UNIVERSITY OF EDUCATION, WINNEBA

THE EFFECT OF COOPERATIVE INSTRUCTIONAL APPROACHES ON SELECTED DIASO SENIOR HIGH SCHOOL STUDENTS' UNDERSTANDING OF REDOX REACTIONS

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A DISSERTATION IN THE DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF SCIENCE EDUCATION, SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE STUDIES, UNIVERSITY OF EDUCATION, WINNEBA, IN PARTIAL FULFILLMENT FOR THE AWARD OF MASTER OF EDUCATION IN SCIENCE.

DECEMBER, 2014

DECLARATION

STUDENT'S DECLARATION

I, Anthony Amune, hereby declare that except for references to other people's work which have been duly cited, this action research is the result of my own work, and that it has neither in whole nor in part presented for another degree in this university or elsewhere.

Signature……………………………………….

Date…………………………………………….

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this dissertation was supervised in accordance with the guidelines on supervision of research work laid down by the University of Education, Winneba.

Supervisor's Name: Prof. John K. Eminah

Signature ……………………………………………………

Date: ………………………………………………………...

DEDICATION

This work is dedicated to the Almighty God for giving me wisdom. The work is also dedicated to my wife, Doris Osei, for supporting me financially.

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I am grateful to Almighty God for giving me the inspiration, knowledge and courage to complete this work. I am highly indebted to my supervisor, Prof. John K.Eminah of the Department of Integrated Science Education, University of Education, Winneba. I thank you very much for the time spent with me to correct my work and complete it. May the Almighty God richly bless you.

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ABSTRACT

The researcher employed cooperative instructional approaches as alternative teaching approaches involving selected Diaso Senior High chemistry students to determine whether the students would gain understanding of redox reaction content better than their counterparts who did not receive this teaching method. The study was conducted using the 2013/2014 and 2014/2015 academic third year students with the 2013/2014 academic year students receiving the traditional lecture method and the 2014/2015 year students receiving the cooperative instructional approach method. The sample size was 64 of which 29 were in the control group and 35 students in the experimental group. The control group was made up of 4 girls and 25 boys and the experimental group was made up of 7 girls and 28 boys. The mean age for both groups was 18.1 years with standard deviation of 1.22. The research design was of the quasi experimental in which mixed methods of qualitative and quantitative methods were used to analyse data. Test, interviews and questionnaires were the instruments used to gather data. Percentages of students of experimental group who responded correctly to the test items were compared to percentages of students of control groups who responded correctly to test items. The post-test mean scores of the experimental and control groups were compared to see if there was any difference in their mean scores. It was found that the mean post-test score of the experimental group was higher than the mean post-test score of the control group. The experimental group students' learning attitudes towards cooperative instructional approaches were also investigated using a questionnaire. Based on the analysis of the questionnaires, it was found that the experimental group students developed positive attitudes towards cooperative instructional approaches. Based on the findings of this research, it was recommended that the Ghana education service organize workshops to introduce SHS science teachers to cooperative instructional approaches. Additionally, it was suggested that studies be conducted on various aspects of the problem investigation in this study.

CHAPTER ONE

INTRODUCTION

1.1 Overview

This introductory chapter provides a general overview of the study. The chapter is organized into nine sections. In the first section, the background of the study is presented. The problem that was investigated is stated in the third section. It is then followed by purpose of the study, research questions, significance and delimitations of the study. The limitations of the study as well as the abbreviations and definitions of terms are then presented. The last section is devoted to the organization of the report.

1.2 Background to the study

In developing countries like Ghana, technological advancement is a tool we need if we want to catch up with the developed countries. It has been observed that the technological gap between the developed countries and the undeveloped countries could be attributed to poor education in science. Technology takes its roots from science and any nation that want to progress should make science its stronghold. Scientific literacy with its associated benefit of technological advancement has long been regarded or been vital for the development of the nation. The development of any nation lies on the type of educational programme with the said nation. Human resources constitute the ultimate foundation for the development of a nation. To promote social advancement the educational system should be geared towards producing highly educated professional manpower to move the country forward by utilizing the available resources. Understanding the content and processes studied by science is crucial for the understanding of numerous challenges of modern society – new technologies, sustainable development, energy crisis and similar (Sevgi, 2006,Özdem, Y., Cavas, P., Cavas, B., Çakiroglu, J.,&Ertepinar, H., 2010). Science play a major role in areas like; Health, Agriculture, Religion, Business, Communication, Transportation, just to mention a few.

Owing to the above facts and the fact that science education remains pivotal to the success of any society, science is made compulsory at pre-university. Also the Ministry of Education of Ghana established Science Resource Centres in about 110 districts. These were to serve as teaching centres to supplement existing facilities in the Senior Secondary Schools (SSSs) with emphasis on practical activities and to provide practical tuition for students who were initially deprived of well-equipped laboratories with a view to enhancing science education. There were also donor organizations like the United Nation Education Scientific and Cultural Organisation, UNESCO; Educational Development Council, EDC; Norwegian Educational Research Council, NERC; Science Education Project in Africa, SEPA; American Technology Education Agency, ATEA, Canadian Educational Supportor African Countries, CESAC and others who support science educationprogrammes in the country.

There are branches of pure science and these are chemistry, biology, and physics. The ideas obtained by studying pure science are applied to the way we live. Courses that are studied by using scientific ideas of pure sciences to improve good living constitute applied sciences.

Chemistry is the cradle of science and hence is one of the science subjects in the developed SHS science curriculum. It is ultimately one of the requirements for admissions into higher institutions of learning in such programmes as engineering, biotechnology, laboratory technology, water and sanitation, the environment and the like.Reduction-Oxidation reaction or simply redox reaction is one of the topics in the SHS chemisty syllabus that provides students with basic understanding of electrochemical processes.Almost all chemical reactions which are carried out for the purpose of generating energy are redox reactions. Examples are the generation of electricity by means of cells (batteries), the combustion of fuels and the metabolism of food. The industrial extraction of metals from their ores and the corrosion of metals are examples of redox reactions.

The researcher believes that knowledge about redox reactions is important, not only for the chemical disciplines themselves but also for people in general. Redox reactions are common chemical reactions in everyday life. Knowledge about this issue provides to the means of understanding and participating in many debates, such as sustainable development. Redox reactions have a significant impact on, for example, the model for global warming where redox reactions explain the production of greenhouse gases: amongst others, the carbon dioxide production by the combustion of carbon compounds, the formation of nitrous oxide by oxidation of ammonia, and methane production such as in anaerobic decomposition of biomass (Solomons&Fryhle, 2008; Zumdahl&Zumdahl, 2010).

However, the performance of students in chemistry exams is appalling. Reports from the Chemistry Chief Examiners available at the WAEC office testify that students have not been performing well in Chemistry. According to the Chemistry Chief Examiner‘s report (2008), most of the candidates could not distinguish between oxidation and oxidizing agent as well as reduction and reducing agent as the question asked them to define oxidizing agent and reducing agent as well as identifying oxidation and reduction and balancing half equations and overall equations. According to the Chemistry Chief Examiner‘s report (2009), students did not have the concept of oxidation numbers and charges as they were asked to determine the oxidation numbers of chromium and vanadium in $K_2Cr_2O_7$ and V_2O_5 respectively. The researcher has also made several observations on a set of students and found their weaknesses in very vital aspects of redox reactions.

Concerned citizens and educators raised questions as to whether the reason lies in socio-cultural changes or the inefficient methods of science teaching or the location of schools.

Diaso Senior High School located in the UpperDenkyira West District of the central region of Ghana with about 700 student population has a mix of students with different abilities, different cultural backgrounds or ethnicities. The researcher has observed that teachers in the school are accustomed to teaching by the traditional lecture method. Due to this the researcher deemed it necessary to use the cooperative instructional method to see whether students would gain understanding in Chemistry. Cooperative Learning is a teaching arrangement that refers to small, heterogeneous groups of students working together to achieve a common goal (Kagan, 1994). Students work together to learn and are responsible for their teammates' learning as well as their own. This approach promises learners with better learning outcomes since heterogeneous grouping of students is essential to the use of cooperative learning and the groupings involved consist of students with varying abilities, from mentally impaired to gifted.

Based on the outcome of this study, the researcher will offer suggestions to chemistry teachers and curriculum developers.

1.3 Statement of the problem

The Chemistry Chief Examiner‘s Report for May/June, 2009 showed that candidates who got the oxidation numbers of chromium and vanadium correct did not show the signs associated with them as they did not know that an oxidation number is a composite of a charge and a numerical figure. The Chemistry Chief Examiner‘s Report, 2008 showed that most of the students could not distinguish between oxidation and oxidizing agents as well as reduction and reducing agents. Similar reports about students handling redox reactions aspect of chemistry poorly in exams have been reported by WAEC (2006). In the 2006 chemistry 2 paper, many students could not arrange Zn, Y and Cu^{2+} according to the electrochemical series let alone assigning reasons for the correct order as well as deducing whether Y can reduce Cu^{2+}. In another instance in the same paper candidates could not identify the type of reaction that occurred when zinc dust was added to copper (II) tetraoxosulphate(VI) solution.

This is an indication that there are underlying problems that require solutions. The researcher deems it necessary to employ the cooperative instructional approaches to see whether SHS students would gain understanding in the content of redox reactions.

1.4 Purpose of the study

The study investigated the use of Cooperative Instructional Approaches as the teaching and learning approach during redox reactions lessons in Diaso Senior High School in finding out its effectiveness as an alternative teaching strategy to the traditional lecture method and also its usefulness to students in understanding the content of Redox reactions.

1.5 Research questions

The following research questions directed investigations in the study:

1. What conceptual difficulties do the SHS 3 students encounter in the writing of ionic chemical symbols and the explanation of oxidation numbers?

2. Do the SHS 3 students have difficulties in identifying redox reaction equations as well as identifying the oxidizing and reducing agents?
3. What difficulties do the SHS 3 students have in writing balanced redox reaction equations by the ion-electron method?
4. Is there any difference in the mean pre-test scores of the control group and experimental group?
5. Is there any difference in the mean post-test scores of the control group and experimental group?
6. What are the students' learning attitudes towards cooperative learning approach?

1.6 Significance of the Study

The outcome of this study could enable science educators, subject advisors, curriculum designers and developers lay emphasis on the best approach to teach redox reactions. The outcomes of the study could act as reference materials for other researchers, especially university chemical engineering and chemistry teachers who want to research on students' performances in electrochemistry.

1.7 Delimitation

It was not possible to conduct the research in all senior secondary schools in Ghana or even those in the central region of Ghana due to physical constraints. The study took place only at Diaso SHS, in the Upper Denkyira West District of the central region of Ghana.

There are so many topics related to the redox reactions, and therefore the items did not cover all topics related to the topic under investigation.

1.8 Limitations of the study

According to Best and Kahn (1989), limitations are conditions beyond the control of the researcher that will place restriction on the conclusion of the study and its application. This study like all other research works is not without limitations. In order to strengthen internal validity of the study, the researcher used a variety of data collection methods including pre-test, post-test and interviews. However, each method has limitations such as respondents misunderstanding of a question or failure to answer some of the questions.Some students of the control group and the experimental group were absent from some school days and this could affect their performance in post-test.A limitation of the study could be the differences in students within each group of the experimental group.Although efforts were made to ensure that each group within the experimental group contained students of comparable abilities, the group make-up could have affected the outcomes. The control group did score lower on the post-test. It would be better for the control group to now receive instruction with cooperative approach to see whether they would increase their score. Due to time restraints, this information is not included in this report.

1.9 Definition of terms

Base or Home Groups

Base groups are long-term cooperative learning groups with stable membership. Learners are chosen for base groups in a manner that will guarantee a good mix of academic levels in the group. These groups are set up to so that members provide support to each other so that all can succeed academically. For example, they may pick up exercise books for each other if one of the group members is absent, and they will coach each other to prepare for individual tests. The use of base groups tends to personalize the classroom, improve attendance and also improve the quality and quantity of learning.

Abbreviations and Acronyms

WASSCE stands for West African Senior School Certificate Examination

WAEC stands for West African Examination Council, the body responsible for organizing examinations in some selected countries of Africa.

DSHS stands for Diaso Senior High School.

1.10Organisation of the Research Report

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. The third chapter outlines the detailed information of research methodology employed in the study. The fourth chapter presents the data collected and their analysis. The fifth chapter presents the discussion of the results, summary of the study, conclusions, and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

Since the study is primarily concerned with investigating students' difficulties in redox reactions the researcher gives a related literature about teaching and learning problems of redox reactions followed by the nature of cooperative learning approach, the traditional perspective of teaching and learning, symbolic language in chemistry, models in science and science education.

2.2 Teaching and learning problems related to redox reactions and stoichiometric mole calculations

Redox reactions involve the transfer of electrons from one reactant to another reactant. The valency (oxidation number) of the reactant changes. When there is oxidation, there is also reduction. The substance which loses electrons is oxidised and the substance which gains electrons is reduced. For the example:$2Fe^{3+} + Sn^{2+}$ -> $2Fe^{2+} + Sn^{4+}$ (8^{+} each side of the equation). The iron (iii) + tin (ii) have reacted to give iron (ii) + tin (iv). This reaction occurred out in the presence of HCl (Hydrochloric Acid), but the oxidation reduction reaction is only between the iron (iii) and tin (ii).

Now, a redoxreaction is the release and uptake of electrons.

So, the Fe^{3+} is reduced to Fe^{2+}, and the Sn^{2+} is oxidised to Sn^{4+}.

Ringnes (1995) described how the conceptualisation of the reactions oxidation and reduction has evolved over time. Four different redox models are commonly used in chemistry education today. These are the oxygen model, the hydrogen model, the electron model and the oxidation number model (Table 1).

Table 1 Ringes' (1995) Four Oxidation-Reduction Models

Model	**Reduction**	**Oxidation**
Oxygen model	loss of O	gain of O
Hydrogen model	gain of H	loss of H
Electron model	gain of electrons	loss of electrons
Oxidation number model	decrease in oxidation number	increase in oxidation number

How to teach oxidation and reduction has been an issue of discussion for a long time among chemistry educators. Davies (1991) explains that the established redox models (Table 1) are incompatible. In an educational context, a rote application of the models may lead to confusion. He illustrates the incompatibility with the following example:

$$5Fe^{2+}(aq) + MnO_4^{-}(aq) + 8H^{+}(aq) \longrightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O$$

If only the hydrogen ion (H^+) in the reaction is considered, then according to the *oxygen model*, an *oxidation* has occurred by gaining oxygen and a water molecule is formed. According to the *electron model*, hydrogen ions have been *reduced* by the taking up of electrons from the oxide ions, and a water molecule is formed. Neither *oxidation* nor *reduction* has taken place according to the *oxidation number model*. The oxidation number is +I both before and after the reaction. Davies writes further that it is easy for the teacher to underestimate the confusion that may be created when different models are used for a scientific explanation, particularly as students may not have a full understanding of the use of models.

The literature shows that teachers perceive redox as one of the most difficult topics to teach. According to De Jong O., Acampo, J., andVerdonk A. (1995), teachers experience difficulties in making the students adopt the electron model over the oxygen model. The students feel the electron model is superfluous since the oxygen model reports the same product in the given reaction. Ringnes (1995) on the other hand reports that most students define an oxidation as a loss of electrons, while few are able to demonstrate the electron transfer in equations.

In a study by Garnett and Treagust (1992), students were asked to explain which inorganic equations represented oxidation-reduction reactions. Many students explained the reaction in which oxygen was a participator as a redox reaction. Schmidt (1997) states that students identifyoxidation as an addition of oxygen and reduction as the removal of oxygen and suggests that this could be due to the syllable ―ox" in redox.

The students' use and understanding of the oxidation number model has been investigated (de Jong et al., 1995; de Jong &Treagust, 2002; Garnett &Treagust, 1992). Garnett and Treagust (1992) show that students believe that oxidation numbers can be assigned by changes in charges in polyatomic species instead of changes in the oxidation numbers of individual atoms. De Jong et al. (1995) maintain that students assign oxidation numbers according to the charges of ions. De Jong and Treagust (2002) summarise that students describe the oxidation number as ‗the number of oxidized substances' and ‗how many times a substance can be oxidized'. Ringnes (1995) on the other hand shows that most students could produce an acceptable redox equation and explain what substance was oxidized by assigning the oxidation number.

Soudani, Sivade, Cros and Médimagh (2000) explained that university students relate the terms “oxidation” and “reduction” to electron transfer. Some students fail to use theoretical redox knowledge in everyday situations such as the combustion of petroleum.

Teachers perceive redox as one of the most difficult topics to teach (De Jong, Acampo &Verdonk, 1995) and research has shown that school students have difficulties in conceptualising redox reactions (De Jong &Treagust, 2002). One of the problems noted by the teachers, and reported in De Jong et al. (1995) is how to explain the transfer of electrons in such a way as to enable students to adopt the electron model correctly. De Jong and Treagust (2002) suggested that students regard oxidation and reduction as independent reactions; they have problems with the meaning and assignment of oxidation numbers and the identification of reactants as oxidizing or reducing agents. There are a number of explanations to the difficulties in conceptualising redox reactions. Schmidt (1997) found that many students believe that oxygen always takes part in all redox reactions and that oxygen is a pre-requisite for a redox reaction. Schmidt suggests that this could be due to the syllable “ox” in “redOX”. Others, such as Anselme (1997) and Soudani, Sivade, Cros and Médimagh (2000) viewed the problem as to do with concept transfer between domains (Bransford, Brown & Cocking, 2000, p. 51). Anselme (1997) discussed the difficulties student have with transferring knowledge about redox between chemistry topics (from, for example, inorganic to organic), and Soudani et al. (2000) found that students have difficulties in using a theoretical knowledge of redox to interpret everyday phenomena. One explanation they gave is that teaching is dominated by solving algorithmic problems and that students find this too abstract.

A great amount of research exists that refers to the difficulties detected in students when applying the mole concept to stoichiometric calculations. Duncan andJohnstone (1973) found that students were in difficulty when the stoichiometric proportion (of amount of substance) in a reaction was not 1:1.

In a study that involved a very large sample (more than 6000 secondary education students) Schmidt (1990)sought to find out the way students carry out stoichiometric calculations. He concluded that when they make these calculations they tend to think that the proportion of the number of molecules that are combined in a chemical reaction is identical to the proportion of masses of reacting substances. He also observed that the students equaled the proportion of molar masses of the reacting substances to the proportion of combination masses, without considering the stoichiometric coefficients. With regard to the calculation of masses in chemical formulas, he pointed out that students usually do not consider that the atoms of different elements have different atomic masses. In a study conducted later, Schmidt (1994), in order to get a sound understanding of the strategies used in the resolution of simple exercises on stoichiometric calculations, emphasized that students avoid the direct calculation of amounts expressed in moles. He deduced that this may be due to the difficulties arising from the mole concept. In addition, the students examined did not use the reasoning strategies for which they had been trained, but their personal methods.

2.3 Nature of Cooperative Learning

Cooperative learning is generally defined as a teaching arrangement in which small, heterogeneous groups of students work together to achieve a common goal. Students work together in groups to accomplish shared goals (Johnson & Johnson, 1999). Students encourage and support each other, assume responsibility for their own and each other's learning, employ group related social skills, and evaluate the group's progress. The basic elements are positive interdependence, equal opportunities, and individual accountability. Human beings are social creatures by nature and cooperation has been used throughout history in all aspects of our lives. Therefore, it follows that cooperative learning groups in schools would be used as a logical teaching method.

For decades cooperative learning has been implemented in classrooms with diverse populations primarily as a means of fostering positive student interactions. In the United States, cooperative learning was first viewed as an approach to facilitate racial integration.

During the 1960s specific cooperative learning methods began to be developed and evaluated in a wide variety of teaching contexts. In an historic overview (Johnson & Johnson, 1999) nine methods of cooperative learning are listed. Johnson and Johnson developed Learning Together and Alone and Constructive Controversy, DeVries& Edwards created Teams-Games-Tournaments (TGT), Sharan&Sharan developed Group Investigation, Aronson developed the Jigsaw Procedure, Slavin created Student Teams Achievement Divisions (STAD), Team Accelerated Instruction (TAI) and Cooperative Integrated Reading and Composition (CIRC), and Kagan developed Cooperative Learning Structures.

A synthesis of research about cooperative learning finds that cooperative learning strategies improve the achievement of students and their interpersonal relationships. In 67 studies of the achievement effects of cooperative learning 61% found significantly greater achievement in cooperative than in traditionally taught control groups. Positive effects were found in all major subjects, all grade levels, in urban, rural, and suburban schools, and for high, average, and low achievers (Slavin, 1991). Johnson, Johnson, andStanne (2000) summarize that cooperative learning strategies are widely used because they are based on theory, validated by research, and almost any teacher can find a way to use cooperative learning methods that are consistent with personal philosophies. In a meta-analysis of 158 studies, Johnson & Johnson report that current research findings present evidence that cooperative learning methods are likely to produce positive achievement results. The studies included eight methods of cooperative learning: Learning Together and Alone, Constructive Controversy, Jigsaw Procedure, Student teams Achievement Divisions (STAD), Team Accelerated Instruction (TAI), Cooperative Integrated Reading & Composition (CIRC), Teams-Games-Tournaments (TGT), and Group Investigation. In each case, the achievement levels were significantly higher when cooperative learning methods were used as compared to individualistic or competitive methods of learning. Grouping is essential to cooperative learning. The most widely used team formation is that of heterogeneous teams, containing a high, two middle, and a low achieving student and having a mix of gender and ethnic diversity that reflect the classroom population. The rationale for heterogeneous groups argues that this produces the greatest opportunities for peer tutoring and support as well as improving cross-culture and cross-sex relations and integration. Occasionally, random or special interest teams could be formed to maximize student talents or meet a specific student need (Kagan, 1994). It is has been suggested that teachers need to be specially trained to be able to teach with cooperative instructional approach. The reason for lack of teacher training is given as lack of funding and/or administrative support. Another study (Nath& Ross, 1996) of teachers using Student Teams-Achievement Divisions (STAD) found that if teachers did not strictly adhere to the framework of cooperative learning, the method was unsuccessful and students spent more time on disagreements or conflict management than they did on academic tasks. Sapon-Shevin and Schniedewind (1989-1990) assert that teacher buy-in is an essential factor for success and that cooperative learning needs to be embraced as a teaching philosophy and a set of principles rather than as a teaching gimmick if it is to reach its full potential. Factors contributing to achievement effects of cooperative learning are group goals and individual accountability. Providing students with an incentive to help each other and encourage each other to put forth maximum efforts increases the likelihood that all group members will learn. As well as individual grades and evaluations there is strong evidence that group grades and team rewards are most successful for motivation (Slavin, 1995). Others argue that the group grades and team rewards allow for the free rider effect of students who do not participate to the fullest extent of their abilities (Joyce, 1999 and Cohen, 1998). Also, it is argued that group grading de-emphasizes the importance of hard-work, personal ability, and perseverance (Kagan, 1995). Cooperative learning enhances social interaction, which is essential to meet the needs of at-risk students (Slavin, Karweit, & Madden, 1989; Johnson, 1998). Within the framework of cooperative learning groups, students learn how to interact with their peers and increase involvement with the school community. Positive interactions do not always occur naturally and social skills instruction must precede and concur with the cooperative learning strategies. Social skills encompass communicating, building and maintaining trust, providing leadership, and managing conflicts (Goodwin, 1999).

Proper formation of cooperative learning teams plays a critical role in the effectiveness of the cooperative learning lesson. Millis and Cottell (1998) report that most university and college instructors prefer heterogeneous groupings of four because students "tend to stay attentive and on task" (p. 50), are not able to "hide" within the large numbers, and groups are still able to "function smoothly when team members are occasionally absent" (p. 50). Aronson, Blaney, Stephan, Sikes, and Snapp (1978) say that it is ideal for groups to be diverse~ containing students who are "boys and girls, assertive and nonassertive" (p. 36), of varying reading levels and personality types, and from different racial and ethnic groups. Ferguson-Patrick (2010) also expresses the importance of proper group formation when quoting a teacher during a study as saying:

When you structure the groups correctly it's like some students scaffold other students' learning, you know like if you sort of put same ability groups I don't think they'd get anywhere but you'll find that some students can pull other students up and support their learning and that sort of thing and it gives them a bit more confidence ... so I found that everyone just scaffolded each other's learning. In two studies (Nelson & Johnson, 1996; Prater, Bruhl, & Serna, 1998) researchers found that students with behavior disorders who did not receive social skills instruction performed better with direct instruction methods rather than cooperative group methods and that students who did receive social skills instruction performed better with cooperative group methods. Cooperative learning has been found to be a successful teaching strategy at all levels, from pre-school to post secondary. The developmental characteristics of middle school students make cooperative learning a good fit of teaching strategy for the needs of the students. Young adolescents need to socialize, be a part of a group, share feelings, receive emotional support, and learn to see things from other perspectives. Cooperative learning groups do not separate students on the basis of class, race, or gender and the goals of middle schools are consistent with the goals of cooperative learning theories. It is a peer-centered pedagogy that promotes academic achievement and builds positive social relationships (Sapon-Shevin, 1994).

Students may use their thinking, communication, and information-sharing skills to increase their content knowledge as well as their interpersonal skills.

2.3.1 Rationale for Cooperative Learning

Cooperative learning is supported by one of the strongest research traditions in education, with many hundreds of studies conducted across a wide range of subject areas and age groups (Bossert, 1988-1989; Cohen, 1994; Johnson & Johnson, 1989; Sharan, 1980; Slavin, 1995). This large body of research suggests that student to student collaboration conducted in a manner consistent with cooperative learning principles produces superior results on a host of variables, including achievement, thinking skills, interethnic relations, liking for school, and self-esteem. The general results of a few of these studies are as follows:

2.3.2. Academic Achievement

In experimental-control comparison studies of the achievement effects of cooperative learning, most found significantly greater achievement in cooperative than in control classes. Group goals and individual accountability had to be present for these academic gains to be present. Research on behaviours within groups that contribute to learning gains has found that learners who provide and receive elaborated explanations are those who gain the most from the activities. (Slavin, 1990) Learners in cooperative learning classrooms liked the subject areas more than other learners. They also had developed peer norms in favour of doing well academically.

Critical thinking is stimulated and students clarify ideas through discussion and debate (Johnson 1973, 1974a, as cited in Macpherson, undated). The level of discussion and debate within groups of three or more and between pairs is substantially greater than when an entire class participates in a teacher led discussion. Students receive immediate feedback or questions about their ideas and formulate responses without having to wait for long intervals to participate in the discussion (Peterson & Swing, as cited in Macpherson, undated).

Using cooperative learning, students are continuously discussing, debating and clarifying their understanding of the concepts and materials being considered during the class. They are constructing their own knowledge base. The emphasis is on understanding the material as evidenced by the student's ability to explain ideas to their peers. This leads to a sense of content mastery versus a passive acceptance of information from an outside expert. This further promotes a sense of helplessness and reliance upon others to attain concepts (Gentile, as cited in Macpherson, undated).

2.3.3 Skilled Communication

Researchers found that learners involved in cooperative learning activities developed skills for interpersonal communications more readily than learners who were in other classroom settings did. They were more considerate of others feelings, worked in cross-cultural situations more easily, liked their classmates and liked their teachers more than other learners. Researchers found that they developed friends from other cultures and kept these friends outside of class. They had positive expectations toward future interactions. They had more accurate understanding of others‘ perspectives. In conflict situations, they were more able to negotiate and solve conflicts in a win-win manner.

Brufee(1993, as cited in Macpherson, undated) researched the concept of learning taking place when individuals move from the society which they are familiar with to the society which they wish to join by learning the vocabulary, language structure, and customs unique to that society. Working collaboratively is an ideal way to facilitate the acquisition of language and to practise the customs of debate and discussion which occur in any particular academic field.

Social interaction skills are developed with cooperative learning strategies. A major component of cooperative learning elaborated by Johnson, Johnson and Holubec (1984, as cited in Macpherson, undated) includes training students in the social skills needed to work collaboratively. Students do not come by these skills naturally. Quite the contrary, in our society and current educational framework competition is valued over cooperation. By asking group members to identify what behaviors help them work together and by asking individuals to reflect on their contribution to the group's success or failure, students are made aware of the need for healthy, positive, helping interactions when they work in groups (Cohen & Cohen 1991, as cited in Macpherson). Developing ways to manage conflict before conflict arises is an important part of this process.

2.3.4 Psychological Health

Learners who were in classrooms with a significant amount of cooperative learning were psychologically healthier than learners who were not. They had higher self-esteem. Learners In cooperative learning classes have more positive feelings about themselves than do learners in traditional classes. Slavin (1990) also documented the findings that these learners had feelings of individual control over their own fate in school, their time on task was higher and their cooperativeness and altruism were higher as well.

2.4Traditional Perspectives of Teaching and Learning

The traditional approach to teaching assumes there is a predetermined body of knowledge that the teacher should pass on to the student. This approach uses testing and competition to evaluate and motivate students.

According to Novak, J. (1998), the traditional position starts from the assumption taken to be so obvious as not to be open to question, that the purpose of teaching is to ensure that those taught acquire a prescribed body of knowledge and a set of values. Both knowledge and values are taken to reflect a society‘s selection of what it most wants to transmit to its future citizens and requires its future workforce to be able to do.

An important characteristic of this traditional view is that it seeks to convey what is already known and, at some level, approved. The relationship between teacher and learner is determined thereby. The learner is seen as the person who does not yet have the required knowledge or values and the teacher as the person who has both and whose function it is to convey them to the learner.

This view is in consonance with the traditional behaviourist-positivist view which supports a transmission view of teaching in which knowledge can be transmitted to students' minds via language, and students simply absorb transmitted knowledge (Hendry, 1996). Knowledge is viewed as a commodity to be transmitted to students, and learning is viewed as receiving and storing knowledge (Gallagher, 1993). Similarly, as Tobin, Tippins andGallard. (1994) indicated, the traditional model assumes that an already developed body of knowledge, generally accepted by the scientific community, can be transmitted to students through passive instructional means.

Traditional education's perception of children, in an extreme form, was also described by Charles Dickens (1854), in Hard Times as seeing them as: ―little vessels arranged in order, ready to have imperial gallons of facts poured into them until they were full to the brim." In short, like a kettle that has to be filled from a tap, the traditional learner is taken to be a passive recipient of whatever is being taught.

Further, the traditional approach to education requires a degree of memorization, the ability to recall with precision what has been taught in the terms in which it has to be reproduced by the learner, this feature is disparagingly described as ―learning by rote." The implication is that the learner's mind has not been required to be engaged in the process. Finally, the assumption that, to the traditionalist, knowledge is something that already exists causes this approach to be seen as backward-looking at a time when new knowledge is being created and reshaped at a bewildering rate.In teacher-centered classroom, which is the main feature of the traditional view of teaching, teachers focus on the content and most of the classroom time is spent on lectures, worksheets, and seatwork. According to Alton-Lee, Nuthall, and Patrick, (1993), (as cited in Hendry, 1996), traditional teaching is one in which students are motivated through the use of rewards and grades to acquire knowledge given to them by a teacher or a textbook. During lessons, students typically are expected to listen, asked not to talk or discuss their interpretations privately, and are expected to speak in public only when questioned by the teacher.

2.5 Symbolic language in chemistry

A reason why many students find chemistry difficult to understand is the multiple-levels of representation used in chemistry instruction (Johnstone, 1993; Gilbert, &Treagust, 2009; Talanquer, 2011). These levels are the macroscopic, particulate and symbolic representations. When we use our five senses to perceive chemical phenomena that include color changes, precipitation and heat, it is referred as the macroscopic representation. Beyond a certain macroscopic level, however, our senses become inadequate at perceiving chemical phenomena. These phenomena include the interactions of atoms, ions, electrons, and molecules and that level is referred as the particulate representation. To express and describe the properties of the macroscopic and the particulate levels, chemists often use symbolic representations that include chemical symbols, chemical equations, and animations, graphed and tabulated data etc. The ability of chemists or students to interpret and transform from one representation to another is referred as the representational competence (Kozma& Russell, 1997). When students are taught chemistry using the three levels, instructors seamlessly move from one level of representation to another while novice students often view the movement in confusion and can develop misconceptions during the instruction. Several researchers have reported students' difficulties in moving from the macroscopic to the particulate level (Osborne and Cosgrove, 1983; Andersson, 1986; Gabel, 1993; Kelly and Jones, 2008) and from the symbolic to the particulate level (Yarroch, 1985;

Nurrenbern and Pickering, 1987; Pickering, 1990; Nakhleh, 1993; Sanger, 2005; Nyachwaya J. M., Mohamed A.-R., Roehrig G. H., Wood N. B., Kern A. L. and Schneider J. L., 2011).

The precision of language in chemistry is problematic (Bradley, Brand andGerrans, 1987; VerBeek&Louters, 1991, Herron, 1996) and if teachers for example use the terms atoms, molecules and ions indiscriminately misconceptions will, invariably, be the result. Difficulties in the learning of chemistry can be precipitated by a lack of chemistry language skills(VerBeekandLouters, 1991; Marais &Jordaan, 2000; Danili& Reid, 2004). In their study investigating the ability of American students to solve problems in chemistry VerBeek and Louters (1991) noticed a threshold response — students could solve problems of increasing difficulty until they had to work with one additional language item they did not understand. In single step problems the subjects in VerBeek and Louters' study could solve 91% of common language problems and 82% of chemical language problems. In three-step common language problems the success rate was 86%, but in three-step chemical language problems the success rate dropped to 32%. The authors recommended the following to address problems in chemical language (VerBeek&Louters, 1991):

1) Students' exposure to chemical language should be maximised.

2) Teachers should not assume that students are familiar with chemical terms and terms should be introduced carefully.Herron (1996) indicated that one of the problems in the use of chemical language is that students do not reject incorrect or unacceptable chemical statements when they are processing chemical sentences superficially. Only if students understand the semantic meaning of chemical phrases and equations (in other words, if they clearly connect symbols to acceptable chemical practice) will they be able to reject

unacceptable chemical statements or equations. The connections between symbolic representations and real-world knowledge of chemical processes are integrated for the expert and the expert relies on experience to interpret chemical symbols and equations meaningfully. The novice lacks the knowledge to assess his or her interpretation of chemical statements and the skill to understand and use chemical language will need to develop before the student has necessarily gained semantic knowledge.

Herron (1996) recommended the introduction of word games and word-attack skills during the teaching of chemistry. He also recommended that certain information should only be accessible by reading. Forcing learners to obtain information from reading would compel them to use chemical language (Herron, 1996). On the basis of experience, students should know when minor changes in symbolic meaning produce major changes in semantic meaning (Herron, 1996).

In a South African context, Marais andJordaan (2000) tested the performance of 136 university first year chemistry students on the meaning of words and symbols describing chemical equilibrium. The study distinguished between letter symbols (e.g. Na, Ca, etc), iconic symbols (e.g. [ ] for concentration in mol dm-3) and combinations of letter and iconic symbols (e.g. Na^{+}). The authors identified the cognitive steps necessary to interpret a simple chemical equation at equilibrium. Marais &Jordaan (2000) found that students experienced greater problems in interpreting symbols than words correctly. Based on their findings, Marais &Jordaan (2000) recommended that:

1) Students‘ understanding of symbols should be tested by including meaning items in content- related tests,

2) Students should be discouraged from regarding chemical symbols as merely short-hand notations which could be adapted to suit the individual user,

3) Students should be provided with a glossary of symbols, and

4) Students should be given group or individual exercises to supply correct symbolic notation.

In a second publication with a South African perspective, Rollnick (2000) discussed the second language learning of science. Some of the disadvantages the bridging students in this study may have suffered during their formal schooling are discussed briefly in the paper by Rollnick. Teachers in formerly disadvantaged schools, particularly in rural areas, are sometimes poorly qualified in both their scientific content knowledge and their command of English. Textbooks written in English are often the only resources for these teachers, but they were unable to mediate the text owing to their own poor background in the use of English. Science texts often present greater challenges to understanding than the texts students use for language instruction. Some problems will also exist in the verbal component if the language of instruction is not the home language. According to Danili and Reid (2004), if students study chemistry in a language other than their mother tongue, difficulties experienced in chemical language could be linguistic, contextual or cultural in nature. Rollnick (2000) recommended that second language science students need the opportunity to practice science in the presence of more capable peers and they need to be introduced overtly to the language requirements of the particular discipline.

2.6 Models in science and science education

Since redox models are scientific models, a brief description of the role of scientific models in science and in science education is given as follows.

The use of models has become recognized as important for scientific inquiry (Giere, 1999). Models in science are viewed as holding an internal structure that represents aspects of some phenomenon or mechanism (Machamer, 1998). These models come in different sorts (e.g., analogous physical conditions, mathematical representations, idealized cognitive models) and serve different roles at various stages of knowledge construction (Schwarz, C. V., Reiser, B. J., Davis, E. A., Kenyon, L., Achér, A., Fortus, D., Shwartz, Y Hug, B. &Krajcik, J., 2009). Modeling in science education draws from philosophy of science and cognitive theory. For example, Windschitl, Thompson, andBraaten, (2008) proposed a view of science that focuses student discourse on learning scientific concepts. They identified several epistemic characteristics of scientific knowledge represented in models. Such models are ―testable, revisable, explanatory, conjectural, and generative" (p. 943). Windschitl et al. propose a model-based inquiry approach that uses a set of conversations to organize knowledge, generate testable research questions, seek evidence, and construct an argument. This model-based approach to inquiry offers the possibility of moving students beyond learning only theoretical knowledge by situating them in a community that considers the epistemic criteria for scientific models (Pluta, Chinn, & Duncan, 2011). Such a view is consistent with the dialogical perspectives in social epistemology.

A scientific model is a human construction used to explain parts of our experienced life-world (Gilbert, Boulter& Elmer, 2000). Scientific models differ in appearance. According to van Driel and Verloop (1999) many attempts have been made to categorise scientific models on the basis of their differences, for example, as physical models – such as an atom – or descriptive models, which show for example the planets moving in orbits in our solar system. However, scientific models also share many common features. For example, a model is always related to a target; the issue that we want the model to represent. This issue can be a scientific phenomenon, an object or a process. A scientific model can also represent an abstract target that is not visible or measured directly, such as the atomic model or a model of the black hole (ibid.). Models are also very important in the scientific research process. Gilbert and Boulter (1998) summarise functions of scientific models as important tools for interpreting results, generating predictions and developing scientific knowledge.

However, depending on the specific research interest, models are simplified and certain aspects of the models are excluded. Thus scientific models can appear in many different forms in their representation of scientific phenomena.

As scientific models segregate our experienced life-world into smaller parts, scientific models are also important for teaching and learning (Harrison, 2000; Harrison &Treagust, 1998). The intention of using models in science education is to make science understandable (Justi& Gilbert, 2002). Teachers argue that without models it is almost impossible to teach non-observable entities such as electron flow, or chemical processes (Harrison, 2000; Harrison &Treagust, 1998). On the other hand, students seldom have a full understanding of how to use models in their explanations of phenomena (Boulter& Buckley, 2000). The nature of the models in science classes is seldom discussed, and the models are presented rather as facts to be learned, thus undermining constructivist teaching and learning strategies (van Driel&Verloop, 1999).

Often, neither the function of the model nor how the model is connected to the studied phenomenon is explained. Consequently, the students cannot imagine the different ways in which models are connected to each other (Boulter& Buckley, 2000). Understanding models becomes a further obstacle if the models are changed without giving the reason for doing so. It should therefore be made clear when a new model is introduced in what way it differs from the previous model, and why this model functions better Carr (1984).

Concepts contain scientific information and scientific models are designed on the basis of concepts (Gericke, 2009; Gilbert et al., 2000; Novak, 1996; Schmidt, 1997). A concept is, like a model, a human construct which is _a package of meaning' describing a pattern or a definition (Novak, 1996). A concept can also be seen as a carrier of a label, where each label corresponds to a meaning, an explanation of a phenomenon; a model. Since scientific theories and models in some cases develop over time, a certain concept can be related to different theories. The meaning of the concept may change, but the label remains (Schmidt, 2000). An example of this is the concept of oxidation which can be explained by a gain of oxygen, a loss of hydrogen, a loss of electrons or an increase in the oxidation number. The same applies to the concept of reduction, which has a label and can be explained as a loss of oxygen, a gain of hydrogen, a gain of electrons or a decrease in oxidation number. Ringnes (1995) has made a summary of the models to which the concepts oxidation and reduction are related. These are shown in Table1. Three of the models, – the hydrogen, the electron and the oxidation number model – also explain the mutuality of a redox reaction; an oxidation and a reduction always occur simultaneously (Nelson & Cox, 2004; Solomons&Fryhle, 2008; Zumdahl&Zumdahl, 2010).

CHAPTER THREE

METHODOLOGY

3.1Overview

This chapter is concerned with the design of the study, population and sampling procedures, instrumentation, interviews, questionnaire, reliability and validity of the instruments, data collection procedure and data analysis are presented.

3.2 Research Design

The study is of a quasi-experimental design. Non-equivalent groups, pretest-intervention-posttest, is the design style of the study with one group (experimental group) receiving cooperative learning instructional method and the other group (control group) receiving more traditional lecture/discussion teaching method. Quasi experimental design was used, because this was appropriate as the study is to investigate a situation where the classes are intact and, therefore, random selection and assignment are not possible.

The study was a combination of qualitative and quantitative approaches and was conducted at different terms because the topic is treated only at third year as it is in the designed syllabus and DSHS has only one third year class studying Elective Chemistry. According to Ary, and Razavieh (1990), qualitative inquiry seeks to understand human and social behaviours from the "inside" perspective. The quantitative inquiry on the other hand is principally concerned with the discovery of "social facts" devoid of subjective perceptions or intrusions and divorced from particular social and historical context. Narkevissei, Pathmanathan, and Browniee (1992), advanced two purposes of combining methods in a single study as follows: that a skilful use of a combination of different techniques can maximise the quality of data collected and reduce the chance of bias and that they compliment each other.

In the light of the above, data collection focused on different approaches including a pretest, posttest, curriculum based assessment, interview and questionnaire. Figure 2 shows the design of the study.

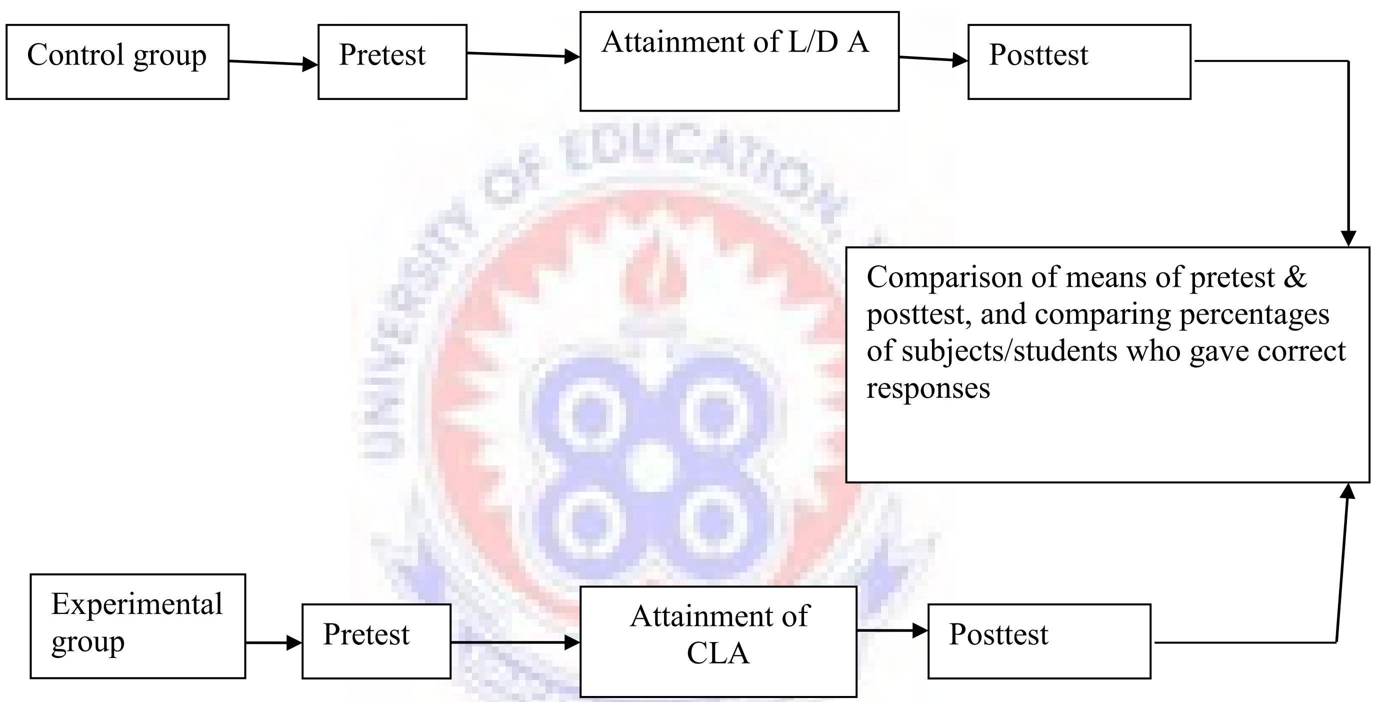

Figure 2 Diagrammatic representation of the design for the study

L/D A means lecture/discussion approach

CLA means cooperative learning approach

3.3 The Study Area

Diaso Senior High School is located 35km west of Dunkwa-On-Offin municipal assembly in the central region of Ghana. The school is considered to have some characteristics of a less-endowered school because there are no enough facilities to enhance students learning science. Programmes that students in the school study are General Arts, Bussiness, Home Economics and Agricultural Science. The overall student population is about 700 (2014/2015 academic year) and consistently about 30 students per Agricultural Science class study elective chemistry. The students in the study are from different backgrounds; homeless children, children of professional and upper-class parents. The students are a mix of abilities, gender, and ethnicity.

3.4 Population and Sampling Procedure

A research population is a large well-defined collection of individuals or objects having similar characteristics (Castillo, 2009). Castillo distinguishes between two types of population: the target population and the accessible population. The target population also known as the theorical population refers to the group of individuals to which researchers are interested in generalizing their conclusions and the accessible population also known as the study population is the population to which the researchers can apply their conclusions. The target population for the study was Senior High School Elective Chemistry students in the Central Region of Ghana. However, the accessible population was 2013/2014 and 2014/2015 third year elective chemistry students of Diaso Senior High School in the central region of Ghana. According toNarkevissei, Pathmanathan, and Browniee (1992) a purposive sampling enables the researcher to use his or her personal judgment based on previous knowledge of the population to select sample for specific purpose and it is convenient, and also the researcher does not need to struggle, as in the case of random sampling, because the individual units of the sample are physically together in groups instead of being scattered.

There are one third year Agriculture Science class students that study redox reactions because the topic is in the third year syllabus. The researcher therefore conducted the study at different times (2013/2014 and 2014/2015 academic years). The researcher has been teaching Integrated Science in the school for the past five years and is very confident to describe the overall potential of a class; that is deduction obtained from comparison of performances of students of different classes. Over the years students‘ performance in Chemistry has been consistent. The researcher therefore was conformable to teach the 2013/2014 third year students (control group) using the lecture method. The sample size was 64 of which 29were in the control group and 35 were in experimental group. The control group was made up of 4 girls and 25 boys, and the experimental group was made up of 7 girls and 28 boys.

The pre- test was conducted to both groups (control and experimental) to assess students‘ knowledge and difficulties in some aspects of Redox reactions. The 2013/2014 students obtained the higher mean score and experimental group obtained the lower mean score.

The ideal size for cooperative learning groups (experimental group) according to most experts in the field is four learners per group. Millis and Cottell (1998) report that most university and college instructors prefer heterogeneous groupings of four because students "tend to stay attentive and on task", are not able to "hide" within the large numbers, and groups are still able to "function smoothly when team members are occasionally absent". Aronson, Blaney, Stephan, Sikes, and Snapp (1978) say that it is ideal for groups to be diverse~ containing students who are "boys and girls, assertive and nonassertive", of varying reading levels and personality types, and from different racial and ethnic groups. When you have four in a group, you can have pairs working together at times and four working together at other times. There are six different pair combinations possible in groups of four.There are also many ways an instructor can place learners into groups. These include**:**Instructor Assigned Groups, Randomly Assigned Groups, Social Integration Groups, Subject-Matter Related Groups, Geographic Groups, Self-Selected Groups.The instructor assigned group was the best criterion for the research in thatthe researcher (instructor) could assign learners to groups to ensure that the groups were heterogeneous. The real advantage to forming groups in this manner was that researcher could see to it that groups were heterogeneous in terms of academic ability, ethnic background, gender, andsome factors that the researcher felt important. The researcher made sure that best friends and worst enemies were not in the same groups. If they were, communication patterns in the group would not be as effective. This was highly possible because the researcher teaches in the school. In the light of this, based or home groups each group consisting of four members and only one 3-member group were formed within the experimental group after conducting the pre-test.

3.5 Instrumentation

Three instruments were used in the study. These were the tests, interviews and questionnaires. Both the pre-test and post-test consisted of 6 items on which subjects were expected to give certain deductions, explanations and calculations. The post-test was same to pre-test. The second instrument was a follow up post intervention semi-structured interview on students who got the items on the post-test wrong. The third instrument was a structure questionnaire to measure students‘ attitudes towards cooperative learning approach.

3.6 Questionnaire

There was a questionnaire provided to the students in the study to see whether students really appreciated the cooperative instructional approaches. The questionnaire was a structured questionnaire with 7 items designed to measure their attitudes.

3.7 Interviews

Follow up interviews were organised for both groups on the items of the post-test students got wrong. In order to get detailed data and be able to pose follow-up questions semi structured interviews were chosen as data collection method. According to Kvale (1997), a semi-structured interview covers a range of themes and issues with the possibility to change the order and the form of the questions to follow up the respondents‘ answers. The interview instrument items were taken from the post-test instrument.

3.8 The reliability and validity of the instruments

The pre-test was first pilot run at SefwiWiawso Technical Senior High School and then given to the subjects of both groups. The Cronbach alpha coefficient of reliability for the items with alpha value of 0.77 and 0.75 for the experimental group and the control group respectively were obtained using SPSS (statistical package for social scientists) and which indicated that the instrument was reliable according to Bork, Gall, and Gall (1993). The post-test was pilot run in the same manner and alpha coefficient of reliability 0.75 and 0.76 for the experimental and control groups respectively. According to Golafshani (2003), validity describes whether the means of measurement are accurate and whether they are actually measuring what they are intended to measure. All instruments were validated and peer-reviewed by Chemistry teachers at Diaso Senior High School and SefwiWiawso Technical Senior High School.

3.9 Data Collection Procedures

The study took three weeks of the third term of 2013/2014 academic year and three weeks of first term of 2014/2015 academic year for control and experimental groups respectively. The chemistry teacher had already introduced the researcher to the students and informed the students that the integrated science teacher would be teaching them redox reactions for three weeks for the purpose of a research work. The researcher conducted the pre-test which lasted for one hour the first period.The pre-test instrument had 6 items on which students were expected to make certain deductions, give explanations and to do calculations. The pre-test was based on 100%; score indicating the percentage of correctly answered items. For the experimental group, students received instruction about working in cooperative groups and practiced before the study began. In the experimental group, 40 - 45 minutes, of each contact period (80 minutes), were used for small group problem solving and activity, 20 minutes, for whole class and group discussion; the remainder for curriculum based assignments. The control group on the other hand, used 65 minutes, of each contact period for traditional whole class instruction; 20 minutes for curriculum based assignments. Two lesson plans on redox reaction concept were prepared by the researcher and presented to a panel of experts for their comments and suggestions. Ultimately corrections on the plans were effected before being used for the intervention. The topics focused on oxidation number, oxidation and reduction as well as oxidizing and reducing agents, and balancing of redox reactions. Appendixes D and E are lesson plans for the control group and experimental group respectively. Appendixes A and B also show the pre-test and post-test items. The pre-test and post-test instruments contained the same type of items, but items altered in numbering.

3.10 Data Analysis

Data from the pre-test and the post-test were analyzed quantitatively, and data from the follow up interviews and questionnaires were analyzed qualitatively. Comparisons of percentages of students with correct responses on post-test items to the percentages of students who gave correct responses to same items on the pre-test within the same group (control or experimental) is a measure of the students' understanding of some aspects of redox reactions.When these comparisons are done in between the groups (control or experimental), the researcher could deduce the usefulness of the instructional approaches used. The mean scores of the pre-test and post-test of students of control and experimental groups were compared to realise the effect of using cooperative instructional approaches to enhance students' understanding of redox reactions. Results from the questionnaire were analyzed qualitatively to draw conclusions about students' learning attitudes towards the cooperative learning approach.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Overview

This chapter is concerned with presentation and discussion of results. Results from pre-test, post-test, group interviews with students who got some of the items of post-test incorrectly and questionnaires are presented. Analyses of these results are used in the discussions with respect to the research questions posed in chapter.

4.2 Results and Discussions

Research Question 1: What conceptual difficulties do the students encounter in the writing of ionic chemical symbols and the explanation of oxidation numbers?

Results of students‘ understanding of writing ionic chemical symbols and their understanding of oxidation numbers are summarized in tables 2(a), 2(b), 3(a), and 3(b). Students‘ conceptual problems of writing ionic chemical symbols are also summarized in table 4. Table 2(a) shows the percentage of students who responded well to each of the items in the pre-test while 2 (b) combines the related items and shows the number and percentage of students who gave correct responses to the combined items in the pre-test. Table 3(a) shows the percentage of students who responded well to each of the items in the post-test while 3 (b) combines the related items and shows the number and percentage of students who gave correct responses to the combined items in the post-test.

Table 2(a): Number and percentage of students who gave correct responses to the items of the pre-test.

	Number and percentage of students	
Item number	**control group (N = 29)**	**experimental group (N = 35)**
1	14(48%)	17(49%)
2	14(48%)	15(43%)
3	2(0.07%)	4(0.1%)
4	0	0
5	0	0
6	0	0

Table 2 (b

Item number	**What items measure?**	**Number and percentage of students**	
		Control group	**experimental group**
1 and 2	students' understanding of writing chemical symbols of ions and their understanding of oxidation numbers	14 (48%)	15 (43%)
3 and 6	students' ability to identify redox reaction equation and oxidizing agents and reducing agents	0	0
4 and 5	students' ability to write balanced redox reaction equations	0	0

Table 3 (a): Number and percentage of students who gave correct responses to the items of the post-test

Item number	Number and percentage of students: control group(N= 29)	Number and percentage of students: experimental group(N = 34)
1	22(76%)	30(88%)
2	23(79%)	30(88%)
3	18(62%)	25(73%)
4	22(76%)	31(91%)
5	15(52%)	21(62%)
6	19(66%)	32(94%)

Table 3 (b):

Item number	What items measure?	Number and percentage of students: Control group	Number and percentage of students: experimental group
1 and 2	students' understanding of writing chemical symbols of ions and their understanding of oxidation numbers	22 (76%)	30 (88%)
3 and 4	students' ability to identify redox reaction equation and oxidizing agents and reducing agents	18 (62%)	25 (73%)
4 and 5	students' ability to write balanced redox reaction equations	15 (52%)	21 (62%)

Table 4: Students' reasons for writing the ions present in molten alumina and lead trioxonitrate(V) solution incorrectly.

Ions present in: (a) molten Alumina, Al_2O_3 (b) lead trioxonitrate(V), $Pb(NO_3)_2$ Solution	Reasons	Number of students	
		control group	experimental group
(a) Al^{2+}, O^{3-}	aluminium has lost 2 electrons and oxygen has gained 3 electrons in the compound	2	0
Al_2^{3+} , O_3^{2-}	there are 2 aluminium atoms and they lost 3 electrons and there are there are 3 oxygen atoms and they gained 2 electrons	3	3
Pb_2^{+}, NO_3^{2-}	there are 2 lead atoms in the in the compound	1	1

In table 2(a), item 1 measured how many students understood oxidation numbers and item 2 in table 2(a) also measured how many students understood writing of ionic chemical symbols before the intervention. Therefore the combined item 1 and 2 of table 2 (b) measured how many students understood oxidation numbers and writing of ionic chemical symbols before the intervention. Similarly, item 1 in table 3(a) measured the number of students who understood how to write ionic chemical symbols only and item 2 of 3 (a) measured the number of students who obtained the concept of oxidation numbers only after the intervention. In 3 (b) the combined items 1 and 2 measured the number of students who obtained the understanding of writing ionic chemical symbols and an understanding of oxidation numbers.

The concepts of chemical symbols of ions and oxidation numbers of atoms were treated before the students entered the third year. However, before the intervention, most students from the control group and the experimental group did lack understanding about writing of chemical symbols of ions. Table 2 (a) shows that only 48% of students from the control group had understanding about writing of chemical symbols of ions before the study and 49% of students from the experimental group also had understanding about writing of chemical symbols of ions. Similar cases were reported by Baah and Anthony-Krueger, (2012) about students' inability to write correct formulae of some radicals and some ions as students wrote the chemical formula of sulphide as SO_3 and SO; tetraoxophosphate (V) ion PO_4^{2-}, PO_4^-, P_4; and nitride ion as NO_3^-, NO^-; trioxocarbonate (IV) ion as CO_3^-, etc. Also oxidation number as a topic was treated before the study, but results showed that they had conceptual problems. Table 2 (a) shows that only 48% of students of control group understood what oxidation number meant and 43% of experimental group could explain oxidation numbers. Similar results about students having conceptual problems with oxidation numbers of atoms were reported by De Jong and Treagust (2002). In table 3 (a), there has been an improvement in obtaining the concept of oxidation number as 79% of students from control group and 88% of students from the experimental group having understanding of oxidation numbers of atoms. Table 2(b) shows that before the intervention, 48% of students of control group had the understanding of writing ionic chemical symbols and understanding of oxidation numbers. Table 3 (b) shows that 76% of students of control group understood writing of ionic chemical symbols as well as oxidation numbers and 88% of students of experimental group also understoodwriting of ionic chemical symbols as well as oxidation numbers after the intervention. It is observed that students taught using the cooperative instructional approach performed better than their counterparts who did not receive this teaching approach.

However, some students still faced conceptual problems so far as oxidation number is concerned and results from group interviews with such students revealed that 21% of students of control group and 12% of students of experimental group merely neglected to indicate the + sign in conformity with the chemistry chief examiner 2009 reporting that though some students were able to determine the oxidation numbers of atoms, they failed to indicate + or – sign.

Not only that but also some students from both groups also faced conceptual problems of writing chemical symbols of ions. Table 4 gives the incorrect responses of students when interviewed about writing the chemical symbols of ions present in molten alumina and lead trioxonitrate (V) solution. Students wrote incorrect chemical formulae of ions, but none did say the ionic compounds formed chemical bonds with water in contrast to Kelly and Jones (2007) probably due to the fact that the solvent water was not mentioned in the test items.

Research Question 2: Do the students have difficulties in identifying redox reaction equations as well as identifying oxidizing and reducing agents?

In table 2(a) item 6 measured the percentage of students with the ability to identify redox reactions before the intervention. Item 3 of table 2(a) also measured the percentages of students who could identify oxidizing and reducing agents before the intervention. Item 4 of table 3(a) also measured the percentage of students who could identify redox reactions after the intervention. Item 3 of table 3 (a) measured the percentage of students who could identify oxidizing and reducing agents after intervention. Table 5 shows the misconceptions a number of students had towards oxidizing agents and reducing agents.

Table 5: Students' incorrect responses and reasons

Students' incorrect Responses	reasons	Number of students	
		control group	experimental group
Oxidizing agent is one which oxidizes whereas reducing agent is one which reduces in chemical reaction.	it has oxygen atoms	5	4
(b) I. oxidizing agent: I^-	it oxidises in the equation	3	2
Reducing agent: Cl_2	it reduces in the equation		
II. Oxidizing agent: CO	it oxidises in the equation	3	3
Reducing agent: Fe_2O_3	it reduces in the equation		

Before the study, the students did not know anything about redox reaction as there was no student who could identify a redox reaction (item 6 in table 2 (a)). After discussion of the topic, students gained understanding and could identify redox reactions with ease as 76% of students of control group having understanding of the nature of redox reactions and 91% of students of the experimental group also gaining understanding of the nature of reactions.

However, a fewer students still faced problems since they selected all the equations to be redox reactions and obtained zero score (since a wrong selection nullified a one correct selection). One explanation students (24% of control group and 9% of experimental group)gave in selecting $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$ as not a redox reaction equation is that since there are water and a salt ($MnCl_2$) at the right hand side of the equation, the equation is a neutralization reaction equation rather than redox reaction equation.

Table 2 (a) shows that before the study, the students did lack the concept of oxidizing and reducing agents while table 3 (a) shows that most students (62% of control group and 73% of experimental group) gained understanding of oxidizing agents and reducing agents. Despite the laboratory activity to enhance students in conceptualizing oxidizing agents and reducing agents, some students still had difficulties in identifying oxidizing agents and reducing agents. De Jong and Treagust (2002) suggested that students regard oxidation and reduction as independent reactions; they have problems with the meaning and assignment of oxidation numbers and the identification of reactants as oxidizing or reducing agents.Some students had conceptual problems in identifying oxidizing and reducing agents and group interviews (Table 5) revealed their conceptual difficulties.What adds to the significance of students having problems in conceptualising redox reactions in this study are similar cases about students‘ difficulties in conceptualising redox reactions (De Jong &Treagust, 2002). Results from group interviews with students who got some of the post-test items wrong also revealed that many students had the misconception that oxygen must take part in redox reactions and if one of the reactants contains oxygen, then that reactant is the oxidizing agent.These findings are in conformity with Schmidt (1997) who found that many students believe that oxygen always takes part in all redox reactions and that oxygen is a pre-requisite for a redox reaction and suggested that this could be due to the syllable ―ox" in ―redOX". Table 3 (b) shows that the percentages of students that gained understanding of redox reactions and oxidizing and reducing agents were 62% and 73%% of the control group and experimental group respectively indicating that the number of students of experimental group who understood nature of redox reactions and oxidizing and reducing agents outnumbered their counterparts of the control group.

Research Question 3: What difficulties do the students have in writing balanced redox reaction equations by the ion-electron method?

Item 4 and 5 of table 2(a) measured students‘understanding of writing balanced redox reaction equations before the intervention. Item 5 and 6 of table 3 (a) measured the percentage of students having the understanding of writing balanced redox reaction equations immediately after the intervention.

Students‘ inability to determine oxidizing and reducing agents persisted well into balancing redox reaction equations since the first step in balancing requires that oxidation and reduction half equations are separated and balanced before combining to obtain the overall balanced equations. Table 2 (a) shows that before the study the students did not know how to write balanced redox reaction equations as none of the students of control or experimental group could write a correct balanced redox equation as the item demanded. Table 3 (a) shows that immediately after the study many students gained understanding of writing balanced redox reaction equations. The difficulties students faced when balancing redox reaction equations were their inability to identify oxidation and reduction half equations, their inability to remove spectator ions, and their lack of understanding to use stoichiometric coefficients to conserve charges. Different items were used to measure students' understanding of writing balanced redox equations. Item 5 of table 3 (a) measured the students' ability to write balanced half equations (oxidation half and reducing half equations) while item 6 of table 3 (a) measured the students' understanding of stoichiometric coefficients to conserve charges. Table 3 (a) shows that 52% of students of control group gained understanding about writing balanced half equations and overall balanced equations. 62% of students of experimental group gained understanding about writing balanced half equations. 66% of students of control group gained understanding about using stoichiometric coefficients to conserve charges when balancing redox equations. 94% of students of experimental group gained understanding about using stoichiometric coefficients to conserve charges when balancing redox equations. The problems a few students (34% students of control group and 6% students of experimental group) still faced in this area were their inability to identify $2Fe^{3+}$ as 2moles of Fe^{3+} and therefore failed to see that $6e^-$ (6 moles of electrons) transferred in $2Fe^{3+}$, but rather they identified $2Fe^{3+}$ as two ions and 3 moles of electrons were transferred in $2Fe^{3+}$; also given this equation:

$CrO_4^{2-} + 2H_2O \rightarrow CrO_2^- + 4OH^-$, they could not identify that $5e^-$are involved in the right side and $2e^-$involved in the left side and therefore, $3e^-$ should be added to the left side, but they argued that there is one negative charge from $4OH^-$ and another from CrO_2^-. Students' lack of understanding of using stoichiometric coefficients in calculations was also reported by Schmidt (1990).

Research Question 4:Is there any difference in the mean pre-test scores of the control group and experimental group?

Table 6 shows the results of the means of the pre-test and post-test scores.

Table 6 Mean achievement scores and standard deviations of subjects in the experimental group and control group

Group	Pre-test		Post-test		Mean difference
	Mean	SD	Mean	SD	
Experimental(N=35)	14.0143	12.1088	69.0882	12.1664	55.0739
Control(N=29)	16.0759	13.1087	63.2414	14.5888	47.1655
Difference in mean	2.0618		5.8468		7.9084

Table 6 shows that pre-test mean score of the control group was 16.0759 with standard deviation of 13.1087 and pre-test mean score of experimental group was 14.0143 with standard of 12.1088. This means that the average performance of students of control group was higher than their counterparts of the experimental group before the intervention. However, the standard deviation of the control group score being higher than the experimental group means there was greater variability in the performance of students of the control group.Themean difference between the groups being 2.0618 means that students of both groups had almost the same level of understanding of redox reactions.

Research Question 5:Is there any difference in the mean post-test scores of the control group and experimental group?

Table 6 shows the results of the means of post-test scores.

Table 6 shows that the mean achievement score ofthe experimental group in the post-test was 69.0882 with astandard deviation of 12.1664, which is higher than the mean of the control group of 63.2414 and a standard deviation of 14.5888.These results show that the average performance of students taught using cooperative instructional approach was higher than their counterparts who were not taught using this instructional approach.

The lower standard deviation in favor of the experimental group means that the performance of these students did not vary much when compared than their counterparts who exhibited greater variability in their performance.

The results were consistent with those of earlier studies comparing other cooperative learning methods against lecture/independent styles of instruction (Slavin, 1991; Johnson & Johnson, 2000). Hundreds of studies have been undertaken to measure the success of cooperative learning as an instructional method regarding social skills, student learning, and achievement across all levels from primary grades through college. The general consensus is that cooperative learning can and usually does result in positive student outcomes in all domains (Johnson & Johnson, 1999). The experimental group performing better than the control group also meant that students of the experimental group grew to like the subject areas more than the other learners (Slavin, 1990). This also meant thatcritical thinking was stimulated and students clarified ideas through discussion and debate (Johnson 1973, 1974a, as cited in Macpherson, undated) leading to better performance than their counterparts of the control groups.The lower learning outcome (performance) of students in the control group could be attributed to the instructional approach used. What adds to the significance of this result is the association between this result and the studies of student learning which, over many years, have consistently shown that surface approaches to learning are related to lower quality learning outcomes (Marton&Säljö 1976; Van Rossum& Schenk 1984; Trigwell& Prosser 1991; Ramsden 1992; Prosser & Millar 1989).

Research Question 6: What are the students' learning attitudes towards cooperative learning approach?

Table 7 is a description, in percentages, the students who showed interest or dislike towards the cooperative instructional approaches they received in learning the content of redox reactions.

Table 7 Students' learning attitudes towards cooperative learning

Statement about learning in groups	Number and percentage agreeing to statement	Number and percentage disagreeing to statement	Number and percentage with no view to statement
I like cooperative learning style.	30(86%)	5(14%)	0
When I work together I achieve more than when I work alone.	28(80%)	5(14%)	2(5.7%)
I willingly participate in cooperative learning activities.	32(91.4%)	3 (0.09)	0
Cooperative learning can improve my attitude towards learning.	30(86%)	5(14%)	0
Group activities make the learning interesting.	29(83%)	4(11.4%)	2(5.7%)
Cooperative learning helps me to have good friendship with my class mates.	28(80%)	5(14%)	0
Creativity is facilitated in the group setting.	24(68.6%)	5(14%)	6(17.1%)
Cooperative learning enhances class participation.	30(86%)	5(14%)	0

Table 7 shows that in total students really appreciated the cooperative learning approach. All the students' responses to questionnaire item 1 and 2 were that they have never experienced this learning style. 86% of the students expressed their liking for the cooperative learning approach as against 14% of students who disliked the approach. Again, 80% of the students confirmed that they achieved better performance when they worked in groups. Interestingly, 91.4% of students expressed their feelings that they enjoyed the learning style; they were not compelled to learn in groups as against 8.6% of the students who felt they would not want to learn this way.

Results in table 7 also indicate 86% of students agreed to the fact that cooperative learning could improve their attitudes towards learning, 83% of students felt group activities make the learning interesting, 80% of students expressing their views that it improves good relationship among learners, 86% of students asserting that it enhances group participation, and also 68.6% students asserting that it facilitates creativity. These positive attitudes towards cooperative learning are supported by many researches regarding attitudes towards cooperative learning. By asking group members to identify what behaviors help them work together and by asking individuals to reflect on their contribution to the group's success or failure, students are made aware of the need for healthy, positive, helping interactions when they work in groups (Cohen & Cohen 1991, as cited in Macpherson, undated).

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

This chapter summarizes the research findings and provides a conclusion for the study. The chapter also provides suggestions for further research.

5.2 Summary

The study investigated the effect of cooperative instructional approaches on selected Diaso Senior High School students' understanding of redox reactions. The main focus was to measure control group students' understanding of redox reactions and experimental group students' understanding of redox reactions after both groups of students have received instruction. The control group students were taught by the lecture method and the experimental group students were taught using cooperative instructional approach. Three instruments; tests, group interviews and questionnaires were used to collect data. Data gathered were quantitatively and qualitatively analyzed and major findings are as follows.

1.Differences in performance between students who received cooperative instructional approaches and those who received the traditional lecture method

Analyses of pre-test scores of both control and experimental groups indicated that the control group students slightly performed better than their counterparts in the experimental group. However, after the experimental group students have received the cooperative instructional learning approach, their performance exceeded their counterparts of the control group who received the traditional lecture method as analyses of post-test scores showed large mean difference in favour of the experimental.

2. Students attitudes towards cooperative instructional approach

Students' responses to items of questionnaire which were of learner's social skills, positive communicative skills, academic work, psychological factors, creativity, and the like were positive attitudes towards cooperative instructional approach.

3 Students' difficulties with redox reactions

One of the misconceptions held by the students was that a chemical reaction equation in which there were water and salt (including any product or not including any product) at the right side of the equation is a neutralization reaction. Hence, students did not select MnO_2 + 4HCl$\rightarrow$$MnCl_2$ + Cl2 + 2H2O as redox reaction arguing that it is a neutralization reaction.Students also believed that oxidizing agent oxidises in the redox reaction and a reducing agent reduces in the reaction. Some students also believe that oxidizing agent contains oxygen atoms. Some students believed that the oxidation half equation contains the oxidising agent at the right side of the half equation and the reduction half equation contains the reducing agent.Some students also argued that the total charges of $4OH^-$, $2Fe^{3+}$ are -1 and +3 respectively instead of -4 and +6, and hence they could not conserve charges when balancing redox reaction equations.

5.3 Conclusion

The study yielded considerable argument in favour of using cooperative instructional approaches with senior high school students. The findings also lend credence to the findings of Ruthren (1996) that heterogeneous teams are promising in arranging cooperative learning in schools. The study also revealed that learners in cooperative learning classes had more positive feelings about themselves than did learners in traditional classes. Results of questionnaire showed that these learners had friendly feelings towards one another, in conformity with Slavin (1990) that these learners had feelings of individual control over their own fate in school, their time on task was higher and their cooperativeness and altruism were higher as well.

Although, the researcher could hardly pinpoint all the possible sources of students' misconceptions, the researcher observed that students come to the classrooms with various backgrounds that might help or hinder their correct understanding of scientific concepts, and hence heterogeneous mix of students did help in students' understanding of redox reactions.

5.4 Recommendations

In the light of the above research findings, the following recommendations have been made:

1. Curriculum developers should incorporate cooperative instructional approaches in the designed syllabus of teacher training institutions to help teachers equip them the knowledge of cooperative instructional approaches so that they will be able to use the approach even if a class has a mix of behaviour disordered students.
2. The Ghana Education Service should organise workshops to teach teachers with the theory and practice of cooperative instructional approaches.
3. Teachers that used cooperative instructional approaches have interests and background in cooperative learning and they received continual support and feedback from trainers and other teachers using the cooperative learning structures. Sapon-Shevin and Schniedewind (1989-1990) found that teacher buy-in is essential to the success of cooperative learning. Teachers are therefore encouraged to buy-in in the course of other teachers having cooperative instructional classes.
4. A source of students' difficulties in conceptualising redox reactions could be the language of the textbook different from textbook the teacher uses. If textbooks authors

do not change their approach to using and explaining redox in different contexts, the teacher must critically review the textbooks and help the students to bridge the different redox models.

5.5 Suggestions for further research

Also based on the research findings, the following suggestions for further research are made.

1. A research is needed to study teachers‘ conceptions of redox models, their use of these models in teaching.
2. This study should be replicated in other schools with pure science students
3. A study is needed to investigate how authors present materials on redox models and other related topics in textbooks and their presentation of redox phenomena in their books.
4. A study should be conducted to investigate gender differences in male and female SHS students‘ understanding of redox reactions.
5. A study should be conducted to determine the predominant instructional approaches utilized by SHS integrated science.
6. A study on the availability of educational materials related to integrated science education at the SHS level should be conducted.

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APPENDIX A

PRE-TEST

Date:……………………………………………Student's Number:……………

Tick √ for male or female.

Sex: Male Female

☐ ☐

Answer all questions Time allowed: 1 hour

1. (a) Define the oxidation number of an element.

(b) State the oxidation number of

I. Chromium in KCr_2O_7.

II. Manganese in $KMnO_4$.

III. Iron in Fe^{3+}.

2. Write, in chemical symbols, the ions present in the following:

(a) Molten alumina, Al_2O_3.

(b) Lead trioxonitrate (V), $Pb(NO_3)_2$.

3. (a) Briefly explain the difference between an oxidizing agent and a reducing agent.

(b) State the oxidizing agent and the reducing agent in each of the redox reaction equations that follow:

(I) $2I^- + Cl_2 \rightarrow I_2 + 2Cl^-$.

(II) $Fe_2O_3 + CO \rightarrow Fe + CO_2$.

4. Consider the redox reaction equation: $HNO_3 + Cu_2O \rightarrow Cu^{2+} + NO + H_20$. (acidic medium)

Write balanced half (oxidation half and reduction half) equations and overall balanced redox reaction equation.

5(a) State the total number of moles of electrons transferred on the left side of the equation below:

$2Fe^{3+} + Sn^{2+} \rightarrow 2Fe^{2+} + Sn^{4+}$.

(b) For a certain redox reaction equation, the reduction half equation is correctly separated and written as: $CrO_4^{2-} + 2H_2O \rightarrow CrO_2^{-} + 4OH^{-}$. How many moles of electrons should be added to the left side of the equation in order to conserve charges?

6. Select the redox processes (redox reaction equations) from among the chemical equations that follow:

(a) $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$.

(b) $Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + H_2O$.

(c) $2Ag^{+} + Cu \rightarrow 2Ag + Cu^{2+}$.

(d) $Pb(NO_3)_2 + H_2S \rightarrow PbS + 2HNO_3$.

APPENDIX B

POST-TEST

Date:……………………………………………Student‘s Number**:**……………

Tick √ for male or female.

Sex: Male ☐ Female ☐

Group No. ……….

Answer all questions

1. write, in chemical symbols, the ions present in the following:

   (a) Molten alumina, Al_2O_3.

   (b) Lead trioxonitrate (V), $Pb(NO_3)_2$.

2. (a) Define the oxidation number of an element.

   (b) State the oxidation number of

   I. Chromium in $K_2Cr_2O_7$.

   II. Manganese in $KMnO_4$.

   III. Iron in Fe^{3+}.

3. (a) Briefly explain the difference between an oxidizing agent and a reducing agent.

   (b) State the oxidizing agent and the reducing agent in each of the redox reaction equations that follow:

(I) $2I^- + Cl_2 \rightarrow I_2 + 2Cl^-$.

(II) $Fe_2O_3 + CO \rightarrow Fe + CO_2$.

4. Select the redox processes (redox reaction equations) from among the chemical equations that follow:

(a) $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$.

(b) $Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + H_2O$.

(c) $2Ag^+ + Cu \rightarrow 2Ag + Cu^{2+}$.

(d) $Pb(NO_3)_2 + H_2S \rightarrow PbS + 2HNO_3$.

5. Consider the redox reaction equation: $HNO_3 + Cu_2O \rightarrow Cu^{2+} + NO + H_20$. (acidic medium)

Write balanced half (oxidation half and reduction half) equations and overall redox reaction equation.

6(a) State the total number of moles of electrons transferred on the left side of the equation below:

$2Fe^{3+} + Sn^{2+} \rightarrow 2Fe^{2+} + Sn^{4+}$.

(b) For a certain redox reaction equation, the reduction half equation is correctly separated and written as: $CrO_4^{2-} + 2H_2O \rightarrow CrO_2^- + 4OH^-$. How many moles of electrons should be added to the left side of the equation in order to conserve charges?

APPENDIX C

QUESTIONNAIRE

My dear student, this section provides you with the opportunity to express your feelings about cooperative learning (learning in groups). You have the freedom to sincerely express your views about this learning style. Remember you do not have to write your name or indicate your identity. Nevertheless, express your feelings honestly. The statements that precede the table, you are to stick √ for Yes or No whether you have ever experienced this learning style or you have not and how often you have learned using this learning style apart from this time. Also, stick √ to agree or disagree with the statement on the first column in the table. If you do not have any view about the statement in the first column, stick √ No View in the fourth column.

1. Have you ever participated in group assignment before?

☐ Yes ☐ No

2. Rate the extent to which teachers use group activities.

☐ Never ☐ Sometimes ☐ Always

Statement about learning in groups	**Agree**	**Disagree**	**No View**
1. I like cooperative learning style			
2. When I work together I achieve more than when I work alone.			
3. I willingly participate in cooperative learning activities.			
4. Cooperative learning can improve my attitude towards learning.			
5. Group activities make the learning interesting.			
6. Cooperative learning helps me to have good friendship with my class mates.			
7. Creativity is facilitated in the group setting.			
8. Cooperative learning enhances class participation.			

APPENDIX D

Lesson plan used for students taught using the tradition lecture method

SUBJECT: CHEMISTRY--------------------------------- CLASS: SHS 3 AGRIC TERM: 1 YEAR: 2013 NUMBER OF LESSONS PER WEEK --3- DURATION OF LESSONS------------------------

NAME OF SCHOOL-------------- NAME OF THE TEACHER----------

Duration	**Topic/ subtopic**	**Learning objectives**	**Teaching/learning materials (TLM)/ Teaching/learning activities (TLAs)**	**Remarks**	**Evaluation**
80minutes	Redox reactions/ Oxidation number	At the end of the lesson the learner should be able to: i) define the oxidation number of an element. ii) write chemical symbols of ions. iii) assign oxidation numbers to some elements.	TLMs: Charts video clips TLAs: Through discussions teacher explains the meaning of oxidation number. With the help of charts teacher explains how atoms obtain charges and how to write the chemical symbols of ions. Teacher explains the rules governing how to assign oxidation numbers to elements.		Assignment 1
80minutes	Oxidation and reduction	*By* the end of the lesson students will be able to: i) define oxidation and reduction. ii) identify a redox reaction and investigate the chemical equations. iii) connect how redox reactions affect their daily lives.	TLMs: charts, empty coke cans, video clips TLAs: teacher explains oxidation and reduction with examples from text book. Using components of Brunner‘s Theory, give examples of reactions that are redox reactions (e.g acid base reactions). Redox Demo: Ask several students to break an empty can of coke that has been oxidized, asks others to break one that has not been. Video Clip: Show students video clip that explains the redox reaction of coke can http://www.stevespanglerscience.com/experiment/00000100		Assignment 2

80minutes	Oxidizing agent and reducing agent	At the end of the lesson the student will be able to: I) identify oxidizing agent and reducing agent.	TLMs: Zn dust and $CUSO_4$ solution. TLAs: Teacher guides students to add Zn dust carefully to $CUSO_4$ solution in test tubes until the blue colour is faded. The ions present in $CUSO_4$ solution are Cu^{2+} and SO_4^{2-} ions and as such when Zn dust is added, the Zn donates 2moles of electrons to the Cu^{2+} (blue) and the Cu^{2+} accepts the electrons and becomes elemental copper (brown) and deposited at bottom. The redox equation is: $Zn + CuSO_4 \rightarrow Cu + ZnSO_4$. As Zn donates electrons to reduce Cu^{2+} in $CuSO_4$, it is known as a reducing agent and Cu^{2+} in CuSO4 that accepts electrons, the whole compound $CuSO_4$ is an oxidizing agent.		Assignment 3
80 minutes	Balancing redox reactions	At the end of the lesson the student will be able to: i)identify spectator ions. ii) separate redox reaction equations into oxidation half equations and reduction half equations. iii) apply rules to balance half equations	TLMs: charts TLAs: explain spectator ions to learners and give examples of spectator ions Through discussions, explain oxidation half and reduction half equations and give several examples. Through discussions explain the rules governing the balancing of redox reaction equations by the ion electron method. With examples balance half equations.		Assignment 4
80 minutes	Balancing redox reactions	At the end of the lesson the student will be able to: i) balance redox reaction equations.	TLMs: charts TLAs: through discussion with several examples guide learners to separate and balance half equations and overall redox reaction equations while concentrating much on stoichiometric moles to conserve charges.		Assignment 5:

APPENDIX E

Lesson plan used for the experimental group

SUBJECT: CHEMISTRY----------------- CLASS: SHS 3 AGRIC TERM: 1YEAR: 2014

Duration	Topic	Learning objectives	Teaching/learning materials (TLM)/Teaching/learning activities (TLAs)	Remarks	Evaluation
80minutes	Redox reactions/ Oxidation number	At the end of the lesson thelearner should be able to: i) define the oxidation number of an element ii) write chemical symbols of ions iii) assign oxidation numbers to some elements	TLMs: Charts video clips TLAs: Through discussions teacher explains the meaning of oxidation number. Teacher explains the rules governing how to assign oxidation numbers to elements. (20min) Jigsaw: Using the Jigsaw Method, students teach each other about the Oxidation Number Rules (20min) Think, Pair, Share: Individually, students find the oxidation numbers of elements, showing each step they made to arrive to the answer. In pairs, they assess each other's answers –**Self, Peer and Teacher Evaluation**(anecdotal notes)(20min) Class Discussion: Teacher takes up correct answers with entire class, (10min)		Assignment 1
80minutes	Oxidation and reduction	Bythe end of the lesson students will be able to: i) define oxidation and reduction ii) identify a redox reaction and investigate the chemical equations iii) connect how redox reactions affect their daily lives	TLMs: charts, empty coke cans, video clips TLAs: teacher explains oxidation and reduction with examples. Using components of Brunner's Theory, give examples of reactions that are not redox reactions (e.g acid base reactions). Redox Demo: Ask several students to break an empty can of coke that has been oxidized, asks others to break one that has not been (30min) Video Clip: Show students video clip that explains the redox reaction of coke can http://www.stevespanglerscience.com/experiment/00000100(5min) (5min) Inquiry + Lecture: Ask essential questions about lab results to help students understand redox equations (10min) Thin Pair Share: Students brainstorming with elbow partner other everyday redox reactions (i.e., corrosion) and share with class. (10min)		Assignment 2:

80minutes	Oxidizing agent and reducing agent	At the end of the lesson the student will be able to: I) identify oxidizing agent and reducing agent.	TLMs: Zn dust and $CUSO_4$ solution. TLAs: Teacher guides students in groups to add Zn dust carefully to $CUSO_4$ solution in test tubes until the blue colour is faded. The ions present in $CUSO_4$ solution are Cu^{2+} and SO_4^{2-} ions and as such when Zn dust is added, the Zn donates 2moles of electrons to the Cu^{2+} (blue) and the Cu^{2+} accepts the electrons and becomes elemental copper (brown) and deposited at bottom. The redox equation is: $Zn + CuSO_4 \rightarrow Cu + ZnSO_4$. (30min) As Zn donates electrons to reduce Cu^{2+} in $CuSO_4$, it is known as a reducing agent and Cu^{2+} in CuSO4 that accepts electrons, the whole compound $CuSO_4$ is an oxidizing agent. <u>Cooperative Problem Solving:</u> Given equations, student groupsidentify oxidizing and reducing agents (35min)		Assignment 3:
80 minutes	Balancing redox reactions	At the end of the lesson the student will be able to: i)identify spectator ions ii) separate redox reaction equations into oxidation half equations and reduction half equations iii) apply rules to balance half equations	TLMs: charts TLAs: explain spectator ions to learners and give examples of spectator ions Through discussions, explain oxidation half and reduction half equations and give several examples. Through discussions explain the rules governing the balancing of redox reaction equations by the ion electron method. With examples balance half equations. (30min) <u>Cooperative Problem Solving:</u> In small groups, students practice balancing half reactions. (30min)		

80 minutes	Balancing redox reactions	At the end of the lesson the student will be able to: i) balance redox reaction equations.	TLMs: charts TLAs: through discussion with several examples guide learners to separate and balance half equations and overall redox reaction equations while concentrating much on stoichiometric moles to conserve charges. (20min) Cooperative Presentations: Each group will present one question and will show step by step how they arrived to that answer. Each person in the group needs to speak. The rest of the class confirms whether or not it is correct. **Peer**(verbal) + **Teacher Evaluation**(formative rating scale)(40min)		Assignment 5: