boburka, R. (2006). The effect of cooperative listening exercises on the critical listening skills of college music-appreciation students. *Journal of Research in Music Education*, 54(1), 57-72.
- Smith, D. L., & McNelis, M. J. (1993). *Distance Education: Graduate Students Attitudes and Academic Performance*. Oslo: Oslo University.
- Springer, L., Stanne, M. E., & Donovan, S. (1999). *Effects of small-group learning on undergraduates in science, mathematics, engineering and technology: A meta-analysis*. Retrieved July 20, 2017, from National Institute for Science Education: Madison, WI: <http://www.wisc.edu/nise/CLI/CL/resource/R2.htm>.
- Stark, R., & Gray, D. (1999). Gender preferences in learning science. *International Journal of Science Education*, 21(6), 633-643.
- Tan, K. C. (2000). *Development and application of a diagnostic instrument to evaluate secondary students' conceptions of qualitative analysis*. Unpublished doctoral dissertation. Curtin University of Technology.
- Tasker, R., & Freyberg, P. (1985). Facing the mismatches in the classroom. In R. Osborne, & P. Freyberg (Eds.), *Learning in science: The implications of children's science* (pp. 66-80). Auckland: Heinemann.
- Tesser, A. (1993). On the importance of heritability in Psychological Research: The case of Attitude. *Psychological Review*, 100, 129-142.
- Thompson, J., & Soyibo, K. (2002). Effect of lecture, teacher demonstrations, discussion and practical work on 10th grader's attitude to chemistry and understanding of electrolysis. *Research in Science and Technology Education*, 20, 25-37.
- Tobin, K. G. (1990). Research on science laboratory activities: In pursuit of better questions and answers to improve learning. *School Science and Mathematics*, 403-418.
- Treagust, D. F. (1995). Diagnostic assessment of students' science knowledge. In S. M. Glynn, & R. Duit, *Learning science in the schools: Research reforming practice* (pp. 327-346). Mahwah, NJ: Lawrence Erlbaum Associates.

- Trochim, W. M. (2006). *Research Methods*. Retrieved July 18, 2017, from <http://WWW.socialresearchmethods.net/kb/order.php>
- Tsoi, M. F. (1994). *Effects of different instructional methods on interpretation skills in chemical qualitative analysis*. Singapore: Unpublished Master's Thesis, National University of Singapore.
- Van Boxtel, C., Van der Linden, J., & Kanselaar, G. (2000). The use of textbooks as a tool during collaborative physics learning. *Journal of Experimental Education*, 69, 57-76.
- Vermunt, J. D. (1998). The regulation of constructive learning processes. *British Journal of Educational Psychology*, 68, 149-171.
- Vincent, J. B. (1999). Piltown man: Combining the instruction of scientific ethics and qualitative analysis. *Journal of Chemical Education*, 76(11), 1501-1502.
- WAEC. (2012). *Chief Examiners Report for May/June SHS Chemistry*. Accra, Ghana: West African Examination Council.
- WAEC. (2013). *Chief Examiners Report for May/June SHS Chemistry*. Accra, Ghana: West African Examination Council.
- WAEC. (2014). *Chief Examiners Report for May/June SHS Chemistry*. Accra, Ghana: West African Examination Council.
- WAEC. (2015). *Chief Examiners Report for May/June SHS Chemistry*. Accra, Ghana: West African Examination Council.
- WAEC. (2016). *West African Examination Council . Chief Examiners Report for May/June SHS Chemistry*.
- Webb, N., Trooper, J., & Fall, R. (1995). Constructive activity and learning in collaborative small groups. *Journal of Educational Psychology*, 87(34), 406-423.
- Weinburgh, M. (1995). Gender differences in student attitudes toward science: A metaanalysis of the literature from 1970 to 1991. *Journal of Research in Science Teaching*, 3, 387-398.
- White, R. T. (1991). Episodes and the purpose and conduct of practical work. In B. E. Woolnough, *Practical science: The role and reality of practical work in school science* (pp. 78-86). Milton Keynes: Open University Press.
- White, R. T. (1994). Dimensions of content. In P. J. Fensham, R. F. Gunstone, & R. T. White, *The content of science: A constructivist approach to its teaching and learning* (pp. 225-262). London: Falmer, Press.
- White, R. T., & Gunstone, R. F. (1992). *Probing understanding*. London: Falmer.
- White, R., & Tisher, R. P. (1986). Research on natural sciences. In M. C. Wittrock, *Handbook of research on teaching* (pp. 874-905). New York: Macmillan.
- Wong, F. L., & Fraser, B. J. (1996). Environment-attitude associations in the chemistry laboratory classroom. *Research in Science and Technological Education*, 14(1), 91-102.

Woolnough, B., & Allsop, T. (1985). *Practical work in science*. Cambridge, UK: Cambridge University Press.

Zieger, H. E. (1993). Whether organic qual will wither? *Journal of Chemical Education*, 70, 387-388.

Zubrick, J. W. (1992). Whither organic qual? *Journal of Chemical Education*, 69(5), 387-388.



APPENDICES

APPENDIX A

TREATMENT VERIFICATION CHECKLIST FOR SHS STUDENTS LEARNING WITH THE COOPERATIVE LEARNING METHOD

Attitude by learners in groups	V. Good (4)	Good (3)	Fair (2)	Poor (1)
Individual contribution to task				
Cooperation with one another to solve problems				
Willingness to ask questions				
Willingness to answer questions.				
Ability to probe into issues not understood				
Exhibition of procedural skill				
Critical and systematic thinking				
Exhibition of curiosity				
Willingness to share ideas				
Willingness to accept others views				
Reporting findings sequentially				
Ability to work independently				
Perception towards science				
Using scientific concepts in everyday life				
Assessing results of an experiment				
Grouping objects and or events based on common characteristics				

Perseverance Respect for evidence Flexibility in idea Ability to predict correctly Ability to put information together as a whole (synthesis) Ability to extend conclusions to similar situation Ability to critically observe Ability to show understanding of knowledge Ability to explain consequences based on a trend Ability to summerize from generalized information Ability to interpret pictorial information Ability to skilfully handle objects and and tools to accomplish a task Ability to use measuring equipment accurately				
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- Very Good (4) - attitude exhibited by all the groups in the class
- Good (3) - attitude exhibited by $\frac{3}{4}$ and above but not all groups
- Fair (2) - attitude exhibited by $\frac{1}{2}$ and above but not $\frac{3}{4}$ of all the groups
- Poor (1) - attitude exhibited by less than $\frac{1}{2}$ of all the groups

APPENDIX B

QUALITATIVE ANALYSIS ACHIEVEMENT ASSESSMENT TEST (QAAAT)

PRE – TEST

Instruction: Answer all the questions

1. Write the IUPAC names of the following compounds (20 marks)

- i. NH_3
- ii. NaOH
- iii. BaCl
- iv. H_2SO_4
- v. Al^{3+}
- vi. SO_3^{2-}
- vii. CO_3^{2-}
- viii. Fe^{2+}
- ix. AgNO_3
- x. Pb^{2+}

2. Write the chemical formula for the following names (20 marks)

- i. Carbon (IV) Oxide
- ii. Iron (III) ion
- iii. Calcium ion
- iv. Iodide ion
- v. Trioxonitrate (V) acid
- vi. Tetraoxosulphate (VI) ion
- vii. Chloride ion
- viii. Copper (II) ion
- ix. Iron (III) fluoride
- x. Hydrochloric acid

3. Balance the following reactions [12 marks]

- a. $\text{NaOH (aq)} + \text{CuSO}_4\text{(aq)} \rightarrow \text{Cu (OH)}_2\text{(aq)} + \text{Na}_2\text{SO}_4\text{(aq)}$
- b. $\text{HCl (g)} + \text{NH}_3\text{(g)} \rightarrow \text{NH}_4\text{Cl (s)}$
- c. $\text{Zn (s)} + \text{HCl (aq)} \rightarrow \text{ZnCl}_2\text{(aq)} + \text{H}_2\text{(g)}$
- d. $\text{H}_2\text{SO}_4\text{(aq)} + \text{KOH (aq)} \rightarrow \text{K}_2\text{SO}_4\text{(aq)} + \text{H}_2\text{O (l)}$

4. State the functions of the following equipment's in the laboratory
- Spatula
 - Test tube
 - Wash bottle
 - Stirring rod
 - Burnsen burner
 - Fume chamber
- [12 marks]
5. (a) Give the reason why Ammonia gas is not collected over water.
(b) Explain how you would test for CO₂ gas in the laboratory.
(c) Explain how you would test for the presence of H₂ gas in the laboratory
- [13 marks]
6. What is the effect of litmus paper on the following substances
- HCl gas
 - NH₃ gas
 - SO₂ gas
 - Cl₂ gas
- [4 marks]
7. (a) State five safety rules in the laboratory.
(b) state two gases each for collecting gases by
- upward displacement of air
 - downward displacement of air
- Give reasons for your answers in (i) and (ii) above
- [15 marks]
8. Name the pieces of apparatus that could be used to:
- Separate a mixture of palm oil and water
 - Isolate precipitate of aluminium hydroxide from an aqueous solution of potassium chloride
 - Transfer 15.00 cm³ of Ethanoic acid from a beaker to a conical flask.
- [4 marks]

APPENDIX C

QUALITATIVE ANALYSIS ACHIEVEMENT ASSESSMENT TEST (QAAAT)

POST – TEST 1

Instruction: Answer *all* the questions

Credit will be given for strict adherence to the instructions, observations precisely recorded and accurate inferences. All tests, observations and inferences must be clearly entered in your answer booklet, in ink at the time they are made.

1. **F** is a mixture of two salts. Perform the following exercises on **F**. Record your observations and identify any gas evolved. State the conclusion you drawn from the result of each test.
 - (a) Put all of **F** into a beaker and add about 10 cm³ of distilled water, stir the mixture thoroughly and filter. Keep both the filtrate and the residue.
 - (b) Put 2cm³ portions of the filtrate into three test tubes
 - (i) To the first portion of the filtrate, add HNO₃ (aq) followed by AgNO₃ (aq) and then excess NH₃ solution.
 - (ii) To the second portion of the filtrate, add NaOH (aq) in drops, then in excess.
 - (iii) To the third portion of the filtrate, add NH₃ Solution in drops, then in excess
 - (c) Put the residue into a test tube and add dilute HCl until all of it dissolves. Divide the resulting solution into three portions.
 - (i) To the first portion add NaOH (aq) in drops, then in excess.
 - (ii) To the second portion, add NH₃ Solution in drops, then in excess.

2. **G** is a mixture of two inorganic compounds. Carry out the following exercises on **G**. Record your observation and identify any gas evolved. State the conclusion you drawn from the results of each test.
 - a) Put all of **G** in a boiling tube and add about 10 cm³ of distilled water. Shake thoroughly and filter. Keep both the filtrate and the residue.
 - b)
 - (i) To about 2 cm³ of the filtrate, add a few drops of AgNO₃ followed by dilute HNO₃
 - (ii) Add excess NH₃ solution to the resulting mixture.
 - c)
 - (i) Put the residue in a test tube, add about 2 cm³ of dilute HCl and shake.
 - (ii) Add NH₃ Solution in drops to the mixture from c(i) above and then in excess.

APPENDIX D

QUALITATIVE ANALYSIS ACHIEVEMENT ASSESSMENT TEST (QAAAT)

Marking Scheme for POST – TEST 1

TEST	OBSERVATION	INFERENCE
1. (a) F + 10 cm ³ distilled water + filtered.	F dissolves partially (1) . On filtration produces a blue filtrate (1) and white residue (1)	F contains soluble and insoluble salt. (1)
(b) (i) 1 st portion of filtrate + dil. HNO ₃ (aq) + AgNO ₃ (aq) + excess NH ₃ (aq)	No gas evolved. (1) White ppt. formed. (1) The ppt. dissolves (1)	CO ₃ ²⁻ , SO ₃ ²⁻ , HCO ₃ ⁻ absent (1*2) Cl ⁻ suspected (1) Cl ⁻ present. (1)
(ii) 2 nd portion of filtrate + NaOH (aq) in drops + in excess	A blue gelatinous precipitate (1) insoluble in excess (1)	Cu ²⁺ present (1) Cu ²⁺ (1)
(iii) 3 rd portion of filtrate + NH ₃ (aq) in drops + in excess	A blue gelatinous precipitate (1) in soluble in excess to form a deep blue solution (1)	Cu ²⁺ present (1) Cu ²⁺ (1)
(b) Residue + dil. HCl (aq)	A gas evolves with effervescence (1), colourless, odourless (1) and turns lime water milky. (1)	Gas is CO ₂ (1) CO ₃ ²⁻ present (1)
(i) resulting solution from (b) + NaOH drop + excess NaOH (aq)	A white chalky ppt. formed. (1) The ppt. insoluble in excess (1)	Ca ²⁺ or Pb ²⁺ suspected Ca ²⁺ Present (1)
(ii) resulting solution from (b) + NH ₃ drops + excess NH ₃ (aq)	No ppt. was formed. (1) No visible reaction (1)	Ca ²⁺ present (1) Ca ²⁺ present (1)

TEST	OBSERVATION	INFERENCE
2. a) sample F + 10 cm ³ distilled water, shaken and filtered	F dissolved partially (1) to form green residue (1) and colourless filtrate (1)	F contains a soluble (1) and insoluble salt.
b) (i) 2 cm ³ of filtrate + drops of AgNO ₃ (aq) + dil. HNO ₃	White ppt. is formed. (1) White ppt. is insoluble in HNO ₃ (1)	CO ₃ ²⁻ , SO ₃ ²⁻ or Cl ⁻ suspected (1*2)
b(ii) resulting mixture from b(i) + excess NH ₃ (aq)	The white ppt (1). dissolves to form a solution (1)	Cl ⁻ present (1)
C (i) residue + 2 cm ³ of dil. HCl + shaken	A gas evolves with effervescence, (1) colourless, odourless (1) and turns lime water milky (1).	Gas is CO ₂ (1) CO ₃ ²⁻ or HCO ₃ ⁻ present. (1)
(ii) resulting solution from c(i) + NH ₃ in drops + Excess NH ₃ (aq)	A pale or light blue gelatinous ppt. formed (1). The ppt. dissolves to form a deep blue solution (1).	Cu ²⁺ suspected (1) Cu ²⁺ present (1).

APPENDIX E

QUALITATIVE ANALYSIS ACHIEVEMENT ASSESSMENT TEST (QAAAT)

POST – TEST 2

Instruction: Answer *all* the questions

1. G was a simple salt.

The tests recorded in the table below were performed as indicated .

Copy and complete the table.

TEST	OBSERVATION	INFERENCE
(a) (i) G + heat	Colourless, odourless gas evolved
(ii) Gas tested with glowing splint	Glowing splint rekindled
G + strong heating	Brown gas evolved which turned damp blue litmus paper red. Residue was yellow when hot and white when cold
(b) Solution of G + FeSO_4 (aq) + conc. H_2SO_4
Solution of G + NH_3 (aq) in drops then in excess	White gelatinous precipitate formed Precipitate dissolved.	

(c) Name G and write its formula

2. C is a mixture of an inorganic salt and an organic solid.

The following tests were carried out on C. Copy and complete the table:

Test	Observation	Inference
(a) (i) C + 10 cm ³ of distilled water, stirred and filtered (ii) filtrate + litmus paper	C dissolved partially forming pale blue solution and white residue Filtrate is acidic
(b) (i) filtrate + Ba(NO ₃) ₂ (aq) + HNO ₃ (aq) in excess (ii) filtrate + NaOH (aq) in drops Then in excess (iii) filtrate + NH ₃ (aq) in drops Then in excess	White chalky precipitate Precipitate remains Blue gelatinous precipitate Precipitate is insoluble
(c) (i) Residue + NaOH _(aq) (ii) mixture above warmed (iii) Gas tested with conc. HCl on glass rod	No visible reaction 	NH ₃ present

APPENDIX F

QUALITATIVE ANALYSIS ACHIEVEMENT ASSESSMENT TEST (QAAAT) MARKING SCHEME FOR POST – TEST 2

TEST	OBSERVATION	INFERENCE
1. (a) (i) G + heat	Colourless, odourless gas evolved	CO₂ or O₂ gas may be present
(ii) Gas tested with glowing splint	Glowing splint rekindled	O₂ gas present
(b) (i) G + strong heating	Brown gas evolved which turned damp blue litmus paper red. Residue was yellow when hot and white when cold	NO₂ gas Acidic gas ZnO
(ii) Solution of G + FeSO ₄ (aq) + conc. H ₂ SO ₄	A brown ring formed	NO₃⁻ present
(iii) Solution of G (aq) + NH ₃ in drops then in excess	White gelatinous precipitate formed. Precipitate dissolved.	Zn²⁺ or Al³⁺ present Zn²⁺ confirmed.

(c) Name G and write its formula

Name of G – **Zinc trioxonitrate (V)**

Formula – **Zn(NO₃)₂**

Test	Observation	Inference
2. (a) (i) C + 10 cm ³ of distilled water, stirred and filtered (ii) filtrate + litmus paper	C dissolved partially forming pale blue solution and white residue Turns blue litmus paper red	C contains soluble salt and insoluble salt. Filtrate is acidic
(b) (i) filtrate + Ba(NO ₃) ₂ (aq) + HNO ₃ (aq) in excess (ii) filtrate + NaOH (aq) in drops Then in excess (iii) filtrate + NH ₃ (aq) in drops Then in excess	White chalky precipitate Precipitate remains Blue gelatinous precipitate Precipitate is insoluble Blue gelatinous precipitate Precipitate dissolves forming deep blue solution	CO₃²⁻, SO₃²⁻, SO₄²⁻ may be present SO₄²⁻ present Cu²⁺ Cu²⁺ present Cu²⁺ Cu²⁺ present
(c) (i) Residue + NaOH _(aq) (ii) mixture above warmed (iii) Gas tested with conc. HCl on glass rod	No visible reaction A colourless gas with pungent smell, turns red litmus paper blue White dense fumes with conc. HCl	NH ₃ present NH₄⁺ confirmed

APPENDIX G

QUALITATIVE ANALYSIS ACHIEVEMENT ASSESSMENT TEST (QAAAT)

Marking scheme PRE – TEST

Instruction: Answer all the questions

1. Write the IUPAC names of the following compounds (20 marks)

- | | | | |
|-------|--------------------------------|---|--------------------------------|
| i. | NH ₃ | - | Ammonia |
| ii. | NaOH | - | Sodium hydroxide |
| iii. | BaCl ₂ | - | Barium chloride |
| iv. | H ₂ SO ₄ | - | Hydrogen tetraoxosulphate (VI) |
| v. | Al ³⁺ | - | Aluminium ion |
| vi. | SO ₃ ²⁻ | - | trioxosulphate (IV) ion |
| vii. | CO ₃ ²⁻ | - | trioxocarbonate (IV) ion |
| viii. | Fe ²⁺ | - | iron (II) ion |
| ix. | AgNO ₃ | - | Silver trioxonitrate (V) |
| x. | Pb ²⁺ | - | Lead nitrate |

2. Write the chemical formula for the following names (20 marks)

- | | | | |
|-------|---------------------------|---|-------------------------------|
| i. | Carbon (IV) Oxide | - | CO ₂ |
| ii. | Iron (III) ion | - | Fe ³⁺ |
| iii. | Calcium ion | - | Ca ²⁺ |
| iv. | Iodide ion | - | I ⁻ |
| v. | Trioxonitrate (V) acid | - | HNO ₃ |
| vi. | Tetraoxosulphate (VI) ion | - | SO ₄ ²⁻ |
| vii. | Chloride ion | - | Cl ⁻ |
| viii. | Copper (II) ion | - | Cu ²⁺ |
| ix. | Iron (III) fluoride | - | FeCl ₃ |
| x. | Hydrochloric acid | - | HCl |

3. Balance the following reactions

- | | | | |
|----|---|---|--|
| a. | 2NaOH (aq) + CuSO ₄ (aq) | → | Cu (OH) ₂ (aq) + Na ₂ SO ₄ (aq) |
| b. | HCl (g) + NH ₃ (g) | → | NH ₄ Cl (s) |
| c. | Zn (s) + 2HCl (aq) | → | ZnCl ₂ (aq) + H ₂ (g) |
| d. | H ₂ SO ₄ (aq) + 2KOH (aq) | → | K ₂ SO ₄ (aq) + 2H ₂ O (l) |

4. State the functions of the following equipment's in the laboratory
 - i. Spatula: **for scooping/ taking solid substances.**
 - ii. Test tube: it is used to carry out reaction.
 - iii. Wash bottle : it is use to contain water for topping up solution
 - iv. Stirring rod: **used to mix solutions/ to maintain uniform mixture/ temperature**
 - v. Burnsen burner: use to heat solution in the laboratroy
 - vi. Fume chamber: **for preparing poisonous/ offensive gases or liquids**
5. (a) Give the reason why Ammonia gas is not collected over water.

Ammonia gas is not collected over water because it is soluble in water. Or it dissolves in water to form ammonia solution

- (b) Explain how you would test for CO₂ gas in the laboratory.

The gas collected is passed through lime water (Ca(OH)₂]. It turns lime water milky.

- (c) Explain how you would test for H₂ gas in the laboratory
A lighted splint/ a glowing splint is sent to the gas, it gives a pop sound

6. What is the effect of litmus paper on the following substances
 - (α) HCl gas – **it turns blue litmus paper red but have no effect on red litmus paper**
 - (β) NH₃ gas – **it turns red litmus paper blue but turns blue litmus paper blue**
 - (¥) SO₂ gas - **it turns blue litmus paper red but turns red litmus paper red**
 - (€) Cl₂ gas - **it turns blue litmus paper claret red (bleach) but turns red litmus paper red**

7. State five safety rules in the laboratory.
 - Do not walk bare footed in the laboratory
 - Do not eat or play in the laboratory
 - Wear protective boots and clothes in the laboratory
 - do not do anything until you are told to do so
 - Always Add acid to water and not water to acid
 - always ask for permission from the teacher or technician before touching anything

- wash your hands and all equipment's before leaving the laboratory
8. Name the pieces of apparatus that could be used to:

(ii) Separate a mixture of palm oil and water

Separating funnel

(iii) Isolate precipitate of aluminum hydroxide from an aqueous solution of potassium chloride **Filter paper, funnel, conical flask/beaker**

(iv) Transfer 15.00 cm³ of Ethanoic acid from a beaker to a conical flask.

Burette

